A Review of Technology for
Arctic Offshore Oil and Gas Recovery

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Appendices

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Table of Contents

APPENDIX A

U. S. Geological Survey Arctic Operating Orders, 1979

APPENDIX B

Det Norske Veritas', Rules for the Design, Construction and
Inspection of Offshore Technology, 1977

APPENDIX C

Alaska Oil and Gas Association, Industry Research Projects, March 1980

APPENDIX D

Arctic Petroleum Operator's Association, Industry Research Projects,
January 1980

APPENDIX E

Selected Additional Arctic Offshore Bibliography

Section 1. Sea Ice

Section 2. Icebreakers

Section 3. Arctic Seafloor Conditions

Section 4. Ice-Structures

Section 5. Frost Heave

Section 6. Structure Icing

APPENDIX A

U. S. Geological Survey Artic Operating Orders. 1979

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back up photo

Proposed Arctic OCS Orders

Proposed Arctic OCS Order No. 1

This Order requires all platforms, drilling rigs, drilling ships, and wells to have signs of standard specifications for identification of the operator, the specific lease block of operation, and well number.

This Order also requires that all subsea objects resulting from lease operations which could present a hazard to other users of the OCS must be identified by navigational markings as required by the U.S. Coast Guard District Commander.

Under this provision, the potential for accidents associated with subsea production systems, "stubs", fishing gear, and ship anchors is substantially reduced.

This Order mitigates impacts caused by subsea completions on commercial fishing activities and anchoring and mitigates impacts caused by the presence of platforms or drilling operations on shipping and navigation.

Proposed Arctic OCS Order No. 2

Order No. 2 concerns procedures for drilling of wells. It requires the operators to file Exploration Plans, Development and Production Plans, and an application for drilling which includes information on the drilling platform vessel, casing program, mud programs, blowout prevention equipment (BOP), well control, training and safety training of operators personnel, and a list describing critical drilling operations which may be performed. The Order then describes certain procedures or equipment to be used in each phase of the drilling operation.

It requires operators to submit plans dealing with emergency situations that, because of harsh climatic conditions, could cause disastrous consequences in the Arctic Areas. The emergency conditions will specifically include a means of drilling a relief well should a blowout occur.

Due to the technical complexity of the proposed Order, not all details are included in describing its mitigatory impact. The reader may refer to appendix 5 to review the entire Order. This proposed Order requires that all drilling platforms and vessels to be used must be capable of withstanding geologic, oceanographic, and meteorological conditions of the Arctic area. Applications must include all pertinent data on the fitness of the platform or vessel and each such drilling structure must be inspected by the USGS for compliance with OCS Orders. This

requirement should eliminate most concerns about the impact of weather, waves, sediment scour, storm surges, and currents on offshore structures and mobile drilling units. Operators must collect and report oceanographic, meteorological, and performance data of the vessels and platforms during operations in order to assist in developing future or revised operational guidelines for the Joint Federal/State Beaufort Sea leases.

Order No. 2 requires operators to conduct shallow geological hazards surveys of the well site or lease block prior to the commencement of drilling operations. The purpose of such surveys is to locate shallow gas deposits, near-surface faults, obstructions, unstable bottom areas, or other conditions which are hazardous to drilling operations.

All wells must be cased and cemented in order to support unconsolidated sediments and prevent leakage of fluids between formations or pressure changes in the well. If there are indications of improper cementing, the well must be recemented and logs must be run to insure proper sealing of the well. The casing design and setting depths are to be based on all engineering and geologic factors including the presence or absence of hydrocarbons, potential geologic hazards, permafrost, hydrates, Arctic conditions, and water depths. An additional casing string may be required if abnormal geopressures are encountered. A pressure test is required of all casing strings, except the drive or structural casing, to determine the presence of leaks and the integrity of the casing. The use of casing as described in this Order should eliminate potential impacts of fresh water zone contamination, lost production, permafrost destruction, or the possibility of accidents caused by improper well protection.

Operators are required to obtain directional surveys on all wells. These surveys, which are filed with the Supervisor, insure that the well is drilled in accordance with approved specifications.

Blowout preventers and related pressure-control equipment, designed for operations under Arctic conditions, must be installed, used, and tested in a manner necessary to insure positive well control. A specific number of these preventers must be used in every well, and they must be equipped with dual control systems and failsafe valving in critical lines and outlets. These devices provide protection against oil spills resulting from loss of well control. Special requirements are included for floating drilling operations which necessitate the placement of the blowout preventer stack on the seafloor. These requirements are designed to mitigate the potential for accidents during deepwater drilling operations.

Arctic OCS Order No. 2 also requires the testing and actuation of the BOP systems on specific time schedules during the drilling of the exploratory hole. This mitigates against the possibility of equipment malfunction due to poor maintenance or climatic conditions.

Order No. 2 specifies requirements for the use and testing of drilling muds. Drilling muds have a number of critical functions, one of the most important being the control of sub-surface pressures and the prevention of gaseous and liquid influxes into the wellbore. Drilling mud programs must be approved prior to the commencement of drilling. The operator must, at all times, maintain sufficient and readily accessible quantities of mud to insure well control.

Special procedures are required for the handling and use of the drilling mud while drilling through zones containing permafrost. This special handling can help prevent serious well problems that can result from the thawing and refreezing of permafrost zones.

Arctic OCS Order No. 2 also includes safety requirements to be followed for areas where combustible gases may accumulate. This could help prevent serious accidents likely to occur because of enclosed areas necessitated by Arctic climatic conditions.

Representatives of the operator must provide on-the-site supervision of drilling operations on a 24 hour basis. A member of the drilling crew or the toolpusher must maintain surveillance of the rig floor continuously from the time drilling operations commence until the well is either completed or abandoned. All supervisory personnel, including drillers, must be trained in present day methods of well control, and records of the training are to be kept at the well site. Specific well-control training requirements are outlined in Geological Survey OCS Standard No. T 1 (GSS-OCS-T 1). The training requirements are intended to minimize the potential for well blowouts caused by human error. Formal training is supplemented with weekly blowout-prevention exercises for all rig personnel. These drills are performed during different drilling procedures to vary the experience of the crew. Drills are frequently witnessed by Geological Survey representatives and must always be recorded in the drillers log.

Procedures to be followed when drilling operations may penetrate reservoirs known or expected to contain hydrogen sulfide gas (H_2S), or in those areas where the presence of H_2S is unknown, or upon encountering H_2S , are included in U.S. Geological Survey OCS Standard No. 1 (GSS-OCS-1), "Safety Requirements for Drilling Operations in a Hydrogen Sulfide Environment." This set of standard operating procedures will assure proper equipment testing and crew training and drill unit safety should highly

toxic H₂S be encountered. Hazards of H₂S are substantially reduced by the institution of these procedures.

Since some operations performed in drilling are considered more critical than others with respect to well-control problems, fires, explosions, oil spills, and other accidents, each operator must file a Critical Operations and Curtailment Plan for the Supervisor's approval.

This Order includes a list and description of critical operation categories. Before exceeding the operation limits of an approved plan, the operator must notify the Supervisor and curtail operations. This allows the Geological Survey to provide either specific approval in advance of the conduct of the critical operation or to dispatch personnel to the lease site for observation of the operation. This part of proposed OCS Order No. 2 will provide additional regulatory review of drilling operations which may be hazardous to the drilling platform, vessel, crew, and the environment.

This Order also recognizes that when sufficient information has been obtained in any area of the OCS, that more detailed and specific procedures for that particular area should be established. This normally occurs during the development and drilling of field wells, these orders and procedures are designated as Field Drilling Rules.

Proposed Arctic OCS Operating Order No. 3

This Order is established to provide control of the plugging and abandonment of wells which have been drilled for oil and gas. For permanent abandonment of wells, cement plugs must be placed so as to extend 30 meters (100 feet) above the top and 30 meters (100 feet) below the bottom of fresh water and oil and gas zones to prevent those fluids from escaping into other strata. Portions of a well in which abnormal pressures are encountered are also required to be isolated with cement plugs. Plugs are required at the bottom of the deepest casing where an uncased hole exists below. Plugs or cement retainers are required to be placed 30 meters (100 feet) above the top and 30 meters (100 feet) below any perforated interval of the well hole used for production of oil and gas. A "surface" plug 45 meters (150 feet) long must be placed 45 meters or less below the ocean floor. A pressure test must be made on top of the first plug below the surface plug. The spacing between plugs must be filled with drilling muds of sufficient density to exceed the greatest formation pressure encountered in drilling the interval.

The casing and piling on the sea floor must be removed to a depth below the ocean floor approved by the Supervisor. For temporary

abandonment, all plugs and mud discussed above must be placed in the well with the exception of the surface plug. (The temporary abandoned well would have to be marked in accordance with proposed Order No. 1.)

The casing and piling on the sea floor must be removed to a depth below the ocean floor approved by the Supervisor. For temporary abandonments, all plugs and mud discussed above must be placed in the well with the exception of the surface plug. (The temporary abandoned well would have to be marked in accordance with proposed Order No. 1.)

This Order should eliminate concern about contamination of freshwater zones or the possibility of oil and gas leaks from abandoned wells. The requirements state that the sea floor above each final abandonment must be cleared, and that the removal depth of casing and piling must be examined on a case-by-case basis. This will provide protection to navigation and fishery interest. The chance that obstructions might become exposed due to changes in bottom conditions is reduced as well.

Special consideration must be given to plugging wells that contain permafrost zones. Fluid left in hole opposite permafrost zones at abandonment shall have freezing point below the temperature of the permafrost and shall not have an oil base. This would assure fluid and plug stability and prevent contamination should leakage occur.

Proposed Arctic OCS Operating Order No. 4

Proposed Order No. 4 provides for the extension of a lease beyond its primary term for as long as oil or gas may be produced in paying quantities and the operator has met the requirements for diligent development. If these circumstances should occur, a lease can be extended beyond its initial term pursuant to Section B(b)(2) of the OCS Lands Act and Title 30 CFR 250.11 and 250.12(d)(1).

In addition to a production test for oil, one of similar duration is required for gas. All pertinent engineering, geologic, and economic data are required to support a claim that a well is capable of being produced in commercial quantities. Each test must be witnessed by the Geological Survey although, with prior approval, an operator affidavit and third-party test results may be acceptable. The primary purpose of this Order is to provide for determination of well productivity which may permit extensions of lease terms. Such extensions are frequently necessary to insure the orderly development of OCS oil and gas resources.

Proposed Arctic OCS Operating Order No. 5

This Order sets forth requirements for the installation, design, testing, operation, and removal of subsurface safety devices.

Proposed Order No. 5 requires that all well tubing installations open to hydrocarbon-bearing zones shall be equipped with a surface-controlled, subsurface-safety device that is placed 30 meters or more below the ocean floor. All wells perforated and completed but not placed on production must be equipped with a subsurface-safety device or tubing plug within 2 days after the well is completed. Subsurface-safety devices shall also be placed in injection wells unless they are incapable of flowing. All safety devices must comply with the minimum standards set forth in the API Spec. 14A, Third Edition, November 1978, "Specification for Subsurface Safety Valves", and recent supplements as approved by the Area Supervisor. Testing of the device must take place monthly for 3 months after installation and half yearly thereafter; if it does not operate correctly, it must be promptly removed and a properly operating device must be put in place and tested. Additional protection equipment is also required with the use of subsurface protective devices. When tubing is open to hydrocarbon zones and is not equipped with a subsurface safety device (during workover), the well must be marked, and a safety device or tubing plug must be available at the field location to be installed if necessary. Records must be kept of all subsurface-safety devices employed at each well with quarterly reports prepared on reasons for any failure of the devices.

The subsurface-safety valves prescribed in this Order serve as a mechanism for automatically shutting in a well below the ocean floor in the event of an accident or natural event which destroys or threatens to destroy surface well-control equipment. The reliability of such devices is maximized through regular testing. As a result of these requirements, the probability of a production well blowout is extremely small.

Proposed Order No. 5 also sets forth requirements for the design, installation, operation, and testing of safety systems for platform production facilities. All new platforms resulting from this sale will have to be in conformance with API RP 14C, "Analysis, Design, Installation, and Testing of Basic Surface Systems on Offshore Production Platforms".

Prior to the installation of platform equipment, operators must submit, for the Supervisor's approval, schematic diagrams with equipment, piping, firefighting, electrical-system, gas-detection, and safety-shutdown specifications. A Safety Analysis Function Evaluation Chart must also be submitted. This

chart relates all sensing devices, shutdown devices, and emergency-support systems to their functions. The chart provides a means of verifying the design logic of the basic safety system. A Safety Analysis checklist is also prepared. This checklist permits an analysis of the system's redundancy and the numbers of types of system failures that would have to occur before an undesirable event would result. The safety analysis procedures prescribed in this Order identify events that might pose a threat to safety or the environment and define reliable protective measures that will prevent such events or minimize their effects should they occur.

All platforms must have curbs, gutters, and drains in all deck areas to collect contaminants in a sump system. This requirement prevents the discharges of such contaminants into the sea.

Whenever operators plan to conduct activities, simultaneously with production operations, which could increase the possibility of accidents, a contingency plan must be filed for the Supervisor's approval. Activities requiring the plan include drilling, workover, wireline, pumpdown, and major construction operations. The intent of this requirement is to permit Geological Survey review of the conduct, control, and coordination of the proposed operations. This review will determine whether the operations can be conducted simultaneously without significantly increasing the risk of accidents or spills.

Prior to welding or burning operations, operators must submit a plan describing personnel requirements and designating safe welding areas. Procedures for establishing safe welding areas and for conducting operations outside such areas are specified in the Order. The requirements reduce the potential for explosions, injuries, and pollution discharges.

To mitigate the potential for accidents resulting from human error, all personnel engaged in installing, inspecting, testing, and maintaining safety devices must meet specific training requirements. The Order also sets forth requirements for employee orientation and motivation programs concerns with safety and pollution prevention in offshore oil and gas operations.

Proposed Arctic OCS Order No. 5

This Order pertains to the development stage of leases and has not yet been finalized and may not be ready for publication in the near future; however, it will be published before development phase is reached.

Order No. 6 sets forth requirements for conducting various types of workover operations and requires all completed wells to have

casing heads, wellhead fittings, and valves which are designed for handling pressures exerted by the well. It also provides limitations to well completion procedures. Accordingly, this Order provides for protection of the well during completion and workover operations from rupture or loss of oil and/or gas by leakage and thus greatly reduces the possibility of environmental impact from release of oil and gas.

Proposed Arctic OCS Order No. 7

Proposed Order No. 7 relates to the prevention of pollution to the marine environment and provides rules for the disposal of waste materials generated as a result of offshore operations.

Proposed OCS Order No. 7 sets forth a means to effectively deal with pollution of the marine environment from offshore petroleum operations. It states that the operator must prevent pollution of the ocean and that the disposal of waste products must not create conditions that can "adversely affect the public health, life or property, aquatic life or wildlife, recreation, navigation, or other uses of the ocean."

The operator must submit a list of drilling mud constituents, additives, and concentrations expected to be used; this provides a means to prohibit or alter the disposal and use of specific components which might be harmful to the environment. Muds and cuttings containing free oil shall not be disposed of into the ocean. The disposal of oil-free muds and oil-free well cuttings into the sea must be approved by the District Supervisor on a site by site basis. These requirements greatly reduce the potential impacts on biological communities, water quality, commercial fisheries, and offshore recreation and also mitigate impacts along the coastline which would be caused by the washing of oil, fuel, chemical residues, or toxic substances to shore.

No solid waste materials or debris can be disposed of in the marine environment. The disposal of equipment into the sea is prohibited except under emergency conditions. The location and description of any equipment so discharged must be reported to the Supervisor and the U.S. Coast Guard District Commander. This requirement is intended to mitigate the potential for interference with navigation or commercial fishing operations.

All personnel must be thoroughly instructed in the prevention of pollution from offshore operations. Rigorous inspection schedules are required for all facilities. Pollution reports are required for all oil spills, and procedures are set forth for the notification of proper authorities. Pollution-control equipment must be maintained or available to each operator. The equipment must include oil spill response boats, booms, skimmers, cleanup

materials, and chemical agents. (Chemical agents may only be used with the consent of the Supervisor in accordance with the National Oil and Hazardous Substances Pollution Contingency Plan.) The equipment must be maintained and inspected monthly.

Operators must submit an oil spill contingency plan for approval to the Supervisor before an application to conduct drilling operations can be approved. The plan must contain provisions for varying degrees of response effort depending on the severity of the oil spill; identification of containment and cleanup equipment availability; notification of responsible persons and alternates in the event of a spill; identification of areas of special biological sensitivity; and specific actions to be taken after the discovery of an oil discharge. Should a spill occur, immediate corrective action must be taken.

Drills and training classes for familiarization with pollution-control equipment and operational procedures must be conducted on a schedule approved by the Supervisor. The drills must include the deployment of equipment. Although the emphasis of the OCS Orders is on the prevention of oil spills, it is recognized that spills will occur. It is also recognized that it is not technically possible to completely control and mechanically remove all oil that is discharged. The intent of this portion of the Order is to insure that all operators have ready access to the best practical control equipment for the area and that personnel are trained to effectively utilize the equipment. The operator's plans must have sufficient flexibility to permit different spill-control strategies for different environmental conditions. This provides for mechanical and chemical measures which best complement the forces of nature and maximize the protection of biological communities, shoreline resources, and commercial interests.

Proposed Arctic OCS Order No. 8

This proposed Order sets forth the requirements for the design, installation, and protection of platforms and structures including artificial islands. Designs must be in accordance with API Recommended practice (RP) 2A, "Planning, Designing, and Constructing Fixed offshore Structure", and sufficient environmental data (wave, wind, current, tide, storm surges, temperatures, seismic, and geotechnical conditions) must be gathered to permit a determination of design. This environmental data must be factored into the design on the basis of the Order's specifications. Proposed structures and proposed structural plans must be certified by Certified Verification Agents. "Criteria for Certifying Verification Agents", First Edition, defines standards which shall be met by individuals or organizations in order to be certified as Certified Verification

Agents (CVA). This Order assures careful review of platform design and minimizes the probability of spills and environmental damage resulting from structural failure.

Proposed Arctic OCS Order No. 9

This proposed order is presently being revised and reviewed and may not be published in the near future; however, it should be published before a development phase is reached.

This Order establishes requirements for oil and gas pipelines including pressure sensors, automatic shut-in systems, check valves, corrosion protection, and hydrostatic testing. Detailed information on the pipeline design and the bottom conditions must be included in all pipeline applications. Pipelines must be designed to be protected against water currents, storm scouring, and bottom instability, and harsh Arctic climatic conditions. All lines must be compatible with all OCS activities. The effect of the order is to minimize the potential for conflicts with commercial fishing operations and for oil spills resulting from pipeline ruptures or leaks.

Proposed Arctic OCS order No. 11

This Order is being revised and reviewed at the present time and may not be ready for publication in the near future; however, it will be published before a development phase is reached.

Order No. 11 establishes procedures for regulating the rate of production from oil and gas wells and reservoirs. The maximum production rate for a reservoir is that rate which will permit economic development without detriment to ultimate recovery. Maximum rates for individual wells are based on surface equipment capabilities, sand and sediment production, gas oil and water oil ratios, location of perforations and type of completions, and prudent operating practices. These requirements will prevent reservoir damage which could reduce the total production from the reservoir and necessitate increased drilling activity. The requirements also reduce the probability of damage to surface production equipment and the chance of oil spillage resulting from such damage.

The Order prohibits the flaring or venting of natural gas except under special conditions approved by the Supervisor. This requirement prevents the waste of natural gas, the cleanest burning fossil fuel. The use of natural gas in urban areas has a positive effect on air quality.

Order No. 11 sets requirements for the location of wells. The Supervisor has the authority to revise well locations for

resource conservation or facility-reduction purposes. An approved unitization plan may also be required if it is determined that such a plan is in the interest of resource conservation. In addition to the resource conservation benefits, unitization may serve to reduce the facility requirements for OCS development and the interference with other OCS activities.

Proposed Arctic OCS order No. 12

This proposed Order sets forth requirements for the public availability of data and records concerning offshore petroleum operations. Under the Order, specific types of data and records pertaining to drilling and production operations, well tests, sales of lease production, accidents, inspections, and pollution incidents are to be available for public inspection. Privileged information such as certain geological and geophysical data would be made available for public inspection only with the lessee's consent or after a fixed period of time has elapsed. By making operations data available, this Order permits increased public awareness of OCS activities and involvement in OCS programs. Increased public interest and understanding should result in continuing improvements in the safety and pollution-prevention programs of both industry and Government.

Proposed Arctic OCS Order No. 13

This proposed order is being revised and reviewed at the present time and may not be ready for publication in the near future; however, it will be published before the developmental phase is reached.

This Order specifies procedures for assuring the accurate measurement of oil and gas production and for commingling production from different leases or operators. The requirements will permit accurate determination of Government royalties and an orderly transfer of production between parties.

Proposed Arctic OCS Order No. 14

This proposed Order is being revised and reviewed at this time and should be published in the near future.

Order No. 14 establishes guidelines for the approval of suspensions of production and provides for diligent development of oil and gas resources. The intent of the Order is to allow sufficient time for proper lease development while prohibiting unnecessary delays in the exploitation of OCS resources. The environmental impacts of OCS development are minimized by proceeding in an orderly, well planned fashion.

2. Inspection Programs and Approval Requirements: To enforce the Geological Survey Operating Regulations (30 CFR 250) and OCS orders, a comprehensive inspection system has been developed. OCS operators must receive approval before commencing any work. Operators are required to submit a notice and detailed description of work they desire to perform to the USGS District Supervisor. This requirement is to insure that no operation is conducted without thorough planning for safety, conservation, and protection of the environment, and to determine that all operations meet the standards established by regulations and OCS Orders.

All operations, regardless of the activity, will receive regular on-site inspection for compliance with regulations and OCS Orders. The Geological Survey uses a systematic program including both scheduled and unannounced inspections to assure the achievement of safety objectives.

c. Statutes and Regulations: The following describes other appropriate regulations which apply to the Joint Federal/State Beaufort Sea Proposed Lease Sale.

The Outer Continental Shelf Lands Act of 1953 (67 Stat 462), as amended (P.L. 95-372, 92 Stat 629) establishes policies and procedures for managing oil and gas resources of the outer continental shelf and administered by the U.S. Dept. of Interior. The Act specifically provides for the protection of the human, marine and coastal environments in the development of oil and gas resources, to minimize or eliminate conflicts between exploration, development, and production activities on the OCS, and the recovery and protection of other resources.

Regulations administered by the Bureau of Land Management govern the leasing of mineral deposits in the OCS, contained in 43 Code of Federal Regulations (CFR), Part 3300, and the granting of rights-of-way for pipelines in the OCS, contained in 43 CFR, Part 2280, Subpart 2883. Regulations administered by the U.S. Geological Survey govern the conduct of mineral operations contained in 30 CFR, Part 250, and are implemented by OCS operating orders on an area-specific basis. The proposed OCS Arctic operating orders are discussed in section IV.C(b).

The following discussion relates to specific sections of the OCS Lands Act, as amended, and the regulations in 30 CFR, Part 250, which mitigate some of the possible adverse impacts resulting from the proposed sale.

Mitigating measures relating to the administration of leasing of the outer continental shelf (Section 5) provide:

(1) For the suspension or temporary prohibition of any activity, including production, pursuant to a lease or permit at the request of a lessee, in the national interest, to facilitate proper development of a lease or to provide for construction or use of transportation facilities;

A-9

UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY
CONSERVATION DIVISION
WESTERN REGION

ALASKA AREA

ARCTIC

OCS ORDER NO. 1

EFFECTIVE

IDENTIFICATION OF WELLS, PLATFORMS, STRUCTURES, MOBILE DRILLING UNITS,
AND SUBSEA OBJECTS

This Order is issued pursuant to the authority prescribed in 30 CFR 250.11 and in accordance with 30 CFR 250.37.

1. Identification of Fixed Platforms or Structures. Platforms and structures shall be identified at two diagonal corners by a sign with letters and figures not less than 30 centimeters (12 inches) in height with the following information:

- a. The name of the lease operator.
- b. The area designation based on OCS Official Protraction Diagrams.
- c. The block number in which the platform or structure is located.
- d. The platform or structure designation.

The information shall be abbreviated as in the following example:

The Blank Oil Company operates "C" platform on Block 999 of the Salisbury Area. The identifying sign on the platform would indicate:

BOC-SAL-999-C.

2. Identification of Mobile Drilling Units. Floating semi-submersible platforms, bottom-setting mobile rigs, and drilling ships shall be identified by one sign with letters and figures not less than 30 centimeters (12 inches) in height affixed to the derrick so as to be visible to approaching traffic and containing the following information:

- a. The name of the lease operator.
- b. The area designation based on OCS Official Protraction Diagrams.
- c. The block number in which the drilling unit is located.
- d. The OCS lease number.
- e. The well number.

3. Identification of Wells. The OCS lease and well numbers shall be painted on, or a sign affixed to, the wellhead of each singly completed well. In multiply completed wells, each completion shall be individually identified at the wellhead. All identifying signs shall be maintained in a legible condition.

4. Identification of Subsea Objects. All subsea objects resulting from lease operations which are determined by the U.S. Coast Guard District Commander to be hazards to navigation or to the deployment of commercial fishing devices shall be identified by suitable aid-to-navigation devices as directed by the District Commander. Prior to the establishment of a subsea object or in the event of the accidental submergence of an object, the owner shall inform the District Commander of the object's description, location, and unobstructed depth of water above the object's highest point. Based on this information, the District Commander will determine what marking and permits, if any, will be required (14 U.S.C. E3, 85; 43 U.S.C. 1333; 33 CFR 67). The owner shall maintain these navigational markings onsite and properly functioning at all times while the obstruction remains.

5. Departures. All departures from the requirements specified in this Order shall be subject to approval, pursuant to 30 CFR 250.12(b).

Rodney A. Smith
Oil and Gas Supervisor
Arctic Area

Approved:

Don E. Kash
Chief, Conservation Division

UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY
CONSERVATION DIVISION
WESTERN REGION

ALASKA AREA

ARCTIC

OCS ORDER NO. 2

EFFECTIVE

DRILLING OPERATIONS

This Order is issued pursuant to the authority prescribed in 30 CFR 250.11. All exploratory and development wells drilled for oil and gas shall be drilled in accordance with 30 CFR 250.34, 250.41, 250.91, and the provisions of this Order except for those provisions superseded by the issuance of field drilling rules.

1. Plans and Applications.

1.1 Exploration Plan and Development and Production Plan.

In accordance with 30 CFR 250.34, the lessee shall submit Exploration Plans and Development and Production Plans to the Supervisor for approval. All wells drilled under the provisions of this Order shall be included in the appropriate plan. In addition, the Exploration Plans and Development and Production Plans shall include provisions to deal with emergency situations

involving:

- a. A means of drilling a relief well should a blowout occur.
- b. Loss or disablement of a drilling unit or a drilling rig.
- c. Loss of or damage to support craft.

1.2 Application for Permit to Drill. Prior to commencing drilling under an approved Exploration Plan or a Development and Production Plan, the lessee shall file, in triplicate, an Application for Permit to Drill (Form 9-331 C) with the District Supervisor for approval. Additionally, the Supervisor will prescribe the number of public information copies to be submitted. If drilling activity does not commence within 6 months after the approval date, the Permit to Drill will expire.

2. Drilling from Fixed Platforms and Mobile Drilling Units.

2.1 General Requirements.

2.1.1 Fitness of Drilling Unit. All fixed and mobile drilling units shall be capable of withstanding the oceanographic and meteorological conditions for the proposed area of operations. The lessee shall submit evidence to the District Supervisor of the fitness of the drilling unit to perform the planned drilling operation. This evidence shall include drawings

and specifications of the following:

- a. The rated capacity of all major drilling equipment.
- b. Drilling safety systems.
- c. Firefighting equipment.
- d. Pollution-prevention equipment associated with the drilling operation.
- e. A schematic diagram of the drilling unit.

2.1.2 Pre-Drilling Inspection. Prior to commencing operations in an OCS Area, all fixed drilling platforms and mobile drilling units shall be made available for a complete inspection by the District Supervisor.

2.1.3 Well-Site Surveys. Lessees shall conduct a shallow geologic hazards survey, and other surveys as required by the Supervisor. In Areas where shallow hazards or hydrocarbons are unknown, shallow high-resolution geophysical data shall be obtained. The results of these surveys and an analysis of the geological hazards shall be furnished to the District Supervisor. All data obtained from the surveys and all geophysical data relating to shallow hazards shall be furnished upon request to the District Supervisor.

2.1.4 Oceanographic, Meteorological, Performance Data.

Operators shall collect and report oceanographic, meteorological, and performance data during the period of operations. The type of information collected, method of collection, and report requirements will be as specified by the Supervisor.

2.1.5 Subfreezing Operations. Operators shall furnish evidence that the drilling equipment, drilling safety systems, and other associated equipment and materials are suitable for operations in those Areas which are subject to subfreezing conditions.

2.2 Mobile Drilling Units. Applications for drilling from mobile drilling units shall include the following:

a. Maximum environmental design criteria, operational criteria, and a critical operations plan as described in paragraph 9 of this Order.

b. Environmental data, statistical data and calculations which indicate the maximum-anticipated wave, wind, current values, and forces due to ice, icing, storm surges, and seismic motion to be encountered at the drill site during the period of drilling operations.

c. Current American Bureau of Shipping Classification, U.S. Coast Guard Certificate of Inspection, or other appropriate classifications, with operational limitations.

Unless required by the Supervisor, after a mobile drilling unit has been approved for use in an area, the information detailed

in subparagraph 2.1.1 need not be resubmitted unless there are changes in equipment which affect the rated capability of the unit.

2.3 Fixed Drilling Platforms. Applications for installations of fixed drilling platforms or structures, including artificial islands, shall be submitted in accordance with OCS Order No. 8.

3. Well Casing and Cementing.

3.1 General Requirements. All wells shall be cased and cemented in accordance with the requirements of 30 CFR 250.41(a)(1). The Application for Permit to Drill shall include the casing design safety factors for collapse, tension, and burst. In addition, the Application for Permit to Drill must include a proposal to fill all annuli within permafrost zones with cement or a liquid with a freezing point below the minimum permafrost temperature to prevent internal freezeback. The cement used to cement through permafrost zones must be designed to set before freezing and to have a low heat of hydration to prevent excessive thawing of the permafrost zones. Wells drilled in areas which are underlain by freshwater aquifers shall have casing programs which are designed to protect the freshwater zones. In cases where cement has filled the annular space back to the ocean floor, upon approval by the District Supervisor, the cement may be washed out or displaced to a depth not exceeding 12 meters (39 feet) below the ocean floor to facilitate casing removal upon well abandonment. For the purpose of this Order, the several casing strings in order of normal installation are drive or structural,

conductor, surface, intermediate, and production casing. If there are indications of inadequate cementing (such as lost returns, cement channeling, or mechanical failure of equipment in the surface-, intermediate-, and production-casing strings), the lessee shall evaluate the adequacy of the cementing operations by pressure testing the casing shoe, running a cement bond log, running a temperature survey, or a combination thereof before continuing operations. If the evaluation indicates inadequate cementing, the lessee shall recement or take other actions in accordance with the instructions of the District Supervisor. The lessee shall verify the adequacy of the remedial cementing operations as required by the District Supervisor.

The design criteria for all wells shall consider all pertinent factors for well control, such as:

- a. Formation fracture gradients.
- b. Formation pressure.
- c. Maximum-anticipated surface pressure.
- d. Casing setting depths.
- e. Permafrost zones.

The lessee shall utilize appropriate drilling technology and state-of-the-art methods, such as drilling-rate evaluation, shale-density analysis, or other appropriate methods in order to enhance the evaluation of conditions of abnormal pressure

and to minimize the potential for the well to flow or kick.

All casing, except drive pipe or structural casing, shall be new pipe which meets or exceeds American Petroleum Institute (API) standards, or reconditioned used pipe that has been tested to assure that it will meet or exceed API standards for new pipe. If casing which is not fabricated to API standards is used, the manufacturer's specifications shall be included on the Application for Permit to Drill (Form 9-331 C).

In permafrost zones, the surface casing shall have minimum axial post-yield strain properties of 0.9 percent in tension and 1.25 percent in compression. Other means for maintaining the integrity of the well from the effects of permafrost thaw may be approved by the Supervisor upon application.

3.2 Drive or Structural Casing. This casing shall be set by drilling, driving, or jetting to a minimum depth of 30 meters (98 feet) below the ocean floor or to other depths, as may be required or approved by the District Supervisor, in order to support unconsolidated deposits and to provide hole stability for initial drilling operations. If this portion of the hole is drilled, the drilling fluid shall be of a type that is in compliance with the liquid disposal requirements of OCS Order No. 7, and a quantity of cement sufficient to fill the annular space of the drilled hole shall be used.

3.3 Conductor and Surface Casing Setting and Cementing Requirements.

3.3.1 Conductor and Surface Casing Setting Depths.

Casing design and setting depths shall be based upon all engineering and geologic factors, including the presence or absence of hydrocarbons, other potential hazards, and water depths. These strings of casing shall be set at the depths specified, subject to approved variation to permit the casing to be set in a competent bed, or through formations determined desirable to be isolated from the well by pipe for safer drilling operations; however, the conductor casing shall be set immediately prior to drilling into formations known to contain oil or gas, or, if unknown, upon encountering such formations. These casing strings shall be run and cemented prior to drilling below the specified setting depths. The District Supervisor may prescribe the exact setting depths for those wells which may encounter abnormal pressure conditions.

In permafrost-free areas, conductor casing setting depths shall be between 91 meters (298 feet) and 305 meters (1,000 feet) TVD below the ocean floor, and surface casing setting depths shall be between 305 meters (1,000 feet) and 1,400 meters (4,593 feet) TVD below the ocean floor.

In areas containing permafrost, the conductor or surface casing shall be set and cemented after drilling a maximum of 150 meters (492 feet) below the base of the permafrost. Where conditions

warrant, the District Supervisor may approve a program where surface casing may be set at a greater depth below the base of permafrost, but not to exceed 1,400 meters (4,593 feet) below the ocean floor.

Engineering, geophysical, and geologic data used to substantiate the proposed setting depths of the conductor and surface casings (such as estimated fracture gradients, pore pressures, shallow hazards, etc.) shall be furnished with the Application for Permit to Drill.

3.3.2 Conductor Casing Cementing Requirements. Conductor casing shall be cemented with a quantity of cement sufficient to fill the calculated annular space up to the top of the casing. Cement fill to the ocean floor shall be verified by the observation of cement returns. In the event that observation of cement returns is not feasible or possible, the method of verifying the cement fill shall be approved by the District Supervisor.

3.3.3 Surface Casing Cementing Requirements. Surface casing shall be cemented with a quantity of cement sufficient to protect all freshwater zones, to provide well control until the next string of casing is set, with sufficient cement to fill the annular space to the top of the permafrost zone, and with the cement fill at least 60 meters (197 feet) inside the conductor casing, or as approved by the District Supervisor. Any portion of the annulus opposite a permafrost zone which is not protected by cement shall be filled with a liquid with a freezing point below

the minimum permafrost temperature to prevent internal freezeback.

After drilling a maximum of 15 meters (49 feet) of new hole, a pressure test shall be conducted to obtain data to be used in estimating the formation fracture gradient. Pressure data shall be obtained either by testing to formation leak-off or by testing to a predetermined equivalent mud weight. The results of this test and any subsequent tests of the formation shall be recorded on the driller's log and used to determine the depth and maximum mud weight to be used in the intermediate hole.

3.4 Intermediate Casing Setting and Cementing Requirements.

One or more strings of intermediate casing shall be set when required by anticipated abnormal pressure, mud weight, sediment, and other well conditions. The setting depth for intermediate casing shall be based on the pressure tests of the exposed formation below the surface casing shoe or on subsequent pressure tests. After drilling a maximum of 15 meters (49 feet) of new hole, a pressure test shall be conducted to obtain data to be used in estimating the formation fracture gradient. Pressure data shall be obtained either by testing to formation leak-off or by testing to a predetermined equivalent mud weight. The results of this test and any subsequent tests of the formation shall be recorded on the driller's log and used to determine the depth and maximum mud weight to be used in the hole below the intermediate-casing string.

A quantity of cement sufficient to cover and isolate all hydrocarbon zones and to isolate abnormal pressure intervals

from normal pressure intervals shall be used. This requirement for isolation may be satisfied by squeeze cementing prior to completion, suspension of operations, or abandonment, whichever occurs first. Sufficient cement shall be used to provide annular fill-up to a minimum of 150 meters (492 feet) above the zones to be isolated or 150 meters (492 feet) above the casing shoe in cases where zonal coverage is not required. Any portion of the annulus opposite a permafrost zone not protected by cement must be filled with a liquid which has a freezing point below the minimum permafrost temperature to prevent internal freezeback.

If a liner is used as an intermediate string, it shall be lapped a minimum of 30 meters (98 feet) into the previous casing string and cemented as required for intermediate casing. The liner shall be tested by a fluid entry or pressure test to determine whether a seal between the liner top and the next larger string has been achieved. The test shall be recorded on the driller's log. If the test indicates an improper seal, the top of the liner shall be squeeze cemented. When such liner is used as production casing, it shall be extended to the surface and cemented to avoid surface casing being used as production casing.

3.5 Production Casing. Production casing shall be set before completing the well for production. It shall be cemented in a manner necessary to cover or isolate all zones above the shoe which contain hydrocarbons; but in any case, a calculated volume sufficient to fill the annular space at least

150 meters (492 feet) above the uppermost hydrocarbon zone must be used. Any portion of the annulus opposite a permafrost zone not protected by cement must be filled with a liquid which has a freezing point below the permafrost temperature to prevent internal freezeback.

When a liner is used as production casing below intermediate casing, it shall be lapped a minimum of 30 meters (98 feet) into the previous casing string and cemented as required for the production casing. Testing of the seal between the liner top and the next larger string shall be conducted as in the case of intermediate liners and recorded on the driller's log. If the test indicates an improper seal, the top of the liner shall be squeeze cemented.

3.6 Pressure-Testing of Casing. Prior to drilling the plug after cementing, all casing strings, except the drive or structural casing, shall be pressure-tested as shown in the table below. The test pressure shall not exceed 70 percent of the internal yield pressure of the casing. If the pressure declines more than 10 percent in 30 minutes or if there is another indication of a leak, the casing shall be recemented, repaired, or an additional casing string run, and the casing tested again. The above procedures shall be repeated until a satisfactory test is obtained.

<u>Casing</u>	<u>Minimum Surface Pressure</u>
Conductor	1,400 kilopascals (kPa) (203 psi)
Surface	*6,900 kPa (1,000 psi)
Intermediate, Liner, and Production	*10,400 kPa (1,508 psi) or 5 kPa/m (0.22 psi/ft.) whichever is greater

*Must not exceed 70 percent of the minimum internal yield pressure.

In the event of unscheduled drill pipe operations such as an unscheduled side-tracking operation or a fishing operation, the surface pipe shall be pressure tested, calipered, or otherwise evaluated, as approved by the District Supervisor.

After cementing any of the above strings, drilling shall not be resumed until a time lapse of 8 hours under pressure for the conductor casing string or 12 hours under pressure for all other strings. Cement is considered under pressure if one or more float valves are employed and are shown to be holding the cement in place or when other means of holding pressure is used. All casing pressure tests shall be recorded on the driller's log.

In addition to the time lapse stated above, sufficient time must elapse to allow the bottom 153 meters (502 feet) of annular cement fill, or total length of annular cement fill, if less, to attain a compressive strength of at least 3,448 kPa (500 psi) or as approved by the District Supervisor before drilling resumes.

The typical performance data for the particular cement mix used in the well shall be used to determine the time lapse required.

4. Directional Surveys. Wells are considered vertical if inclination does not exceed an average of 3 degrees from the vertical or the maximum individual inclination survey does not exceed 6 degrees. Inclination surveys shall be obtained on all vertical wells at intervals not exceeding 150 meters (492 feet) during the normal course of drilling.

Wells are considered directional if inclination exceeds an average of 3 degrees from the vertical or the maximum individual inclination survey exceeds 6 degrees. Directional surveys giving both inclination and azimuth shall be obtained on all directional wells at intervals not exceeding 150 meters (492 feet) during the normal course of drilling and at intervals not exceeding 30 meters (98 feet) in all planned angle-change portions of the hole.

On both vertical and directional wells, directional surveys giving both inclination and azimuth shall be obtained at intervals not exceeding 150 meters (492 feet) prior to, or upon, setting surface or intermediate casing, liners, and at total depth. Composite directional surveys shall be filed with the District Supervisor. The interval shown will be from the bottom of conductor casing or, in the absence of conductor casing, from the bottom of drive or structural casing to total depth. In calculating all surveys, a correction from true north to Universal Transverse Mercator Grid north or Lambert Grid north shall be made after making the magnetic-to-true-north correction.

5. Blowout-Preventer (BOP) Equipment Requirements.

5.1 General Requirements. Blowout preventers and related well-control equipment shall be installed, used, maintained, and tested in a manner necessary to assure well control.

5.1.1 BOP Equipment. Blowout-preventer equipment shall consist of an annular preventer and the specified number of ram-type preventers. The pipe rams shall be of proper size to fit the drill pipe in use. The working pressure of any blowout preventer shall exceed the maximum-anticipated surface pressure to which it may be subjected, except that the working pressure of the annular preventer need not exceed 34,475 kPa (5,000 psi).

Information submitted with the Application for Permit to Drill shall include the maximum-anticipated surface pressure and the criteria used to determine this pressure. All blowout-preventer systems shall be equipped with:

a. A hydraulic actuating system that provides sufficient accumulator capacity to supply 1.5 times the volume necessary to close all BOP equipment units with a minimum pressure of 1,400 kPa (203 psi) above the precharge pressure. An accumulator backup system, supplied by a secondary power source independent from the primary power source, shall be provided with sufficient capacity to close all blowout preventers and hold them closed. Locking devices shall be provided on the ram-type preventers. The method of BOP

actuation control such as hydraulic, acoustic, or other methods, shall be described and included in the Application for Permit to Drill.

b. At least one operable remote blowout-preventer-control station, in addition to the one on the drilling floor. This control station shall be in a readily accessible location away from the drilling floor.

c. A drilling spool with side outlets, if side outlets are not provided in the BOP body, to provide for separate kill and choke lines.

d. A kill line equipped with 2 kill-line valves is required. The master valve shall be located adjacent to the BOP. This valve shall not normally be used for opening or closing on flowing fluid. The second valve shall be located adjacent to the master valve. This valve shall be used as the control valve.

e. A fill-up line above the uppermost preventer.

f. A choke manifold equipped in accordance with "API Recommended Practice for Blowout-Prevention Equipment Systems," API RP 53, First Edition, February 1976, reissued February 1978, Sections 3A and 3B, or subsequent revisions which the Chief, Conservation Division, has approved for use.

g. Valves, pipes, and fittings upstream of, and including, the choke manifold shall have a pressure rating at

least equal to the maximum-anticipated surface pressure.

h. A wellhead assembly with a working pressure at least equal to the maximum-anticipated surface pressure.

5.1.2 Auxiliary Equipment. The following auxiliary equipment shall be provided and maintained in operable condition at all times:

a. A kelly cock shall be installed below the swivel and an essentially full-opening valve of such design that it can be run through blowout preventers shall be installed at the bottom of the kelly. A wrench to fit each valve shall be stored in a conspicuous location readily accessible to the drilling crew.

b. An inside blowout preventer and an essentially full-opening drill string safety valve in the open position shall be maintained on the rig floor at all times while drilling operations are being conducted. These valves shall be maintained on the rig floor to fit all connections that are in the drill string.

c. A safety valve shall be available on the rig floor assembled with the proper connection to fit the casing string that is being run in the hole at the time.

5.1.3 Subfreezing Operations. The blowout preventers and related control equipment shall be suitable for operations in those Areas which are subject to subfreezing conditions.

3.2 Subsea BOP Requirements. The minimum requirements for drilling below the casing strings for subsea blowout-preventer stacks are tabulated below:

Drive or Structural	None required <u>1/</u> , <u>2/</u>
Conductor	1 - Annular 1 - Diverter System <u>3/</u> , <u>4/</u>
Surface	1 - Annular 2 - Pipe Rams 1 - Blind Shear Ram
Intermediate	1 - Annular <u>5/</u> 2 - Pipe Rams 1 - Blind Shear Ram

Note.--1. When drilling fluids are circulated to the drilling vessel, a diverter system as described in subparagraph 5.4.1 shall be installed on top of the marine riser.

--2. If returns to the surface cannot be established, refer to subparagraph 5.4.2.

--3. The choke and kill lines or equivalent vent lines, equipped with necessary connections and fittings, can be used for diversion, if approved by the Supervisor, or an annular preventer or pressure-rotating, packoff-type head, equipped with suitable diversion lines, shall be installed on top of the marine riser.

--4. To be installed on top of the marine riser. The diverter system shall provide, as a minimum, two 15-centimeter (6-inch) internal diameter lines and full-opening valves.

--5. When a tapered drill string is in use, the BOP stack shall be equipped with pipe rams to fit both sizes of drill pipe.

Subsea blowout-preventer stacks shall be equipped with blind shear rams. A subsea accumulator or a suitable alternate approved by the District Supervisor is required to provide fast closure of the preventers and to operate all critical functions in case of loss of power fluid connection to the surface. The blowout-preventer system shall include dual pod control systems in accordance with API RP 53, First Edition, February 1976, reissued February 1978, Subsection 5.8.13, or subsequent revisions which the Chief, Conservation Division, has approved for use. Prior to the removal of the marine riser for installing casing, the riser shall be displaced with seawater. Sufficient hydrostatic head shall be maintained within the well bore to compensate for the reduction in head and to maintain a safe well condition. If repair or replacement of the blowout-preventer stack is necessary after installation, this work shall be accomplished after casing has been cemented prior to drilling out the casing shoe or by setting a cement or bridge plug to assure safe well conditions.

5.3 Surface BOP Requirements. The minimum requirements for drilling below the casing strings for conventional surface blowout-preventer stacks are tabulated below:

Drive or Structural	1 - Diverter System ¹²
Conductor	1 - Annular
	1 - Diverter System ^{1/}
Surface	1 - Annular
	2 - Pipe Rams
	1 - Blind Ram
Intermediate	1 - Annular
	2 - Pipe Rams ^{2/}
	1 - Blind Ram

Note.--1. The diverter system shall include a minimum of two 15-centimeter (6-inch) internal diameter lines and full-opening valves.

--2. When a tapered drill string is in use, the BOP stack shall be equipped with pipe rams to fit both sizes of drill pipe.

5.4 Drive Pipe or Structural Casing BOP Requirements.

5.4.1 Drilling Operations from Bottom-Supported Rigs. Before drilling below this string with a bottom setting rig, a diverter system and related equipment shall be installed for circulating the drilling fluid to the drilling structure. The diverter system shall be equipped with remote control valves in

the main and diverter flow lines that can be operated from the control panel prior to shutting in the well. The diverter lines shall vent in different directions to permit downwind diversion. A schematic diagram and operational procedure for the diverter system shall be submitted with the Application for Permit to Drill (Form 9-331 C) to the District Supervisor for approval.

5.4.2 Floating Drilling Operations. In drilling operations where a floating or semi-submersible type of drilling vessel is used and formation competency at the structural casing setting depth is not adequate to permit circulation of drilling fluids to the vessel while drilling the conductor hole, a program which provides for safety in these operations shall be described and submitted to the District Supervisor for approval. This program shall include all known pertinent information, including seismic and geologic data, water depth, drilling-fluid hydrostatic pressure, a schematic diagram indicating the equipment to be installed from the rotary table to the proposed conductor-casing seat, and a contingency plan for moving off location.

5.5 Conductor Casing. Before drilling below this string, at least one remote-controlled, annular-type blowout preventer shall be installed. A diverter system and other equipment for circulating the drilling fluid to the drilling structure or vessel shall be installed as described in subparagraph 5.4.1.

5.6 Surface and Intermediate Casing. Before drilling below these strings, the blowout-preventer system shall consist of at least four remote-controlled, hydraulically operated blowout preventers including at least two equipped with pipe rams, one with blind rams, and one annular type. Subsea blowout-preventer stacks used with floating drilling vessels shall include one set of blind shear rams.

5.7 Testing of BOP Systems. Prior to conducting high-pressure tests, all BOPs shall be tested to a low pressure of 1,400 to 2,000 kPa (203 to 290 psi).

5.7.1 BOP Testing Frequency. Surface and subsea BOP stacks shall be tested as follows:

- a. When Installed.
- b. Before drilling out after each string of casing has been set.
- c. At least once each week, but not exceeding 7 days between tests, alternating between control stations. A period of more than 7 days between tests may be allowed where drilling problems prevent testing and remedial efforts are being made, provided BOP tests will be conducted as soon as possible. Testing shall be at staggered intervals to allow each drilling crew to operate the equipment.

- d. Following repairs that require disconnecting a pressure seal in the assembly.

5.7.2 Pressure Testing Surface BOP Systems. Ram-type BOPs and related control equipment shall be tested at the maximum-anticipated surface pressure or at 70 percent of the minimum internal yield pressure of the casing, whichever is the lesser. The annular-type BOP shall be tested at 70 percent of its rated working pressure or 70 percent of the minimum internal yield pressure of the casing, whichever is the lesser. Before drilling out of each casing or liner shoe, the blind rams shall be tested as required for pipe rams. When a tapered drill string is in use, the smaller pipe rams shall be tested when the smaller pipe is within the stack during a trip.

5.7.3 Pressure Testing Subsea BOP Systems. Subsea BOPs and all related well-control equipment shall be stump tested at the surface with water to the maximum-anticipated surface pressure, except that the annular-type BOP shall not be tested above 70 percent of its rated working pressure. After the installation of the BOP stack on the sea floor, the control equipment and pipe rams, conforming to the drill string within the stack, shall be tested as required under subparagraph 5.7.2. Before drilling out of each casing or liner shoe, the blind shear rams shall be tested as required for blind rams under subparagraph 5.7.2.

5.7.4 Actuation of Surface BOP Systems. The following minimum-actuation frequencies are required:

- a. Pipe Rams - Daily. In order to prevent damage

to the rams, complete closure of the rams on drill pipe is not required, provided proper operation is indicated.

b. Blind Rams - Once each trip while the drill pipe is out of the hole. If multiple trips are made, only one action per day is required.

c. Annular-Type Preventer - Once each week in conjunction with the pressure test.

d. Control Stations - Once each trip while the drill pipe is out of the hole; however, not more than once each day, if multiple trips are made.

e. Choke manifold valves, kelly cocks, drill pipe safety valves - Weekly.

5.7.5 Actuation of Subsea BOP Systems. The actuation frequency requirements for subsea BOP systems shall be the same as those listed in subparagraph 5.7.4 for surface BOP systems, except item "b" pertaining to blind rams.

The blind shear rams shall be actuated once each trip from alternate control stations and control systems; however, not more than once each day, if multiple trips are made. During the weekly pressure tests, all hydraulic systems except those actuating the blind shear rams shall be actuated from each control station and control system.

5.8 Inspection and Maintenance. All BOP systems, marine risers, and associated equipment shall be inspected and maintained in accordance with the manufacturer's recommended procedures. The BOP systems and marine risers shall be visually inspected at least once each day if the weather and sea conditions permit the inspection. Inspection of subsea installations may be accomplished by the use of television equipment.

5.9 Blowout-Preventer Drills. All drilling personnel shall be indoctrinated in blowout-preventer drills and be familiar with the blowout-preventer equipment before starting work on the well. A blowout-preventer drill shall be conducted for each drilling crew in accordance with the well-control drill requirements of the U.S. Geological Survey (USGS) Outer Continental Shelf Standard, "Training and Qualifications of Personnel in Well-Control Equipment and Techniques for Drilling on Offshore Locations, No. T-1 (GSS-OCS-T 1), First Edition, December 1977, and subsequent revisions thereto. A BOP drill may be required by a USGS designated representative at any time during the drilling operation.

6. Mud Program. The characteristics, use, and testing of drilling mud and the implementation of related drilling procedures shall be designed to prevent the loss of well control. Sufficient quantities of mud materials shall be maintained readily accessible for use at all times to assure well control.

Mud temperatures shall be controlled to minimize heat loss to and thawing of the permafrost which can result in serious well problems.

To insure maximum safety, hydrate zones shall be anticipated and diagnosed quickly, and drilled at controlled rates with mud cooled to the hydrate equilibrium temperature. To prevent problems after hydrate zones are penetrated, cooled muds shall continue to be used, and where possible, hydrate zones should be cased off with high-collapse-strength casing.

24
25
6.1 Mud Control. Before starting out of the hole with drill pipe, the mud shall be properly conditioned. Proper conditioning requires either circulation with the drill pipe just off bottom to the extent that the annular volume is displaced, or proper documentation in the driller's log prior to pulling the drill pipe as follows:

a. There was no indication of influx of formation fluids prior to starting to pull the drill pipe from the hole.

b. The weight of the returning mud is not less than the weight of the mud entering the hole.

c. Other mud properties recorded on the daily drilling log are within the specified ranges required by the mud program.

When the mud in the hole is circulated, the driller's log shall be so noted.

When coming out of the hole with drill pipe, the annulus shall be filled with mud before the change in mud level decreases the hydrostatic pressure 517 kPa (75 psi) or every 5 stands of drill pipe, whichever gives a lower decrease in hydrostatic pressure. The number of stands of drill pipe and drill collars that may be pulled prior to filling the hole and the equivalent mud volume shall be calculated and posted. A mechanical, volumetric, or electronic device for measuring the amount of mud required to fill the hole shall be utilized.

When there is an indication of swabbing or influx of formation fluids, the necessary safety devices and action shall be employed to control the well. The mud shall be circulated and conditioned, on or near bottom, unless well or mud conditions prevent running the drill pipe back to the bottom.

For each casing string, the maximum pressure to be contained under the blowout preventer, before controlling excess pressure by bleeding through the choke, shall be posted near the driller's control console.

An operable vacuum-type gas separator shall be installed in the mud system prior to commencement of drilling operations. The separator shall be maintained for use throughout the drilling and completion of the well.

The mud in the hole shall be circulated or reverse-circulated prior to pulling the drill-stem test tools from the hole.

25

6.2 Mud Testing and Monitoring Equipment. Mud-testing equipment shall be maintained on the drilling rig at all times, and mud tests shall be performed once each tour, or more frequently, as conditions warrant. Such tests shall be conducted in accordance with procedures outlined in "API Recommended Practice for Standard Procedure for Testing Drilling Fluids," API RP 13B, Seventh Edition, April 1978, or subsequent revisions which the Chief, Conservation Division, has approved for use. The results of the tests shall be recorded and maintained at the drill site.

The following mud-system monitoring equipment shall be installed with derrick floor indicators and used when mud returns are established and throughout subsequent drilling operations:

a. Recording mud pit level indicator to determine mud pit volume gains and losses. This indicator shall include both a visual and an audio warning device.

b. Mud-volume measuring device for accurately determining mud volumes required to fill the hole on trips.

c. Mud-return indicator to determine that returns essentially equal the pump discharge rate.

d. Gas-detecting equipment to monitor the drilling mud returns, with indicators located in the mud-logging compartment or on the derrick floor. If the indicators are in the mud-logging compartment, there shall be a means of

immediate communication with the rig floor, and the equipment shall be continually manned.

6.3 Mud Quantities. The lessee shall include, with his Application for Permit to Drill, a tabulation of well depth versus minimum quantities of mud material, including weighting material, to be maintained at the drill site. The minimum quantities of mud material required shall be based on the following:

a. The volume required to replace the calculated capacity of the downhole and active surface mud system.

b. The quantity of weighting material required to overcome the highest anticipated formation pressure.

When the mud quantity required exceeds the storage capacity of the drilling facility, the lessee shall maintain maximum mud inventories and must receive approval from the District Supervisor of the lessee's plans to resupply mud inventories in the event of an emergency. The plan shall include an estimate of the time required for delivery of the mud supplies.

Daily inventories of mud materials, including weighting material, shall be recorded and maintained at the well site. Drilling operations shall be suspended in the absence of minimum quantities of mud material specified in the table or as modified in the approved plan.

6.4 Safety Precautions in Enclosed Mud-Handling Areas.

All enclosed mud-handling areas where dangerous concentrations of combustible gases may accumulate shall be equipped with a ventilation system and with gas monitors. These enclosed areas shall be:

a. Ventilated with high-capacity, mechanical ventilation systems capable of changing the air once every 2 minutes.

b. Maintained at a negative pressure relative to the surrounding areas where discharge to an adjacent enclosed area may be hazardous.

c. Fitted with gas detectors and alarms.

d. Equipped with electrical equipment of the "explosion proof" type. Alternatively, the equipment may be pressurized to prevent the ingress of explosive gases, and where air is used for pressurizing, the air intake shall be located outside of, and as far as practicable from, hazardous areas.

7. Supervision, Surveillance, and Training.

7.1 Supervision. A representative of the operator shall provide onsite supervision of drilling operations on a 24-hour basis.

7.2 Surveillance. From the time drilling operations are initiated and until the well is completed or abandoned, a member of the drilling crew or the toolpusher shall maintain

rig-floor surveillance continuously, unless the well is secured with blowout preventers, bridge plugs, or cement plugs.

7.3 Training. By December 1, 1979, lessee and drilling contractor personnel shall be trained and qualified in accordance with the provisions of the USGS Outer Continental Shelf Standard, "Training and Qualifications of Personnel in Well-Control Equipment and Techniques for Drilling on Offshore Locations," No. T 1 (GSS-OCS-T 1), First Edition, December 1977, and subsequent revisions thereto.

Any driller, toolpusher, or operator's representative who received training in well-control operations between December 1, 1975, and December 1, 1979, will be credited with having met the training requirements of GSS-OCS-T 1.

After December 1, 1979, in order to maintain qualification, employees must successfully complete a USGS-approved refresher course annually and repeat the basic well-control course every 4 years, as described in the provisions of GSS-OCS-T 1. Credit for these courses shall be obtained from USGS-approved schools. The refresher course shall be completed within 45 days of the student's anniversary date. The anniversary date is established upon the student's successful completion of a basic course in well control.

Records shall be maintained at the drill site for the affected personnel, indicating the specific training and refresher courses

successfully completed, the dates of completion, and the names and dates of the courses.

In those Areas which are subject to subfreezing conditions, the lessee shall ensure that personnel responsible for maintenance of the blowout-preventer stack, the associated-control equipment, and the hydraulic-control fluids shall be instructed in the proper procedures to prevent freezing of the hydraulic-control fluids in the control system and the fluids in the chokes and kill lines.

27
28
8. Hydrogen Sulfide. When drilling operations are planned which will penetrate reservoirs known or expected to contain hydrogen sulfide (H_2S), or in those Areas where the presence of H_2S is unknown, or upon encountering H_2S , the preventive measures and the operating practices set forth in USCS Outer Continental Shelf Standard, "Safety Requirements for Drilling Operations in a Hydrogen Sulfide Environment," No. 1 (CSS-OCS-1), Second Edition, June 1979, or subsequent revisions thereto, shall be followed.

9. Critical Operations and Curtailment Plans. Certain operations performed in drilling are more critical than others with respect to well control, and for the prevention of fire, explosion, oil spills, and other discharges or emissions. The lessee shall file with the District Supervisor, for approval, a Critical Operations and Curtailment Plan to be followed while conducting drilling operations on each lease. This plan shall include:

a. A list or description of the critical drilling operations

that are, or are likely to be, conducted on the lease. This list or description shall specify the operations to be ceased, limited, or not to be commenced under given circumstances or conditions. This list shall include operations such as:

- (1) Drilling in close proximity to another well.
- (2) Drill-stem testing.
- (3) Running and cementing casing.
- (4) Cutting and recovering casing.
- (5) Logging or wireline operations.
- (6) Well-completion operations.
- (7) Moving the drilling vessel off location in an emergency, repositioning the vessel on location, and reestablishing entry into the well.

b. A list or description of circumstances or conditions under which such critical operations shall be curtailed. This list or description shall be developed from all the factors and conditions relating to the conduct of operations on the lease, and shall consider but not necessarily be limited to the following:

- (1) Whether the drilling operations are to be conducted from mobile or fixed platforms.
- (2) The availability and capability of containment and cleanup equipment and spill-control system response time.

(3) Abnormal or unusual conditions expected to be encountered during drilling operations.

(4) Known or anticipated meteorological or oceanographical conditions.

(5) Availability of personnel and equipment for particular operations to be conducted.

(6) Other factors peculiar to the particular lease under consideration.

c. The name of the person who has overall responsibility, as the person in charge at the site, for safety of drilling operations.

When any circumstance or condition listed or described in the plan occurs or other operational limits are encountered, the lessee shall notify the District Supervisor and shall curtail the critical operations as set forth under 9a.

Deviations from the plan shall require prior approval of the District Supervisor. If emergency action requires deviation from the plan, the District Supervisor shall be notified as soon as possible.

The lessee shall review the plan at least annually. The lessee shall notify the District Supervisor of the results of this review. Any amendments or modifications of the plan are subject to the approval of the District Supervisor.

10. Field Drilling Rules. When sufficient geological and engineering information is obtained as a result of drilling operations, the lessee may make an application or the Supervisor may require an application for the establishment of field drilling rules. After field drilling rules have been established by the Supervisor, development wells shall be drilled in accordance with these rules and the requirements of this Order which are not affected by such rules.

11. Departures. All departures from the requirements specified in this Order shall be subject to approval, pursuant to 30 CFR 250.12(b).

Rodney A. Smith
Oil and Gas Supervisor
Arctic Area

Approved:

Don E. Kash
Chief, Conservation Division

UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY
CONSERVATION DIVISION
WESTERN REGION

ALASKA AREA

ARCTIC

OCS ORDER NO. 3

EFFECTIVE

PLUGGING AND ABANDONMENT OF WELLS

29

The Order is issued pursuant to the authority prescribed in 30 CFR 250.11 and in accordance with 30 CFR 250.15. The operator shall comply with the following minimum plugging and abandonment procedures which have general application to all wells drilled for oil and gas. Plugging and abandonment operations shall not be commenced prior to obtaining approval from the appropriate District Supervisor. Oral or telegraphic approvals shall be in accordance with 30 CFR 250.13.

1. Permanent Abandonment.

1.1 Isolation of Zones in Open Hole. In uncased portions of wells, cement plugs shall be spaced to extend 30 meters (98 feet) below the bottom to 30 meters (98 feet) above the top of any oil, gas, and freshwater zones so as to isolate them in the strata in which they are found and to prevent them from escaping into other strata or the surface. The placement of

additional cement plugs to prevent the migration of formation fluids in the well bore may be required by the District Supervisor.

1.2 Isolation of Open Hole. Where there is open hole below the casing, a cement plug shall be placed in the deepest casing string in accordance with "a" or "b" below. In the event lost circulation conditions have been experienced or are anticipated, a permanent-type bridge plug may be placed in accordance with "c" below:

a. A cement plug set by the displacement method so as to extend a minimum of 30 meters (98 feet) above and 30 meters (98 feet) below the casing shoe.

b. A cement retainer with effective back-pressure control set not less than 15 meters (49 feet) nor more than 30 meters (98 feet) above the casing shoe, with a cement plug calculated to extend at least 30 meters (98 feet) below the casing shoe and 15 meters (49 feet) above the retainer.

c. A permanent-type bridge plug set within 45 meters (148 feet) above the casing shoe with 15 meters (49 feet) of cement on top of the bridge plug. This bridge plug shall be tested in accordance with subparagraph 1.7 prior to placing subsequent plugs.

1.3 Plugging or Isolating Perforated Intervals A cement plug shall be set by the displacement method opposite all open perforations (perforations not squeezed with cement) extending

a minimum of 30 meters (98 feet) above and 30 meters (98 feet) below the perforated interval or down to a casing plug, whichever is less. In lieu of setting a cement plug by the displacement method, the following two methods are acceptable, provided the perforations are isolated from the hole below:

a. A cement retainer with effective back-pressure control set not less than 15 meters (49 feet) nor more than 30 meters (98 feet) above the top of the perforated interval with a cement plug calculated to extend at least 30 meters (98 feet) below the bottom of the perforated interval and 15 meters (49 feet) above the retainer.

b. A permanent-type bridge plug set within 45 meters (148 feet) above the top of the perforated interval with 15 meters (49 feet) of cement on top of the bridge plug.

1.4 Plugging of Casing Stubs. If casing is cut and recovered leaving a stub, one of the following methods shall be used to plug the casing stub.

1.4.1 Stub Termination Inside Casing String. A stub terminating inside a casing string shall be plugged by one of the following methods:

a. A cement plug set so as to extend 30 meters (98 feet) above and 30 meters (98 feet) below the stub.

b. A cement retainer set 15 meters (49 feet) above the stub with 45 meters (148 feet) of cement set below and 15 meters (49 feet) above.

c. A permanent bridge plug set 15 meters (49 feet) above the stub and capped with 15 meters (49 feet) of cement.

1.4.2 Stub Termination Below Casing String. If the stub is below the next larger string, plugging shall be accomplished in accordance with either subparagraph 1.1 or 1.2.

1.5 Plugging of Annular Space. Any annular space communicating with any open hole and extending to the ocean floor shall be plugged with cement.

1.6 Surface Plug. A cement plug at least 45 meters (148 feet) in length, with the top of the plug 45 meters (148 feet) or less below the ocean floor, shall be placed in the smallest string of casing which extends to the ocean floor.

1.7 Testing of Plugs. The setting and location of the first plug below the surface plug shall be verified by one of the following methods:

a. By placing a minimum pipe weight of 6,800 kilograms (15,000 pounds) on the cement plug, cement retainer, or bridge plug. The cement placed above the bridge plug or retainer need not be tested.

b. By testing the plug with a minimum pump pressure of 6,900 kPa (1,000 psi) with no more than a 10-percent pressure drop during a 15-minute period.

1.8 Mud. Each of the respective intervals of the hole between the various plugs shall be filled with mud fluid of sufficient density to exert hydrostatic pressure exceeding the greatest formation pressure encountered while drilling the intervals between the plugs: Fluid left in the hole adjacent to the permafrost zone shall have a freezing point below the temperature of the permafrost zone and shall not have an oil base.

1.9 Clearance of Location. All casing, wellhead equipment, and piling shall be removed to a depth of at least 5 meters (16 feet) below the ocean floor or at a depth approved by the District Supervisor after a review of data on the ocean-bottom conditions. The operator shall verify that the location has been cleared of all obstructions.

1.10 Cement. The cement used for cement plugs placed across the permafrost zones must be designed to set before freezing and to have a low heat of hydration.

2. Temporary Abandonment. Any drilling well which is to be temporarily abandoned shall be mudded and cemented as required for permanent abandonment except for the requirements in subparagraphs 1.6 and 1.9. When a drilling well is temporarily abandoned, a bridge plug or a cement plug shall be set at the

base of the deepest casing string. If a cement plug is set, it is not necessary for the cement plug to extend below the casing shoe into the open hole. When a casing stub extends above the ocean floor, the operator shall comply with the following requirements:

a. A mechanical, retrievable, or permanent bridge plug, or a cement plug at least 30 meters (98 feet) in length shall be set in the casing between 5 and 60 meters (16 and 197 feet) below the ocean floor.

b. The requirements of OCS Order No. 1, paragraph 4, "Identification of Subsea Objects."

3. Departures. All departures from the requirements specified in this Order shall be subject to approval, pursuant to 30 CFR 250.12(b).

Rodney A. Smith
Oil and Gas Supervisor
Arctic Area

Approved:

Don E. Kaah
Chief, Conservation Division

UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY
CONSERVATION DIVISION
WESTERN REGION

ALASKA AREA

ARCTIC

OCS ORDER NO. 4

EFFECTIVE

DETERMINATION OF WELL PRODUCIBILITY

This Order is issued pursuant to the authority prescribed in 30 CFR 250.11 and in accordance with 30 CFR 250.12. An OCS lease provides for extension beyond its primary term for as long as oil or gas may be produced from the lease in paying quantities. The term "paying quantities" as used herein means production of oil and gas in quantities sufficient to yield a return in excess of operating costs. An OCS lease may be maintained beyond the primary term, in the absence of actual production, when a suspension of production has been approved in accordance with 30 CFR 250.12.

1. Application for Determination of Well Producibility. An application shall be submitted to the District Supervisor for the determination of every new well's capability of producing until a well, drilled on the lease, has been determined to be capable of producing oil or gas in paying quantities. The

application shall be submitted within 60 days after the drilling rig has been moved from the well.

2. Criteria for the Determination of Well-Productivity. The Supervisor shall prescribe which of the following criteria is to be used to determine the capability of a well to produce in paying quantities.

2.1 Production Tests. All tests must be witnessed by an authorized representative of the U.S. Geological Survey. Test data accompanied by operator's affidavit, or third-party test data, may be accepted in lieu of a witnessed test, provided approval is obtained from the District Supervisor prior to the performance of the test. All tests must conform to the following minimum requirements:

a. A production test for oil wells of at least 2 hours' duration following stabilization of flow.

b. A deliverability test for gas wells of at least 2 hours' duration following stabilization of flow or a 4-point back-pressure test.

2.2 Production Capability Determination. When the District Supervisor determines that open-hole evaluation data, such as wireline formation tests, drill stem tests, core data, and logs, have been demonstrated as reliable in a geologic area, such data may be considered as acceptable evidence that a well is capable of producing in paying quantities.

3. Departures. All departures from the requirements specified in this Order shall be subject to approval, pursuant to 30 CFR 250.12(b).

Rodney A. Smith
Oil and Gas Supervisor
Arctic Area

Approved:

Don E. Kash
Chief, Conservation Division

UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY
CONSERVATION DIVISION
WESTERN REGION

ALASKA AREA

ARCTIC

OCS ORDER NO. 5

EFFECTIVE

PRODUCTION SAFETY SYSTEMS

This Order is issued pursuant to the authority prescribed in 30 CFR 250.11 and 250.12(a), and in accordance with 30 CFR 250.41(b), 250.42, and 250.46. The lessee shall be responsible for compliance with the requirements of this Order in the installation and operation of the production safety systems on all platforms and structures including those facilities not operated or owned by the lessee. All applications for approval under the provisions of this Order shall be submitted to the District Supervisor.

1. Technological Improvement. The lessee is encouraged to continue the development of safety-system technology. As research and product improvement result in increased effectiveness of existing safety equipment or the development of new equipment systems, such equipment may be used or required.

2. Quality Assurance and Performance of Safety and Pollution-Prevention Equipment. Safety and Pollution-Prevention Equipment (SPPE) shall conform to the following quality assurance standards

or subsequent revisions which the Chief, Conservation Division, has approved for use.

a. American National Standards Institute/American Society of Mechanical Engineers Standards "Quality Assurance and Certification of Safety and Pollution Prevention Equipment Used in Offshore Oil and Gas Operations," ANSI/ASME SPPE-1-1977, December 1977 (formerly ANSI/ASME-CCS-1-1977).

b. American National Standards Institute/American Society of Mechanical Engineers Standard "Accreditation of Testing Laboratories for Safety and Pollution Prevention Equipment Used in Offshore Oil and Gas Operations," ANSI/ASME-SPPE-2-1977, December 1977 (formerly ANSI/ASME-CCS-2-1977).

The dates for compliance with these quality assurance standards, the applicable SPPE components, and the applicable SPPE specifications are identified in subparagraph 3.2 and subparagraph 4.2.

3. Subsurface-Safety Devices.

3.1 Installation. All tubing installations open to hydrocarbon-bearing zones shall be equipped with a subsurface-safety device such as a Surface-Controlled Subsurface-Safety Valve (SCSSV), a Subsurface-Controlled Safety Valve (SSCSV), an injection valve, or a tubing plug, unless, after application and justification, the well is determined to be incapable of flowing. The device shall be installed at a depth of 30 meters (98 feet) or more below the ocean floor within 2 days after production is stabilized. In

areas with permafrost, the device shall be installed at a depth of 30 meters (98 feet) or more below the base of the permafrost within 2 days after production is stabilized.

The well shall be attended at the wellhead while open to a hydrocarbon-bearing zone, unless a subsurface-safety device is installed.

3.1.1 Subsurface-Safety Valves. The requirements for subsurface-safety valves vary according to the shut-in tubing pressure of the well. Alternatives to the following requirements may be approved by the Supervisor when greater reliability or safety can be demonstrated.

Wells completed after the effective date of this Order shall be equipped with one of the following:

a. All tubing installations shall be equipped with a surface- or other remotely controlled subsurface-safety device if the shut-in tubing pressure of the well is 27,600 kilopascals (kPa) (4,000 psi) or less.

b. If the shut-in tubing pressure of the well is greater than 27,600 kPa (4,000 psi), the well shall be equipped with a subsurface-controlled subsurface-safety valve. When the shut-in tubing pressure declines below 27,600 kPa (4,000 psi), a surface- or other remotely controlled subsurface-safety valve shall be installed when the tubing is first removed and reinstalled.

36
128

3.2 Specification for Subsurface-Safety Valves. Surface-controlled and subsurface-controlled subsurface-safety valves required by subparagraphs 3.4 and 3.5, which are installed on new installations after July 1, 1979, shall conform to "American Petroleum Institute (API) Specification for Subsurface-Safety Valves, API Spec 14A, Third Edition, November 1978, or subsequent revisions which the Chief, Conservation Division, has approved for use at the time of installation.

3.3 Design, Installation, and Operation. After the effective date of this Order, new installations of subsurface-safety valves shall be in accordance with "API Recommended Practice for Design, Installation, and Operation of Subsurface Safety Valve Systems," API RP 14B, First Edition, October 1973, or subsequent revisions which the Chief, Conservation Division, has approved for use.

3.4 Surface-Controlled Subsurface-Safety Valves. After the effective date of this Order, all tubing installations open to a hydrocarbon-bearing zone shall be equipped with a surface-controlled subsurface-safety valve, except as specified in subparagraphs 3.1, 3.5, and 3.6. The surface controls may be located on the site or at a remote location.

The lessee shall furnish evidence that the surface-controlled subsurface-safety devices and related equipment are capable of normal operation in those Areas which are subject to subfreezing conditions.

3.4.1 Testing of Surface-Controlled Subsurface-Safety Valves. Each surface-controlled, or other remotely controlled, subsurface-safety valve installed in a well shall be tested in accordance with Appendix 2 of API RP 14B, when installed or reinstalled, at least monthly for the first 3 months, and thereafter at intervals not to exceed 6 months. If the device does not operate properly, it shall be promptly removed, repaired, reinstalled, or replaced, and tested to ensure proper operation.

3.5 Subsurface-Controlled Subsurface-Safety Valves. Tubing installations in wells completed from single-well and multiwell satellite casissons or jackets and ocean floor completions may be equipped with a subsurface-controlled subsurface-safety valve in lieu of surface- or other remotely controlled subsurface-safety valves.

3.5.1 Inspection and Maintenance of Subsurface-Controlled Subsurface-Safety Valves. Each subsurface-controlled subsurface-safety valve installed in a well shall be removed, inspected, and repaired or adjusted as necessary and reinstalled at intervals not exceeding:

(1) 6 months for those valves not installed in a landing nipple.

(2) 12 months for those valves installed in a landing nipple.

3.6 Tubing Plugs in Shut-in Wells. A tubing plug shall be installed in lieu of, or in addition to, other subsurface-safety

37

devices if a well has been shut in for a period of 6 months. Tubing plugs shall be set at a depth of 33 meters (98 feet) or more below the ocean floor. In areas containing permafrost, each tubing-plug installation shall be approved by the District Supervisor on a case-by-case basis. All retrievable plugs installed after the date of this Order shall be of the pump-through type. All wells perforated and completed but not placed on production shall be equipped with a subsurface-safety valve or tubing plug within 2 days after completion. A surface-controlled subsurface-safety valve of the pump-through type may be used as a pump-through tubing plug for the purpose of this subparagraph, provided the surface control has been rendered inoperative. A shut-in well which is equipped with a tubing plug shall be inspected for leakage by opening the well to possible flow at intervals not exceeding 6 months. If a liquid leakage rate in excess of 400 cc/min or a gas leakage rate in excess of 7 dm³/sec (15 cubic ft/min) is observed, the plug shall be removed, repaired, and reinstalled, or an additional tubing plug may be installed in lieu of removal and repair.

3.7 Injection Wells. A surface-controlled subsurface-safety valve or an injection valve capable of preventing backflow shall be installed in all wells placed in injection service after the effective date of this Order.

This requirement is not applicable if the District Supervisor concurs that the well is incapable of flowing. The lessee shall

verify the no-flow condition of the well annually and submit an annual report certifying the no-flow status of the well.

3.8 Temporary Removal for Routine Operations. Each wireline- or pumpdown-retrievable subsurface-safety device may be removed, without further authorization or notice, for a routine operation which does not require the approval of a Sundry Notice and Report on Wells (Form 9-331), for a period not to exceed 15 days. The well shall be identified by a sign on the wellhead stating that the subsurface-safety device has been removed. The removal of the subsurface-safety device shall be noted in the records as required by subparagraph 3.11g. The well shall be attended at the wellhead until the subsurface-safety device has been reinstalled, unless attendance has been waived by the District Supervisor.

3.9 Additional Safety Equipment. All tubing installations in which a wireline- or pumpdown-retrievable subsurface-safety device is installed after the effective date of this Order shall be equipped with a landing nipple, flow couplings to prevent internal abrasion, or other protective equipment, above and below, to provide for the setting of the subsurface-safety valve. The control system for all surface-controlled subsurface-safety valves shall be an integral part of the platform Emergency Shutdown System (ESD) as defined in API RP 14C, Appendix C, Section C1. In addition to the activation of the ESD system by manual action on the platform, the system may be activated by a signal from a remote location. Surface-controlled subsurface-safety valves shall

close in response to shut-in signals from the ESD system or the fire loop, or both.

3.10 Emergency Action. All tubing installations open to hydrocarbon-bearing zones in which the subsurface-safety device has been removed, in accordance with the provisions of this Order, shall be identified by a sign on the wellhead stating the subsurface-safety device has been removed. A subsurface-safety device shall be available for each well on the platform. In the event of an emergency such as an impending storm, this device shall be properly installed as soon as possible with due consideration being given to personnel safety.

3.11 Records. The lessee shall maintain records for a minimum period of 5 years for each subsurface-safety device installed. These records shall be maintained in the nearest offshore field office for a minimum period of 2 years. The records may then be transferred to the onshore field office for the remaining 3 years of the 5-year retention period. These records shall be available for review by any authorized representative of the U.S. Geological Survey (USGS). The records to be maintained shall contain verification of:

a. The design, including make, model, and type. For subsurface-controlled valves, number of the spacers, size of beans, springs, and the pressure settings.

b. The devices having been manufactured in accordance with the quality-assurance requirements of ANSI/ASME-SPPE-1 (formerly ANSI/ASME-OCS-1) as required by paragraph 2.

c. The completion and return of the receiving report to the manufacturer as required by ANSI/ASME-SPPE-1.

d. The record of all configuration modifications to the certified design.

e. Installation at the required setting depth and in accordance with the manufacturer's instructions and API RP 14B.

f. The qualifications of the personnel who directed all installations and removals.

g. The results of tests required by this Order, the dates of removals and re-installations, and the reasons for removals and re-installations.

h. The completion and submission of all failure reports required by paragraph 6 and all investigation reports required by paragraphs OE-2129 and OE-2670 of ANSI/ASME-SPPE-1.

3.12 Reports. Well completion reports (Form 9-330) and any subsequent reports of workover (Form 9-331) shall include the type and the depth of the subsurface-safety devices.

4. Design, Installation, and Operation of Production Safety Systems. All production facilities, including separators, treaters, compressors, headers, and flowlines, shall be designed, installed, and

maintained in a manner which will facilitate an efficient, safe, and pollution-free operation.

The lessee shall furnish evidence that the surface-safety systems and related equipment are capable of normal operation in those Areas which are subject to subfreezing conditions, and that all equipment and operating procedures take into account floating ice, icing, and other extreme environmental conditions that may occur in the Area.

4.1 New Platforms. New platform production facilities shall be protected with a basic and ancillary surface-safety system designed, analyzed, tested, and maintained in operating condition in accordance with the provisions of "API Recommended Practice for Analysis, Design, Installation, and Testing of Basic Surface Safety Systems on Offshore Production Platforms, API RP 14C, Second Edition, January 1978, except Section A9, "Pipelines," which will be covered under OCS Order No. 9, or subsequent revisions which the Chief, Conservation Division, has approved for use and the additional requirements of the Order. For this application, the word "should" contained in API RP 14C shall be read "shall," except for those contained in explanatory statements, sections 3.4c and 4.3a(4)(a)-(f). If processing components are to be utilized, other than those for which Safety Analysis Checklists (SAC's) are included in API RP 14C, the analysis technique and documentation specified therein shall be utilized to determine the effects and requirements of these components upon the safety system.

4.2 Specification for Wellhead Surface-Safety Valves.

All wellhead Surface-Safety Valves (SSV's) required by subparagraph 4.1 which are installed on new installations after July 1, 1979, shall conform to "API Specification for Wellhead Surface Safety Valves for Offshore Service," API Spec 14D, Second Edition, November 1977, as amended by Supplement 1, March 1978, or subsequent revisions which the Chief, Conservation Division, has approved for use at the time of installation.

4.3 Submittal of Safety-System Design and Installation Features. Prior to installation, the lessee shall submit for approval to the District Supervisor, in duplicate, information relative to design and installation features, as indicated in subparagraphs a through g. This information shall also be maintained at the lessee's onshore field engineering office. All approvals are subject to field verifications. This information shall include:

a. A schematic flow diagram showing size, capacity, and design working pressure of separators, treaters, storage tanks, compressors, pipeline pumps, and metering devices.

b. A schematic flow diagram (reference API RP 14C, example: figure E1) and the related Safety Analysis Function Evaluation (SAFE) chart (reference API RP 14C, Subsection 4.3c). These diagrams and charts shall be developed in accordance with the provisions of API RP 14C and the additional requirements of this Order.

c. A schematic piping diagram showing the size and design pressure with reference to welding specification(s) or

code(s) used. The maximum-allowable working pressures shall be determined in accordance with "API Recommended Practice for Design and Installation of Offshore Production Platform Piping Systems," API RP 14E, First Edition, August 1975, and Supplement 2, October 1977, or subsequent revisions which the Chief, Conservation Division, has approved for use. The recommendations contained in API RP 14E are acceptable for the design and installation of the platform piping system.

d. A diagram of the fire-fighting system.

e. Electrical system information including the following:

(1) A plan of each platform deck outlining any nonrestricted area, i.e., areas which are unclassified with respect to electrical equipment installations and outlining areas in which potential ignition sources, other than electrical, are to be installed. The area outline shall include the following information:

(a) Any surrounding production or other hydrocarbon source and a description of the deck, overhead, and firewall.

(b) Location of generators, control rooms, panel boards, major cabling or conduit routes, and identification of the wiring method, including the identification of each wire and cable type that is utilized.

(2) Elementary electrical schematic of any platform safety-shutdown system with a functional legend.

(3) Classification of areas for electrical installations in accordance with the National Electrical Code, 1978 Edition, and with the "API Recommended Practice for Classification of Areas for Electrical Installations at Drilling Rigs and Production Facilities on Lands and on Marine Fixed and Mobile Platforms," API RP 500B, Second Edition, July 1973, or subsequent revisions which the Chief, Conservation Division, has approved for use.

f. The design and schematics of the installation and maintenance of all fire and gas detection systems shall include the following:

(1) Type, location, and number of detection heads.

(2) Type and kind of alarm, including emergency equipment to be activated.

(3) Method used for detection.

(4) Method and frequency of calibration.

(5) Name of organization to perform system inspection and calibration.

(5) A functional block diagram of the detection system, including the electric power supply.

g. Certification that the design for the mechanical and electrical systems were approved by registered professional engineers. After these systems are installed, the lessee shall submit a statement to the District Supervisor certifying that the complete installations conform to the approved designs or the lessee shall request approval of the "As-Built" changes.

5. Additional Safety and Pollution-Control Requirements. The following requirements modify or are in addition to those contained in API RP 14C.

5.1 Design, Installation, and Operation.

5.1.1 Pressure Vessels. Pressure vessels shall be designed, fabricated, stamped, and maintained in accordance with specific sections of the ASME Boiler and Pressure Vessel Code as listed below. The pressure vessels shall conform to the July 1, 1977, edition of the Code or subsequent revisions which the Chief, Conservation Division, has approved for use.

a. Pressure relief valves shall be designed, installed, and maintained in accordance with applicable provisions of sections I, IV, and VIII. The relief valves shall conform to the valve-sizing and pressure-relieving requirements specified in these documents; however, the relief valves shall be set no higher than the maximum-allowable working pressure of the vessel. All relief valves and vents shall be piped in such a way as to prevent fluid from striking personnel or ignition sources.

b. Steam generators shall be equipped with low-water-level controls in accordance with applicable provisions of sections I and IV.

c. The lessee shall determine and record the operating pressure ranges of all pressure-operated vessels in order to establish the pressure-sensor settings. The high-pressure shut-in sensor shall be set no higher than 10 percent above the highest operating pressure of the vessel. This setting shall also be sufficiently below the relief valve's set pressure to assure that the pressure source is shut in before the relief valve starts relieving. The low-pressure shut-in sensor shall activate no lower than 15 percent or 35 kPa (5 psi), whichever is greater, below the lowest pressure in the operating range.

d. All pressure or fired vessels used in the production of oil or gas, ordered after the effective date of this Order, shall conform to the requirements stipulated in the edition of the ASME Boiler and Pressure Vessel Code, sections I, IV, and VIII, as appropriate, in effect at the time the vessel is ordered. Uncoded vessels now in use shall have been hydrostatically tested to a pressure 1.5 times their work pressures.

The test date, test pressure, and working pressure shall be marked on the vessel in a prominent place. A record of the test shall be maintained by the lessee in the field area.

5.1.2 Flowlines.

a. All flowlines from wells shall be equipped with high- and low-pressure shut-in sensors located downstream of the well choke. All pressure sensors shall be equipped to permit testing with an external pressure source. The lessee shall determine and record the operating pressure ranges in order to establish pressure-sensor settings. The high-pressure shut-in sensor shall be set no higher than 10 percent above the highest operating pressure of the line; but, in all cases, it shall be set sufficiently below the maximum shut-in wellhead pressure or the gas-lift supply pressure to assure actuation of the surface-safety valve. The low-pressure shut-in sensor shall be set no lower than 10 percent or 33 kPa (5 psi), whichever is greater, below the lowest operating pressure of the line in which it is installed.

b. If a well flows directly to the pipeline before separation, the flowline and valves from the well located upstream of, and including, the header inlet valve(s) shall be able to withstand the maximum shut-in pressure of the well, unless the flowline is protected by one of the following:

(1) A relief valve which vents into the platform flare scrubber or some other location approved by the District Supervisor.

(2) An additional automatic shutdown valve controlled by an independent high-pressure sensor. The platform

flare scrubber shall be designed to handle, without liquid-hydrocarbon carryover to the flare, the maximum-anticipated flow of liquid-hydrocarbons which may be relieved to the vessel.

5.1.3 Pressure Sensors. Pressure sensors may be of the automatic- or nonautomatic-reset type. When the automatic-reset types are used, a nonautomatic-reset relay shall be installed. All pressure sensors shall be equipped to permit testing with an external pressure source.

5.1.4 Emergency Shutdown System. The manually operated ESD valve shall be quick-opening and nonrestricted to enable the rapid actuation of the shutdown system. ESD stations may utilize a loop of breakable synthetic tubing in lieu of a valve. The time for the safety system to effect platform shutdown shall not exceed 45 seconds after the automatic detection of an abnormal condition or the actuation of an ESD station. A schematic of the ESD system shall be posted at a prominent location on the platform. This schematic shall indicate the control functions of all safety devices.

5.1.5 Engine Exhausts. Engine exhausts shall be equipped to comply with the insulation and personnel-protection requirements of API RP 14C, Section 4.2c(4). Exhaust piping from internal-combustion engines shall be equipped with spark arrestors.

5.1.6 Glycol-Dehydration Units. A pressure relief system or an adequate vent shall be installed on the glycol regenerator, or at a location approved by the District Supervisor,

which will prevent overpressurization of all glycol-dehydration units. The set pressure of the pressure-relief system shall be determined by the lessee and approved by the District Supervisor. The discharge of the relief valve must be vented in a nonhazardous manner. The glycol-dehydration unit shall be properly maintained to prevent overpressurization of the unit.

5.1.7 Gas Compressors.

a. New Compressor Installations. Each compressor installed after the effective date of this Order shall be equipped with the following protective equipment:

- (1) A PSH, a PSL, a PSV, and an LSH to protect each interstage scrubber.
- (2) An LSL to protect each interstage scrubber, unless the fluid is dumped through a choke restriction to another pressure vessel. An LSL shut-in control(s) installed in interstage scrubber(s) may be designed to actuate the automatic Shutdown Valve(s) (SDV's) installed in the scrubber dump line(s).
- (3) A TSH on each compressor cylinder or other components as applicable.
- (4) In addition to the provisions of API RP 14C, Subsection A8.3, PSH and PSL shut-in sensors and LSH shut-in controls protecting compressor suction and interstage scrubbers shall be designed to actuate automatic SDV's located in each compressor

suction and fuel gas line so that the compressor unit and the associated vessels can be isolated from all input sources.

All automatic SDV's installed in compressor suction and fuel gas piping shall also be actuated by the shutdown of the prime mover.

b. Small Compressor Installations. Compressor installations of 745 kilowatts (1,000 horsepower) or less are excluded from those requirements of API RP 14C, A8.3d, which provide for installation of a blowdown valve (BDV) on the discharge line.

5.1.8 Firefighting Systems. Firefighting systems installed after the effective date of this Order shall conform to Subsection 5.2, "Fire Water Systems," of "API Recommended Practice for Fire Prevention and Control on Open Type Offshore Production Platforms," API RP 14C, First Edition, September 1978, or to subsequent revisions which the Chief, Conservation Division, has approved for use and to the additional requirements of this subparagraph.

A firewater system consisting of rigid pipe with firehose stations shall be installed. A fixed water-spray system shall be installed in the well bays. The system shall be installed to provide needed protection at all times in all areas where production-handling equipment is located.

Acceptable pump drivers include diesel engines, natural gas engines, and electric motors. Fuel or power shall be available for at least 30 minutes of run-time during platform shut-in time. If necessary,

an alternate fuel supply shall be installed to provide for this pump-operating time.

A firefighting system using chemicals may be used or may be required in lieu of a water-spray system if the District Supervisor determines that the use of a chemical system provides equivalent fire-protection control. A diagram of the firefighting system showing the location of all firefighting equipment shall be posted in a prominent place on the platform or structure.

5.1.9 Fire and Gas Detection System.

a. Fire (flame, heat, or smoke) sensors shall be used in all enclosed high-hazard areas. Gas sensors shall be used in all inadequately ventilated, enclosed, high-hazard areas. A high-hazard area is defined as:

(1) Any enclosed area containing a gas source, except a meter house with adequate ventilation.

(2) A compressor building.

(3) Any nonsealed enclosed area within 25 feet of a producing well or service area of a producing well, unless the enclosed area does not contain an ignition source. A diagram of the detection system showing the location of all detection points shall be posted in a prominent place on the platform or structure.

b. All detection systems shall be capable of continuous monitoring. The systems shall be of the manual-reset type.

c. A fuel gas odorant and an automatic gas-detection and alarm system are required in enclosed, continuously manned areas of the facility.

d. The District Supervisor may require a gas detector or alarm in any potentially hazardous area.

e. Fire and gas detection systems shall be of a type as defined in the National Electrical Code, 1978 Edition, or subsequent revisions which the Chief, Conservation Division, has approved for use.

5.1.10 Electrical Equipment. The following requirements shall be applicable to all electrical equipment and systems:

a. All engines with ignition systems shall be equipped with a low-tension ignition system of a low-fire-hazard type and shall be designed and maintained to minimize the release of sufficient electrical energy to cause ignition of an external, combustible mixture.

b. All electrical generators, motors, and lighting systems shall be installed, protected, and maintained in accordance with the edition of the National Electrical Code and API RP 500B in effect at the time of approval.

c. At the time of approval, wiring methods shall conform to the National Electrical Code, 1978 Edition, or to the Institute of Electrical and Electronic Engineers (IEEE) "Recommended Practice for Electric Installation on Shipboard,"

IEEE Std. 45-1977, or subsequent revisions which the Chief, Conservation Division, has approved for use. Each conductor of a wire, a cable, or a bus bar shall be made of copper on all new installations constructed after the effective date of this Order.

d. An auxiliary power supply shall be installed to provide emergency power, capable of operating all electrical equipment required to maintain safety of operations, in the event of a failure in the primary electrical power supply.

e. The elementary electrical schematic of the platform safety-shutdown system required by subparagraph 4.3e(2) shall be posted in a prominent place on the platform or structure. This schematic shall indicate the control functions of all electrically actuated safety devices.

f. Maintenance of these systems shall be by qualified personnel.

5.1.11 Erosion. A program of erosion control shall be in effect for wells or fields having a history of sand production. The erosion-control program may include sand probes, X-ray, ultrasonic, or other satisfactory monitoring methods. An annual report, by lease, indicating the wells which have erosion-control programs in effect and the results of the programs shall be submitted by the first of December to the appropriate District Supervisor.

5.2 General Platform Operations.

a. Safety devices and safety systems on wells which are capable of producing shall not be bypassed or blocked out of service. Safety devices may be bypassed or blocked out of service if they are temporarily out of service due to startup, maintenance, or testing procedures, provided that personnel are monitoring the blocked-out functions. Any device on wells, vessels, or flowlines which is temporarily out of service shall be flagged.

b. When wells are disconnected from producing facilities and blind-flanged or equipped with a tubing plug, compliance is not required with the provisions of API RP 14C or this Order concerning:

(1) Installation of automatic fail-close SSV on wellhead assemblies.

(2) Installation of the PSH and the PSL shut-in sensors downstream of the choke in flowlines from wells.

(3) Installation of flow safety valves (FSV's) in header individual flowlines.

c. All open-ended lines connected to producing facilities shall be plugged or blind-flanged, except those lines designed to be open-ended, such as flare or vent lines.

5.3 Simultaneous Platform Operations. Prior to conducting activities simultaneously with production operations which could increase the possibility of occurrence of undesirable events, such

as harm to personnel or to the environment or damage to equipment, a "General Plan for Conducting Simultaneous Operations" in a producing field shall be filed for approval with the District Supervisor. This plan shall be modified and updated by supplemental plans when actual simultaneous operations are scheduled. Activities requiring these plans are drilling, completion, workover, wireline, pumpdown, and major construction operations.

The "General Plan for Conducting Simultaneous Operations" shall include:

a. A narrative description of operations.

b. Procedures for the mitigation of potentially undesirable events including:

(1) The guidelines the lessee will follow to assure coordination and control of simultaneous activities.

(2) An indication of the person having overall responsibility at the site for the safety of platform operations.

The "Supplemental Plan for Conducting Simultaneous Operations" shall include:

a. A floor plan of each platform deck indicating critical areas of simultaneous activities.

b. An outline of any additional safety measures that are required for simultaneous operations.

c. Specification of any added or special equipment or procedural conditions imposed when simultaneous activities are in progress.

5.4 Welding Practices and Procedures. The following requirements are applicable to any welding practice or procedure performed on:

a. An offshore mobile-drilling unit during the drilling mode.

b. A mobile workover unit during any drilling, completion, recompletion, remedial, repair, stimulation, or other workover activity.

c. A platform, structure, artificial island, or other installation during any drilling, completion, workover, or production operation.

d. A platform, structure, artificial island, or other installation which contains a well open to a hydrocarbon-bearing zone.

For the purpose of this Order, the terms "welding" and "burning" are defined to include arc or acetylene cutting and arc or acetylene welding.

Each lessee shall file, for approval by the District Supervisor, a "Welding and Burning Safe Practices and Procedures Plan." The plan shall be filed within 90 days after the effective date of

47
16

this Order and shall include the qualification standards or requirements for personnel and the methods by which the lessee will assure that only personnel meeting such standards or requirements are utilized. A copy of this plan shall be available in the field area. Any person designated as a welding supervisor shall be thoroughly familiar with this plan.

Prior to welding or burning operations, the lessee shall establish approved safe-welding areas. These areas shall be constructed of noncombustible or fire-resistant materials, be free of combustible or flammable contents, and be suitably segregated from adjacent areas. National Fire Protection Association Bulletin "Cutting and Welding Processes," No. 518, 1971, or subsequent revisions which the Chief, Conservation Division, has approved for use, shall be used as a guide to designate these areas. A drawing showing the location of these areas shall be posted in a prominent place on the facility. All offshore welding and burning shall be minimized by onshore fabrication when feasible.

All welding equipment shall be inspected prior to beginning any welding or burning. Welding machines located on production or process platforms shall be equipped with spark arrestors and drip pans. Welding leads shall be completely insulated and in good condition; oxygen and acetylene bottles secured in a safe place; and hoses leak-free and equipped with proper fittings, gauges, and regulators.

All welding which cannot be done in the approved safe-welding area shall be performed in compliance with the procedures outlined below:

a. Prior to the commencement of any welding or burning operation on a structure, the lessee's designated person-in-charge at the installation shall personally inspect the qualifications of the welder or welders to assure that they are properly qualified in accordance with the lessee-approved qualification standards or requirements for welders. The designated person-in-charge and the welders shall personally inspect the work area for potential fire and explosion hazards. After it has been determined that it is safe to proceed with the welding or burning operation, the designated person-in-charge shall issue a written authorization for the work.

b. During all welding and burning operations, one or more persons shall be designated as a Fire Watch. Persons assigned as a Fire Watch shall have no other duties while actual welding or burning operations are in progress. The Fire Watch shall not be a member of the welding crew. If welding is to be done in an area which is not equipped with a gas detector, the Fire Watch shall also maintain a continuous surveillance with a portable gas detector during welding.

c. Prior to any welding or burning operation, the Fire Watch shall have in his possession firefighting equipment in a usable condition. At the end of the welding operation, the equipment shall be returned to a usable condition.

d. No welding shall be done on piping, containers, tanks, or other vessels which have contained a flammable substance unless the contents have been rendered and determined to be safe for welding or burning by the designated person-in-charge.

e. If drilling, workover, or wireline operations are in progress on the platform, welding operations in other than approved safe-welding areas shall not be conducted unless the well(s) where these operations are in progress contain noncombustible fluids and the entry of formation hydrocarbons into the wellbore is precluded. All other provisions of this section shall also be applicable.

f. If welding or burning operations are conducted on wells or in the well-bay area, all producing wells shall be shut in at the surface-safety valve.

5.5 Safety Device Testing. The safety-system devices which are required by this Order shall be tested by the lessee at the interval specified below or more frequently if operating conditions warrant.

Testing shall be in accordance with API RP 14C, appendix D, and the following:

a. All PSV's shall be tested for operation at least annually. These valves shall be either bench-tested or equipped to permit testing with an external pressure source.

b. All Pressure Sensors-High/Low (PSHL) shall be tested at least once each calendar month, but at no time shall more than 6 weeks elapse between tests.

c. All SSV's shall be tested for operation and for leakage at least once each calendar month, but at no time shall more than 6 weeks elapse between tests. The SSV's shall be tested for operation in accordance with the test procedure specified in API RP 14C, appendix D, section D4, table D2, subsection L, and tested for leakage in accordance with subsection M. If the valve does not operate properly or any fluid flow is observed in step 3 of the leakage test, the valve shall be repaired or replaced.

d. All flowline FSV's shall be checked for leakage at least once each calendar month, but at no time shall more than 6 weeks elapse between tests. The FSV's shall be tested for leakage in accordance with the test procedure specified in API RP 14C, appendix D, section D4, table D2, subsection D. If the leakage measured in step 6 exceeds a liquid flow of 400 cc/min or a gas flow of 7 dm³/sec (15 cubic ft/min), the FSV's shall be repaired or replaced.

e. All LSH and LSL controls shall be tested at least once each calendar month, but at no time shall more than 6 weeks elapse between tests. These tests shall be conducted by raising and lowering the liquid level across the level-control detector.

f. All automatic inlet SDV's which are actuated by a sensor on a vessel or a compressor shall be tested for operation

at least once each calendar month, but at no time shall more than 6 weeks elapse between tests.

g. All SDV's located in liquid-discharge lines and actuated by vessel low-level sensors shall be tested for operation once each calendar month, but at no time shall more than 6 weeks elapse between tests.

h. The TSH shutdown controls installed in all compressors which are protected against abnormal pressures solely by temperature safety devices shall be tested semiannually and repaired or replaced as necessary.

i. All pumps for firefighting water systems shall be inspected and test-operated weekly.

j. All fire (flame, heat, or smoke) and gas detection systems shall be tested for operation and recalibrated semiannually, if necessary.

k. The lessee shall notify the District Supervisor when the lessee is ready to conduct a preproduction test and inspection of the integrated safety system. The lessee shall also notify the District Supervisor upon commencement of production in order that a post-production test and inspection of the integrated system may be conducted.

l. All other safety devices shall be tested annually and repaired or replaced as necessary.

5.6 Records. The lessee shall maintain records for a minimum period of 5 years for each surface-safety device installed. These records shall be maintained in the nearest offshore field office for a minimum period of 2 years. The records may then be transferred to the onshore field office for the remaining 3 years of the 5-year retention period. These records shall be available for review by any authorized representative of the U.S. Geological Survey (USGS). The records shall show the present status and history of each device, including dates and details of installation, inspection, testing, repairing, adjustments, and reinstallation. The records shall also include all failure and inventory reports required by paragraph 6 of this Order.

5.6.1 Surface-Safety Valve and Associated Actuator Records. Records for surface-safety valves and associated actuators which require compliance with paragraph 2 shall contain additional information showing verification of:

a. The devices having been manufactured in accordance with the quality assurance requirements of ANSI/ASME-SPPE-1 (formerly ANSI/ASME-OCS-1) as required by paragraph 2.

b. The completion and return of the receiving report to the manufacturer as required by ANSI/ASME-SPPE-1.

c. The completion and submission of all failure reports required by paragraph 6 and all investigation reports required by paragraphs OE-2529 and OE-2670 of ANSI/ASME-SPPE-1.

50

5.7 Safety Device Training. Prior to the commencement of production, the lessee shall ensure that all personnel engaged in installing, inspecting, testing, and maintaining these safety devices will have been qualified under a program as recommended by "API Recommended Practice for Qualification Programs for Offshore Production Personnel Who Work With Anti-Pollution Safety Devices," API RP T-2, revised October 1975, or subsequent revisions which the Chief, Conservation Division, has approved for use.

Documented evidence of the qualifications of individuals performing these functions shall be maintained in the field area.

Manufacturers' representatives need not be qualified in accordance with API RP T-2 if they are working on equipment supplied by their company and if they are directly supervised by a qualified person who is capable of evaluating the impact of the work on the total system.

On-the-job trainees working with safety devices shall be directly supervised by a qualified person.

At the time that the lessee submits the Plan of Development and Production, required by 30 CFR 250.34-2, the lessee shall submit an application for approval to the Chief, Conservation Division, describing the training to be conducted and the methods the lessee will utilize. The application shall include:

- a. A designation of the lessee's representative who is responsible for training and coordinating training matters

with the USGS.

6. Failure and Inventory Reporting System (FIRS). The USGS has established a safety and pollution-prevention device Failure and Inventory Reporting System (FIRS) to enhance the reliability and safety of operations in the OCS. This system applies to offshore structures, including satellites and jackets, which produce or process hydrocarbons and includes the attendant portions of hydrocarbon pipelines, when physically located on the structure.

When the devices specified herein are used as a part of the production-safety and pollution-prevention system, the lessee shall:

- a. Submit an initial inventory and periodic updates in accordance with the procedures described in subparagraph 6.1.3.
- b. Report all device failures which occur. The report content and format shall be in accordance with the procedures described in subparagraph 6.1.4.

Inventory and failure data required by this Order shall be submitted to the USGS Conservation Manager in the appropriate regional office.

5.1 Data and Reporting Requirements.

6.1.1 Format. Inventory and failure data shall be submitted in a format containing the same information that is in the Safety Device Inventory Report (Form 9-1994) and the Safety Device Failure Report Form (Form 9-1995) and as outlined in the

respective User's Instruction Booklets. Copies of the forms and booklets may be obtained from the USCS Conservation Manager in the appropriate regional office.

The specific method of submitting the required data may be selected from the following:

a. USCS Forms 9-1994 and 9-1995, using a standard coding convention (e.g., all letters capitalized, E, I, letter O, number O).

b. ADP card decks of standard 80-column cards.

c. Magnetic tapes which are 9-track, 800 BPI, unlabeled, blocking cannot exceed 1040 characters, odd parity, single gap (i.e., compatible with IBM equipment EBCDIC).

6.1.2 Device Coverage. Inventory and failure reports are to be submitted on the safety- and pollution-prevention devices on offshore structures, including satellites and jackets, which produce or process hydrocarbons, and the hydrocarbon pipelines thereon. These reports shall be submitted on the following:

- a. Blowdown Valve (BDV)
- b. Burner Flame Detector (BSL)
- c. Check Valve (FSV)
- d. Combustible Gas Detector (ASH)
- e. Emergency Shutdown Valve (ESD)

5-34

- f. Level Sensor
 - High (LSH)
 - Low (LSL)
 - Hi/Lo (LSHL)
- g. Pressure Sensor
 - High (PSH)
 - Low (PSL)
 - Hi/Lo (PSHL)
- h. Relief Valve (PSV)
- i. Shutdown Valve (SDV)
- j. Subsurface-Safety Valve (SSSV)
- k. Surface-Safety Valve (SSV)
- l. Temperature Sensor
 - High (TSH)
 - Low (TSL)
 - Hi/Lo (TSHL)
- m. Valve Actuator on, the shutdown valve, the blowdown valve, the surface-safety valves. (VA)

6.1.3 Device Inventory Reporting.

6.1.3.1 Initial Inventory.

a. For platforms in existence at the time this Order becomes effective, a complete inventory of the safety and pollution-prevention devices shall be submitted no later than 6 months after the effective date of this Order.

5-35

b. For platforms completed after this Order becomes effective, a complete inventory of the safety and pollution-prevention devices shall be submitted no later than 1 month after the initial platform production date.

6.1.3.2 Inventory Updates. An updating of or addition/deletion to the latest inventory shall be submitted on a monthly basis so as to maintain a current and accurate data base. The inventory will be updated by using the contents of the Safety Device Inventory Report (Form 9-1994) and the Safety Device Failure Report (Form 9-1995).

Inventory updating due to the addition, deletion, or changeout of a device is accomplished by the lessee's reporting of all the data required on the Safety Device Inventory Report (9-1994).

Whenever a device fails and is either replaced with a new device or "fixed" and put back into service, the inventory shall be updated to reflect this change. Inventory updating, due to the failure of a device, will be performed by the USGS, using the contents of the Safety Device Failure Report (Form 9-1995). Inventory updating information shall be received no later than 30 days following the month in which the device change was made.

6.1.3.3 Inventory-Reporting Methods. Inventory data shall be reported either on the Safety Device Inventory Reporting forms (Form 9-1994), punched cards, or magnetic tapes.

The reports shall contain all of the required information in the standard format as described in subparagraph 6.1.1.

6.1.3.4 Inventory Verification. The device inventory shall be verified by the lessee to ensure that the inventory data base is maintained on a current basis and that changes are being incorporated as they occur. The verification shall be accomplished no more frequently than once each 6-month period. When verification is required, the USGS will provide the lessee with a copy of the information on record, in the lessee's selected reporting format. The lessee shall review the information and either submit a letter stating that the information is correct, or make the appropriate corrections to the information provided by the USGS. The letter or appropriate corrections shall be received no later than 30 days following the month in which the inventory information which is to be verified was forwarded to the lessee.

6.1.3.5 Inventory-Reporting Deviation. A lessee may submit an inventory, update, or verification report differing from that described in subparagraph 6.1.3 when authorized by the USGS.

6.1.4 Device Failure Reporting.

6.1.4.1 Failure-Data Submittal. Device failure data shall be recorded as soon as possible after detecting the failure as defined in subparagraph 6.1.4.3. This data shall be received no later than 30 days following the month in which the failure was detected. This data must contain all of the required information

and be submitted in the standard format either on Safety Device Failure Report forms (Form 9-1995), punched cards, or magnetic tape, as previously described in subparagraph 6.1.1. Information on the failed device must match that previously submitted in inventory reporting. A formal failure analysis is not required by this Order, but each failed device shall undergo sufficient test/disassembly to establish the basic cause(s) of the failure.

6.1.4.2 Failure-Data Verification. After receipt of the complete failure data from the lessee, a printout shall be made of all failures by manufacturer, model, and reported cause. Each manufacturer listed shall be furnished a copy of the printout containing the reported failures of his devices only. If he disagrees with the reported failure causes, he is invited to investigate the questioned causes in coordination with the reporting lessee and provide a coordinated reply within 30 days after receipt of the printout. If no reply is received within that time period, the originally reported causes shall be considered to be correct, and the data shall be evaluated accordingly.

6.1.4.3. Failure Definition. The safety and pollution-prevention device Failure and Inventory Reporting System does not differentiate between a malfunction and a failure. For the purpose of this program, a failure is defined as the inability of a device to perform its designed function within specified limits. A device is considered to have failed if it does not operate (perform its function) as required within the specified tests' tolerances.

A failure report is not required for:

a. Adjustments made within specified tolerances.

b. Adjustments required due to changes in operating conditions.

7. Crane Operations. Cranes shall be operated and maintained to ensure the safety of facility operations in accordance with the provisions of "API Recommended Practice for Operation and Maintenance of Offshore Cranes," API RP 2D, October 1972, or subsequent revisions which the Chief, Conservation Division, has approved for use. Records of inspection, testing, maintenance, and crane operators qualified in accordance with the provisions of API RP 2D shall be kept in the field area for a period of 2 years.

"API Specification for Offshore Cranes," API Specification 2C, February 1972, or subsequent revisions which the Chief, Conservation Division, has approved for use, shall be used as a guideline for the selection of cranes.

8. Employee Orientation and Motivation Programs for Personnel Working Offshore. The lessee shall make a planned, continuing effort to eliminate accidents due to human error. This effort shall include the training of personnel in their functions. A program to achieve safe and pollution-free operations shall be established. This program shall include instructions in the provision of "API Recommended Practice Orientation Program for

Personnel Going Offshore for the First Time," API RP T-1, January 1974, or subsequent revisions which the Chief, Conservation Division, has approved for use. "API Employee Motivation Programs for Safety and Prevention of Pollution in Offshore Operations," API Bulletin T-5, September 1974, or subsequent revisions which the Chief, Conservation Division, has approved for use, shall be used as a guide in developing employee safety and pollution-prevention motivation programs.

9. Requirements for Drilling Rigs.

9.1 Fixed Structures. The following requirements contained in this Order are applicable to drilling rigs on fixed structures:

- a. Subparagraph 5.1.10, "Electrical Equipment."
- b. Subparagraph 5.4, "Welding Practices and Procedures."
- c. Paragraph 8, "Employee Orientation and Motivation Programs for Personnel Working Offshore."

9.2 Mobile Drilling Units. The following requirements contained in this Order are applicable to drilling rigs on mobile drilling units:

- a. Subparagraph 5.4, "Welding Practices and Procedures."
- b. Paragraph 8, "Employee Orientation and Motivation Programs for Personnel Working Offshore."

10. Departures. All departures from the requirements specified in this Order shall be subject to approval, pursuant to 30 CFR 250.12(b).

Rodney A. Smith
Oil and Gas Supervisor
Arctic Area

Approved:

Don E. Kash
Chief, Conservation Division

UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY
CONSERVATION DIVISION
WESTERN REGION

ALASKA AREA

ARCTIC

OCS ORDER NO. 7

EFFECTIVE

POLLUTION PREVENTION AND CONTROL

This Order is issued pursuant to the authority prescribed in 30 CFR 250.11 and in accordance with 30 CFR 250.43. The lessee shall comply with the following requirements.

1. Pollution Prevention. During the exploration, development, production, and transportation of oil and gas, the lessee shall prevent pollution of the ocean. Furthermore, by the disposal of waste materials into the ocean, the lessee shall not create conditions which will adversely affect the public health, life, property, aquatic life, wildlife, recreation, navigation, commercial fishing, or other uses of the ocean.

1.1 Liquid Disposal.

1.1.1 Drilling-Mud Components. The lessee shall submit, as a part of the Application for Permit to Drill (Form 9-331 C), a detailed list of drilling-mud components including the common chemical or chemical trade name of each component, a list of

the drilling-mud additives anticipated for use in meeting special drilling requirements, and the proposed method of drilling-mud disposal. The disposal of drilling mud is subject to the Environmental Protection Agency's permitting procedures, pursuant to the Federal Water Pollution Control Act, as amended. Approval of the method of drilling-mud disposal into the ocean shall be obtained from the District Supervisor; each request will be decided on a case-by-case basis.

1.1.2 Hydrocarbon-Handling Equipment. All hydrocarbon-handling equipment for testing and production such as separators, tanks, and treaters shall be designed and operated to prevent pollution. Maintenance or repairs which are necessary to prevent pollution of the ocean shall be undertaken immediately.

1.1.3 Curbs, Gutters, and Drains for Fixed Platforms or Structures and Mobile Drilling Units.

a. Fixed Platforms, Structures, and Artificial Islands. Curbs, gutters, and drains shall be installed in all deck areas to collect all contaminants in a closed sump. When open decks are used, drip pans or the equivalent shall be placed under equipment and piped to a closed sump. Closed sumps shall automatically maintain fluid at a level sufficient to prevent the discharge of oil into the ocean. Contaminants that are removed from sumps shall be disposed of in a manner which will not create pollution.

All walking and working surfaces shall be equipped with proper drainage to provide safety for personnel and to prevent pollution.

On artificial islands, all vessels containing hydrocarbons shall be placed inside an impervious berm. The volume enclosed by the berm must be in excess of the volume of the vessels containing hydrocarbons. In addition, the rig mat must be made impervious, and all drainage ditches must be directed away from the drilling rig to an impervious sump.

b. Mobile Drilling Units. Curbs, gutters, and drains which collect contaminants associated with the drilling operation on a mobile drilling unit shall be installed as required by subparagraph 1.1.3a.

Curbs, gutters, and drains which collect contaminants not associated with the drilling operations are subject to regulation by the U.S. Coast Guard.

1.1.4 Discharges from Fixed Platforms or Structures and Mobile Drilling Units. Discharges from fixed platforms or structures and mobile drilling units, including sanitary waste, produced water, drilling mud, and deck drainage, are subject to the Environmental Protection Agency's permitting procedures, pursuant to the Federal Water Pollution Control Act, as amended.

1.2 Solid Material Disposal.

1.2.1 Well Solids. The disposal of drill cuttings, sand, and other well solids containing oil is subject to the Environmental Protection Agency's permitting procedures, pursuant to the Federal Water Pollution Control Act, as amended. Approval of the method of disposal of drill cuttings, sand, and other well solids shall be obtained from the District Supervisor.

1.2.1 Containers. Containers and other similar solid-waste materials shall not be disposed of into the ocean.

1.2.3 Equipment. Disposal of equipment into the ocean is prohibited except under emergency conditions. The location and description of any equipment disposed of into the ocean shall be reported to the District Supervisor and to the U.S. Coast Guard in accordance with paragraph 4 of OCS Order No. 1.

2. Personnel, Inspections, and Reports.

2.1 Personnel. The lessee's personnel shall be instructed in the techniques of equipment maintenance and operation for the prevention of pollution. Contractor personnel providing services offshore shall be informed in writing, prior to executing contracts, of the lessee's obligations to prevent pollution and of the provisions of this Order.

2.2 Pollution Inspections.

2.2.1 Manned Facilities. Manned drilling and production facilities shall be inspected daily to determine if pollution is occurring. Maintenance or repairs which are necessary to prevent pollution of the ocean waters shall be undertaken and performed immediately.

2.2.2 Unattended Facilities. Unattended facilities, including those equipped with remote control and monitoring systems, shall be inspected daily or at intervals prescribed by the District Supervisor to determine if pollution is occurring. Necessary maintenance or repairs shall be made immediately.

2.3 Pollution Reports. All spills of oil and liquid pollutants shall be reported orally to the District Supervisor and shall be confirmed in writing. All reports shall include the cause, location, volume of spill, and action taken. Reports of spills of more than 5.0 cubic meters (31.5 barrels) shall include information on the sea state, meteorological conditions, size, and appearance of slick. All spills of oil and liquid pollutants shall also be reported in accordance with the procedure contained in 33 CFR 153.203.

2.3.1 Spills. Spills shall be reported orally within the following time limits:

a. Within 12 hours, if spills are 1.0 cubic meters (6.3 barrels) or less.

b. Without delay, if spills are more than 1.0 cubic meters (6.3 barrels).

2.3.2 Observed Malfunctions. Lessees shall notify each other of observed pollution resulting from another's operation.

58 3. Pollution-Control Equipment and Materials and Oil Spill Contingency Plans. The lessee shall submit a description of procedures, personnel, and equipment that will be used in reporting, cleanup, and prevention of the spread of any pollution resulting from an oil spill which might occur during exploration or development activities. The following subparagraphs describe the minimum requirements for pollution-control equipment and procedures.

3.1 Equipment and Materials. Pollution-control equipment and materials shall be maintained by, or shall be available to, each lessee at an offshore location or at a location approved by the Supervisor. The equipment shall include containment booms, skimming apparatus, cleanup materials, and chemical agents which shall be available prior to the commencement of operations. The equipment and materials shall be inspected monthly and maintained

in a state of readiness for use. The results of the inspections shall be recorded and maintained at the site.

3.2 Oil Spill Contingency Plans. The lessee shall submit an Oil Spill Contingency Plan for approval by the Supervisor, prior to the approval of an Exploration Plan or a Development and Production Plan. Oil Spill Contingency Plans shall be reviewed annually. All modifications of the Oil Spill Contingency Plan and the results from the review of the plan shall be submitted to the Supervisor for approval. The Oil Spill Contingency Plan shall contain the following:

a. Provisions to assure that full resource capability is known and can be committed during an oil spill, including the identification and inventory of applicable equipment, materials, and supplies which are available locally and regionally, both committed and uncommitted, and the time required for deployment of the equipment.

b. Provisions for varying degrees of response effort depending on the severity of the oil spill.

c. Provisions for identifying and protecting areas of special biological sensitivity.

d. Establishment of procedures for the purpose of early detection and timely notification of an oil spill including a current list of names, telephone numbers, and addressees of the responsible person and alternates on call to receive

notification of an oil spill; and the names, telephone numbers, and addresses of regulatory organizations and agencies to be notified when an oil spill is discovered.

e. Provisions for well-defined and specific actions to be taken after discovery and notification of an oil spill, including:

(1) Specification of an oil-spill-response operating team consisting of trained, prepared, and available operating personnel.

(2) Predesignation of an oil-spill-response coordinator who is charged with the responsibility and is delegated commensurate authority for directing and coordinating response operations.

(3) A preplanned location for an oil-spill-response operations center and a reliable communications system for directing the coordinated overall response operations.

(4) Provisions for disposal of recovered spill materials.

4. Drills and Training.

4.1 Drills. Drills for familiarization with pollution-control equipment and operational procedures shall be held by the lessee. The personnel identified as the oil-spill-response operating team in the Contingency Plan shall participate in these

drills. The drills shall be realistic and shall include deployment of equipment. A time schedule with a list of equipment to be deployed shall be submitted to the Supervisor for approval. The drill schedule shall provide sufficient advance notice to allow U.S. Geological Survey (USGS) personnel to witness any of the drills. Drills shall be recorded, and the records shall be made available to USGS personnel. Where drill performance and results are deemed inadequate, the Supervisor may require an increase in the frequency or a change in the location of the drills until satisfactory results are achieved.

4.2 Training. The lessee shall ensure that training classes for familiarization with pollution-control equipment and operational procedures are provided for the oil-spill-response operating team. The supervisory personnel responsible for directing the oil-spill-response operations shall receive oil-spill-control instruction suitable for all seasons. The lessee shall retain course-completion certificates or attendance records issued by the organization where the instruction is provided. These records shall be available to any authorized representative of the USGS, upon request.

5. Spill Control and Removal. Immediate corrective action shall be taken in all cases where pollution has occurred. Corrective action taken under the lessee's Oil Spill Contingency Plan shall be subject to modification when directed by the Supervisor. The primary jurisdiction to require corrective action to abate the source of pollution shall remain with the Supervisor, pursuant to

the provisions of this Order and the Memorandum of Understanding (MOU) between the Department of Transportation (U.S. Coast Guard) and the Department of the Interior (U.S. Geological Survey) dated August 16, 1971. The use of chemical agents or other additives shall be permitted only after approval by the Supervisor in accordance with Annex X, National Oil and Hazardous Substances Pollution Contingency Plan and in accordance with the previously mentioned MOU.

6. Departures. All departures from the requirements specified in this Order shall be subject to approval, pursuant to 30 CFR 250.12(b).

60

Rodney A. Smith
Oil and Gas Supervisor
Arctic Area

Approval:

Don E. Kash
Chief, Conservation Division

UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY
CONSERVATION DIVISION

OCS ORDER NO. 8

EFFECTIVE

PLATFORMS AND STRUCTURES

This Order is issued pursuant to the authority prescribed in 30 CFR 250.11 and in accordance with 30 CFR 250.19(a).

1. Applicability.

1.1 New Platforms. Subsequent to the effective date of this Order, the design fabrication and installation of all new fixed or bottom-founded platforms or other structures (e.g., single-pile caissons, ice islands, and gravel islands) shall be designed, fabricated, and installed in accordance with the applicable provisions of the document, entitled "Requirements for Verifying the Structural Integrity of Outer Continental Shelf (OCS) Platforms," and shall require approval under the provisions of this Order.

Where doubt exists as to the applicability of this Order, questions shall be referred to the Supervisor.

1.2 Major Modifications and Repairs. Subsequent to the effective date of this Order, major modifications or repairs of damage to all fixed or bottom-founded platforms or other

structures shall require approval under the provisions of this Order. Major modifications or repairs of damage are generally defined as any operation affecting structural members included in the space-frame analysis of the platform design. Where doubt exists as to the applicability of this Order, questions shall be referred to the Supervisor.

1.3 Platform Verification.

All new platforms or other structures, and major modifications or repairs of damage to platforms or other structures, shall be subject to review under the requirements of the Platform Verification Program and to the approval of the Supervisor.

1.4 References. Other aspects of the Platform Verification Program are described in more detail in the following documents, and these documents shall be considered as references for this Order.

1.4.1 Operating Procedures for the Platform Verification Program. The document, entitled "Operating Procedures for the Platform Verification Program," First Edition, describes the elements of the Platform Verification Program, the verification steps, the function of the Platform Verification Section, and the procedures for resolution of disputes; defines standards which shall be met by individuals or organizations in order to be certified as Certified Verification Agents (CVA); and provides instructions to the CVA.

1.4.2 Requirements for Verifying the Structural Integrity of OCS Platforms. The document, entitled "Requirements for Verifying the Structural Integrity of OCS Platforms," First Edition, is identified in this Order as "Requirements." It identifies mandatory state-of-the-art performance standards which shall be met in designing, fabricating, and installing platforms or other structures and major modifications or repairs to platforms or other structures.

1.4.3 Appendices to Requirements for Verifying the Structural Integrity of OCS Platforms. The document, entitled "Appendices to Requirements for Verifying the Structural Integrity of OCS Platforms," First Edition, is identified in this Order as "Appendices." It identifies alternative engineering design procedures which may be utilized, where applicable, to conform to the "Requirements."

1.4.4 Commentary on Requirements for Verifying the Structural Integrity of OCS Platforms. The document, entitled "Commentary on Requirements for Verifying the Structural Integrity of OCS Platforms," First Edition, is identified in this Order as "Commentary." It provides an explanation of the basic intent of the "Requirements" and also discusses the "Requirements," the "Appendices," and the current relative development of the state of practice for pertinent parts of both.

2. Responsibility.

2.1 Submission. All applications for approval under the provisions of this Order shall be submitted to the Supervisor. All significant changes or modifications (i.e., any structural change which materially alters the original plan or any major deviation from operations) to approved applications shall be submitted for approval to the Supervisor prior to commencing any such work. Where doubt exists as to whether a change is significant, questions shall be referred to the Supervisor.

2.2 Certification. The lessee shall have detailed structural plans and specifications for new platforms or other structures, and major modifications or repairs, certified by a registered professional structural engineer or civil engineer specializing in structural design. The lessee shall also sign and date the following certification:

(Lessee) certifies that the design of the (structure/modification/repair) has been certified by a registered professional structural engineer or a civil engineer specializing in structural design, and the (structure/modification/repair) will be fabricated, installed, and maintained as described in the application and any approved modification thereto. Certified design and as-built plans and specifications are on file at _____.

2.3 Verification. The lessee shall nominate a CVA(s) and have the design, fabrication, and installation of all platforms or other structures, and modifications or repairs to platforms or other structures, which are subject to review under the requirements of the Platform Verification Program, verified by a CVA(s).

2.4 Notification. The lessee shall be responsible for notifying the Supervisor at least 1 week prior to transporting the platform or other structure to the installation site.

2.5 Commencement. For new platforms or other structures and major modifications or repairs subject to review under the requirements of the Platform Verification Program, the lessee shall obtain approval for the design prior to commencing the fabrication and obtain approval for the fabrication prior to transporting the platform or other structure to the installation site.

3. Submissions.

3.1 General. The lessee shall submit to the Supervisor, in triplicate, all documentation necessary for approval of new platforms or other structures, and major modifications or repairs, in accordance with the provisions of this Order. Listed hereafter is the documentation which shall be submitted; however, more detailed information and data may be required on a case-by-case basis and upon specific request by the Supervisor.

3.2 Design.

3.2.1 Design Documentation. The lessee shall submit design documentation subsequent to the approval of the Plan of Development/Production. The design documentation shall include finalized construction (i.e., fabrication and installation) drawings and specifications, the certification by the lesser, and the name of the registered professional engineer. In addition, the design documentation shall incorporate the following:

- a. General platform information.
- b. Environmental and loading information.
- c. Foundation information.
- d. Structural information.

3.2.1.1 General Platform Information. The general platform information shall include the following:

a. Identification data including the platform or structure designation, the lease number, the area name, the block number, and the lessee's name.

b. Location data consisting of longitude and latitude coordinates, Universal Transverse Mercator grid system coordinates, state plane coordinates in the Lambert or Transverse Mercator Projection system, and a plat drawn to a scale of 1 centimeter = 240 meters (1 inch = 2,000 feet) showing surface location and distance from the nearest block lines.

c. Intended primary use and other intended functions such as planned drilling, production, processing, well protection, compression, pumping or storage facility, or other operations.

d. Personnel facilities, personnel access to living quarters, number and location of boat landings, heliports, cranes, and evacuation routes.

e. Platform or structure details which consist of drawings, plans, front and side elevations of the entire structure, and plan views that clearly illustrate essential parts (i.e., equipment arrangement, number and location of well slots), design loadings of each deck, water depth, nominal size and thickness of all jacket and deck structural members, nominal size, makeup, thickness, and design penetration of piling, etc.

f. Corrosion protection or durability details which consist of the corrosion-protection method; expected life; and durability criteria for the submerged, splash, and atmospheric zones.

g. Material specifications.

h. Design standards.

3.2.1.2 Environmental and Loading Information. The environmental and loading information shall include the following:

a. Environmental data which consists of a summary listing of data, as addressed in the "Requirements," which have a bearing on the design installation and operation (e.g., wave heights and periods, current, wind and gust velocities with relative heights, water depth, storm and astronomical tide data, marine growth, snow and ice effects, and air and sea temperatures).

b. Geophysical data which consists of a summary report of shallow geological and geophysical conditions in the area of the structure; incorporating multisensor, high-resolution profiling information obtained from geophysical instruments (e.g., a sparker and a subbottom profiler); describing any anomalous geological conditions known to exist in the area; and correlating soil borings with the profiling information.

c. Loading data which consists of a listing of total design functional loads and loads due to wind, wave, ice, and current forces for longitudinal, transversal, and diagonal approaches.

3.2.1.3 Foundation Information. The foundation information shall include the following:

a. Seabed testing results which consist of a brief summary of the major strata encountered at the location of the boring presented in tabular form, a detailed subsurface profile illustrating results of field and laboratory testing, a listing of field and laboratory investigations and tests with a basic summary of resultant determinations, the identification of properties and conditions of the seabed and the subsoil, and the identification of any manmade hazards or obstructions.

b. Load effects which consist of a description of the effect of the environmental and functional loads on

The requirement for fatigue analysis shall be determined on a case-by-case basis. Where doubt exists concerning the requirement for this analysis, questions shall be referred to the Supervisor.

The plan shall include a short summary which nominates the CVA, states the qualifications of the CVA, describes how the lessee intends to use the CVA, identifies the level of work to be performed by the CVA, and identifies the documents which will be furnished to the CVA. The plan shall also include a summary description of the following:

- a. Structural tolerances.
- b. Welding procedures.
- c. Fabrication standards.
- d. Material quality-control procedures.
- e. Methods and extent of Non-Destructive Examinations (NDE) for welds and materials.
- f. Quality Assurance procedures.

The fabrication verification plan shall be resubmitted for approval if the CVA changes, if the CVA's qualifications change, or if the level of work to be performed by the CVA changes. However, the summary of technical details needs not be resubmitted unless changes are made in the technical details.

3.3 Fabrication Verification Plan. For new platforms or other structures, and for modifications or repairs, which are subject to review under the requirements of the Platform Verification Program, the lessee shall submit a fabrication verification plan subsequent to the approval of the design.

3.4 Installation Verification Plan. For new platforms or other structures, and for modifications or repairs, subject to review under the requirements of the Platform Verification Program, the lessee shall submit an installation verification

67
19

plan, subsequent to the approval of the fabrication. The plan shall include a short summary which nominates the CVA, states the qualifications of the CVA, describes how the lessee intends to use the CVA, identifies the level of work to be performed by the CVA, and identifies the documents which will be furnished to the CVA. The plan shall also include a summary description of the planned marine operations, contingencies considered, alternate courses of action, and a summary description of the inspections to be performed during marine operations, including a graphical identification of areas to be inspected and acceptance/rejection criterion. The installation verification plan shall be resubmitted for approval if the CVA changes, if the CVA's qualifications change, or if the level of work to be performed by the CVA changes. However, the summary of technical details needs not be resubmitted unless changes are made in the technical details.

For structures fabricated and installed in place (e.g., ice islands and gravel islands), the fabrication and installation verification plans may be combined.

4. Records. The lessee shall compile, retain, and make available for review for the functional life of the platform or other structure that is subject to the provisions of this Order, the as-built final design, the design assumptions and analysis, the fabrication records, the marine operations records, and the inspection records.

5. Departures. All departures from the requirements specified in this Order shall be subject to approval, pursuant to 30 CFR 250.12(b).

Approved:

Chief, Conservation Division

UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY
CONSERVATION DIVISION
WESTERN REGION

ALASKA AREA

ARCTIC

OCS ORDER NO. 1E

EFFECTIVE

PUBLIC INSPECTION OF RECORDS

This Order is issued pursuant to the authority prescribed in 30 CFR 250.11 and in accordance with 30 CFR 250.34, 250.97, 252.6, and 43 CFR Part 2. Requests for information made under the Freedom of Information Act, 5 U.S.C. § 552, will be governed by the provisions of 43 CFR Part 2 (40 F.R. 7304, February 19, 1975).

1. Filing of Reports. All reports on Forms 9-152, 9-330, 9-331, 9-331 C, 9-1869, 9-1870 and the forms used to report the results of multipoint back-pressure tests shall be filed by the lessee in accordance with the following:

a. All reports submitted on these forms shall include a copy with the words "Public Information" shown on the lower right-hand corner. This copy of the form shall be made available for public inspection.

b. All items on the form not marked "Public Information" shall be completed in full, and such forms and all attachments thereto shall not be available for public inspection.

c. The copy marked "Public Information" shall be completed in full except that the items described in subparagraphs 2.1 through 2.4 below and the attachments relating to such items may be excluded.

2. Availability of Records. It has been determined that certain records pertaining to leases and wells in the OCS and submitted under 30 CFR 250 shall be made available for public inspection, as specified below, in the Area office.

2.1 Form 9-152 - Monthly Report of Operations. All information contained on this form shall be available except the information required in the "Remarks" column.

2.2 Form 9-330 - Well-Completion or Recompletion Report and Log.

2.2.1 Prior to Commencement. Prior to commencement of production, all information contained on this form shall be available except:

- a. Item 1a, Type of Well.
- b. Item 4, Location of Well, at top production interval and at total depth.
- c. Item 22, If Multiple Completion, how many.

d. Item 24, Producing Interval.

e. Item 26, Type Electric and Other Logs Run.

f. Item 28, Casing Record.

g. Item 29, Liner Record.

h. Item 30, Tubing Record.

i. Item 31, Perforation Record.

j. Item 32, Acid, Shot, Fracture, Cement Squeezes Etc.

k. Item 33, Production.

l. Item 37, Summary of Porous Zones.

m. Item 38, Geologic Markers.

2.2.2 After Commencement of Production. After commencement of production, all information shall be available except Item 37, Summary of Porous Zones, and Item 38, Geologic Markers.

2.2.3 5 Years' Elapsed Time. If production has not commenced after an elapsed time of 5 years from the date of filing Form 9-330 as required in 30 CFR 250.38(b), excluding the total time that operations and production are suspended by direction of the Secretary of the Interior or his duly authorized representative, and further excluding the total

time that operations and production are stopped or prohibited by Court order, all information contained on this form shall be available except Item 37, Summary of Porous Zones, and Item 38, Geologic Markers. Within 90 days prior to the end of the 5-year period, exclusive of exceptions noted above, the lessee shall file a Form 9-330 containing all information requested on the form except Item 37, Summary of Porous Zones, and Item 38, Geologic Markers, to be made available for public inspection. Objections to the release of such information may be submitted with the completed Form 9-330.

2.3 Form 9-331 - Sundry Notices and Reports on Wells.

2.3.1 "Request for Approval to." When used as a "Request for Approval to:" conduct operations, all information contained on this form shall be available except Item 4, Location of Well, at top production interval and at total depth, and Item 17, Describe Proposed or Completed Operations.

2.3.2 "Subsequent Report of." When used as a "Subsequent Report of:" operations, and after commencement of production, all information contained in this form shall be available, except information contained in Item 17 pertaining to subsurface locations and measured and true vertical depths for all markers and zones not placed on production.

2.4 Form 9-331 C - Application for Permit to Drill, Deepen, or Plug Back. All information contained on this form and the location plat attached thereto shall be available except Item 4,

Location of Well at Proposed Production Zone, and Item 23, Proposed Casing and Cementing Program.

2.5 Form 9-1869 - Quarterly Oil-Well-Test Report. All information contained on this form shall be available.

2.6 Form 9-1870 - Semi-Annual Gas-Well-Test Report. All information contained on this form shall be available.

2.7 Multi-point Back-Pressure-Test Report. All information contained in this report shall be available.

2.8 Sales of Lease Production. Information contained on the monthly U.S. Geological Survey computer printout showing sales volumes, value, and royalty on production of oil, condensate, gas, and liquid products by lease shall be made available.

2.9 Availability of Inspection Records. All accident-investigation reports, pollution-incident reports, facilities-inspection data, and records of enforcement actions are also available for public inspection.

2.10 Availability of Data and Information Submitted by Lessees. It has been determined that much information submitted by lessees, as a result of OCS Orders and OCS Notices to Lessees and Operators, is nonproprietary in nature or that release of such information is necessary for the proper development of the lease. This information will be made available for public inspection, except for those portions which the lessee shall designate, with the Supervisor's approval, as trade secrets

and commercial or financial information which is privileged or confidential. The available information will include:

- a. Notices of support activity.
- b. Oceanographic and meteorological data collected from drilling units and production facilities during the period of operations.
- c. Results of site surveys required prior to drilling or placement of platforms or structures, such as shallow geologic hazards surveys, archeological/cultural resource surveys, or other surveys related to the placement of platforms or structures.
- d. Drawings, maximum environmental design criteria, and rated capability data of mobile drilling units and structures.
- e. Oil Spill Contingency Plans.
- f. Critical Operations and Curtailment Plans.
- g. Other data required under 30 CFR 150.34.

2.11 Expired Leases. All information is available upon the expiration of a lease.

3. Information Exempt from Public Inspection. The information in subparagraphs 2.1 through 2.4 which has been restricted from public inspection is classified as geological and geophysical data. The release of this data is subject to the following restrictions.

3.1 Leases Issued Prior to June 11, 1976. For leases issued prior to June 11, 1976, the classified data is exempt from disclosure under exemption No. (9) of the Freedom of Information Act [5 U.S.C. 552(b)(9) and 43 CFR 2.13 subsection (c), "Statutory Exemptions," (9)].

3.2 Leases Issued After June 11, 1976. For leases issued after June 11, 1976, the classified data is available in accordance with 30 CFR 250.97, Public Inspection of Records, as follows:

a. Geophysical Data. Geophysical data shall not be available for public inspection, except as provided in 2.10c, without consent of the lessee as long as the lease remains in effect or for a period of 10 years after the date of submission, whichever is less, unless the Supervisor, with the approval of the Director, determines that earlier release of this information is necessary for proper development of the field or area.

b. Geological Data. Geological data shall not be made available for public inspection without the consent of the lessee as long as the lease remains in effect or for a period of 2 years after the date of submission, whichever is less, unless the Supervisor, with the approval of the Director, determines that earlier release of such information is necessary for the proper development of the field or area. In accordance with 30 CFR 250.38, Well Records, data and well records shall be transmitted to the Supervisor upon request or, if not requested, within 30 days following completion of suspension of any well.

For the purpose of orderly release of data, in all cases the date of submission will be considered to be 30 days following such completion or suspension.

4. Departures. All departures from the requirements specified in this Order shall be subject to approval, pursuant to 30 CFR 250.12(b).

Rodney A. Smith
Oil and Gas Supervisor
Arctic Area

Approved:

Don E. Kash
Chief, Conservation Division

APPENDIX B:

Det Norske Veritas'
Rules for the Design, Construction, and
Inspection of Offshore Structures, 1977

APPROVED BY THE PERMANENT COMMITTEE AS OF:

MAY 1st, 1977

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FOREWORD

The intention of these Rules is to lay down minimum requirements regarding structural strength, serviceability, and inspection of offshore structures.

The Rules are intended to be used where Det norske Veritas is requested to carry out surveillance of the design and the construction of an offshore structure.

Where Det norske Veritas is recognized as an inspection body by National Authorities, the Rules will serve as a supplement to any National Regulations that may exist.

Where discrepancy may exist between National Regulations and these Rules, the former will apply.

Design guidance supplementing these Rules is given in a set of Appendices which are issued separately.

CONTENTS

PART I: RULES

Section 1 Definitions and Notation

1.1	Definitions	1
1.2	Notation	1
1.3	System of Dimensions	2

Section 2 General Regulations

2.1	General	3
2.1.1	Application	3
2.1.2	Amendments	3
2.1.3	Alternative design methods	3
2.1.4	Assumptions	3
2.2	Certificate of Approval	3
2.2.1	Issuance of Certificate	3
2.2.2	Withdrawal of Certificate	3
2.3	Documentation	3
2.3.1	Submission of plans, information and calculations	3
2.3.2	Operations manuals	4
2.3.3	Filing of documentation	4
2.4	Surveillance	4
2.4.1	General	4
2.4.2	Surveillance during construction	4
2.4.3	Surveillance during transportation and installation	4
2.4.4	Surveillance during operation	4

Section 3 Environmental Conditions

3.1	General	5
3.1.1	Definitions	5
3.1.2	Notation	5
3.2	Environmental phenomena	5
3.3	Acceptable data	5
3.4	Statistical methods	5
3.5	Description of environmental conditions	5
3.5.1	Wind	5
3.5.2	Waves	6
3.5.3	Current	6
3.5.4	Ice	6
3.5.5	Temperature	6
3.5.6	Tide	6
3.5.7	Marine fouling	7
3.5.8	Earthquake	7

Section 4 General Design Requirements

4.1	General	8
4.1.1	Safety requirements	8
4.1.2	Functional requirements	8
4.1.3	Supplementary standards	8
4.2	Probabilistic design	8
4.2.1	General	8
4.2.2	Probability levels	8
4.3	Working stress design	8
4.3.1	General	8
4.3.2	Permissible stresses	8
4.4	Semiprobabilistic limit state design	8
4.4.1	General	8
4.4.2	Limit states	8
4.4.3	Characteristic values	8
4.4.4	Load and material coefficients	9
4.5	Loading effects	9
4.5.1	Determination of loading effects	9
4.6	Design by testing	10
4.7	General design considerations	10
4.7.1	General	10
4.7.2	Protection against accidental damage	10
4.7.3	Air gap	10
4.7.4	Access for inspection	11

Section 5 Loads

5.1	General	12
5.2	Load categories	12
5.2.1	Permanent loads	12
5.2.2	Live loads	12
5.2.3	Deformation loads	12
5.2.4	Environmental loads	12
5.2.5	Accidental loads	12
5.3	Determination of environmental loads	13
5.3.1	General	13
5.3.2	Wind loads	13
5.3.3	Wave loads	13
5.3.4	Current loads	14
5.3.5	Ice loads	14
5.3.6	Earthquake loads	14

Section 6 Steel Structures

6.1	Materials	16
6.1.1	General	16
6.1.2	Documentation and identification	16

77

7.13	Testing of materials and inspection	50
7.13.1	General	50
7.13.2	Testing of concrete constituents	50
7.13.3	Testing of concrete	50
7.13.4	Testing of concrete in the structure	50
7.13.5	Testing of grout for prestressing tendons	51
7.13.6	Testing of reinforcing steel	51
7.13.7	Testing of repair materials	51

Section 8

Hydrostatic Stability, Watertight Integrity and Anchoring

8.1	General	52
8.2	Hydrostatic stability	52
8.2.1	General	52
8.2.2	Inclining tests and weight determination	52
8.2.3	Intact stability requirements	52
8.2.4	Subdivision and damage stability requirements	53
8.3	Watertight integrity	53
8.3.1	General	53
8.3.2	Watertight doors and hatches	54
8.4	Anchoring	54
8.4.1	Anchors	54
8.4.2	Anchor lines	54
8.4.3	Mechanical joints	54

Section 9

Foundations

9.1	General	55
9.1.1	Application	55
9.1.2	Notation	55
9.2	Site investigations	55
9.2.1	General	55
9.2.2	Bottom topography	55
9.2.3	Site geology	55
9.2.4	Soil exploration	55
9.2.5	Geotechnical properties	56
9.3	General design requirements	56
9.3.1	General	56
9.3.2	Characteristic properties of soil	56
9.3.3	Effects of repeated loadings	56
9.3.4	Stability	56
9.3.5	Settlements and displacements	56
9.3.6	Soil-structure interaction	57
9.4	Stability of sea bottom	57
9.4.1	Slope stability	57
9.4.2	Safety against slope failure	57
9.4.3	Hydraulic stability	57
9.4.4	Scour and scour protection	57
9.5	Design of pile foundations	58
9.5.1	General	58
9.5.2	Resistance of piles in compression	58
9.5.3	Resistance of piles in tension	58
9.5.4	Resistance of laterally loaded piles	59

9.5.5	Safety requirements for pile foundations	59
9.5.6	Group effects	59
9.6	Design of gravity type foundations	59
9.6.1	General	59
9.6.2	Stability of foundations	59
9.6.3	Soil reaction on foundation structure	60
9.6.4	Safety requirements for gravity type foundations	60
9.6.5	Dynamic soil properties	60
9.6.6	Filling of voids	60
9.6.7	Jack-up platform foundations	61
9.7	Supervision during installation	61
9.7.1	General	61
9.7.2	Conductor installation	61

Section 10

Marine Operations

10.1	General	62
10.1.1	Application	62
10.1.2	Assumptions	62
10.1.3	Surveillance	62
10.1.4	Permissible loadings	62
10.1.5	Hydrostatic stability	62
10.1.6	Electrical and mechanical systems	62
10.1.7	Documentation	63
10.2	Construction afloat	63
10.2.1	General	63
10.2.2	Mooring systems	63
10.2.3	Instrumentation systems	63
10.2.4	Special installation equipment	63
10.3	Transportation	63
10.3.1	General	63
10.3.2	Transfer operations	63
10.3.3	Towing operations	64
10.4	Installation	64
10.4.1	General	64
10.4.2	Launching and upending	64
10.4.3	Positioning and submergence	64
10.4.4	Penetration and levelling	64
10.4.5	Pile installation	64
10.4.6	Filling of voids	65
10.5	Construction offshore	65
10.5.1	General	65
10.5.2	Installation of structural parts	65
10.5.3	Lifting	65
10.5.4	Special operations	65

Section 11

Maintenance of Certificate of Approval

11.1	General	66
11.2	Periodical surveys	66
11.2.1	General requirements	66
11.2.2	Extent of periodical surveys	66
11.2.3	Frequency of periodical surveys	66

11.3	Special surveys	67
11.3.1	General	67
11.3.2	Owner's obligation	67
11.3.3	Execution	67
11.3.4	Extent and methods	67
11.4	Repairs	67
11.5	Conversion	67

PART II: APPENDICES
(issued separately)

Appendix A
Environmental Conditions

Appendix B
Loads

Appendix C
Steel Structures

C1	Buckling of Bars and Frames
C2	Buckling of Plates
C3	Buckling of Circular Cylindrical Shells
C4	Stresses in Closed Cylinders
C5	Effective Flange
C6	Tubular Joints
C7	Fatigue Analysis
C8	Testing of Steel Materials
C9	Tolerances

Appendix D
Concrete Structures

D1	Cement
D2	Admixtures
D3	Permeability
D4	Tensile Strength of Concrete
D5	Temperature Effects
D6	Structural Instability
D7	Shear Design
D8	Fatigue Analysis
D9	Testing of Concrete in Structure

Appendix E
Hydrostatic Stability and Anchoring

E1	Hydrostatic Stability
E2	Anchoring

Appendix F
Foundations

F1	Bearing Capacity of Foundations
F2	Analysis of Axial Pile Resistance
F3	Analysis of Laterally Loaded Piles
F4	Analysis of Penetration Resistance
F5	Local Soil Reaction Stresses

Appendix G
Dynamic Analysis

Appendix H
Marine Operations

Appendix I
In Service Inspection

I1	Inspection of Steel Structures
I2	Inspection of Concrete Structures

Appendix J
Documentation

SECTION 1 DEFINITIONS AND NOTATION

1.1 Definitions

Approval – DnV's approval in writing of criteria, plans, drawings and specifications, etc.

Acceptance – DnV's acceptance in writing that information submitted in connection with approval, e.g. methods, calculations or special investigations, has been found acceptable.

Design life – the period of time from commencement of construction till condemnation of structure.

Design phases – the design life of an offshore structure is normally divided into five design phases as defined in the following:

- Phase C – Construction:
This phase includes construction ashore and construction afloat.
- Phase T – Transportation:
This phase includes transportation of the structure or a part of the structure, including transportation from shore to sea, or from shore to barge, and mooring operations in protected waters.
- Phase I – Installation:
This phase includes installation of the structure at its final location, i.e., the period from start of submerging from transport position or launching from barge, including piling, grouting or anchoring, until the platform is ready for normal operation. See 10.4 and 10.5.
- Phase O – Operation:
This phase is the period from completed installation till condemnation or removal from location.
- Phase R – Retrieval:
This phase includes retrieval or removal of the structure. See 2.1.4.3.

Offshore structure – a structure designed to remain permanently fixed to the sea bed by gravity, piles or anchors.

Recognized standard – a design code that is approved by Det norske Veritas to be used together with these Rules. See 4.1.3.1.

Limit States – see 4.4.2.

Design period – the time period to be used in establishing the characteristic value of a random parameter used as the basis for design.

Load – any action causing stress or strain in the structure.

Loading effect – effect of load on the structure, such as stress, stress resultants (internal forces and moments), deformation, displacement, motion, etc.

Characteristic load – the value of a randomly variable load that has a given probability of not being passed in the

unfavourable direction by the randomly variable load during the specified design period.

Load coefficient – coefficient by which the characteristic load is multiplied to obtain the design load. See 4.4.4.

Design load – load used in the design of a structure, i.e. characteristic load multiplied by the load coefficient.

Design loading – combination of design loads.

Design loading effect – the loading effect calculated on the basis of the design loading.

Characteristic strength – the material strength, determined by tests, which has a given probability of being attained.

Material coefficient – coefficient by which the characteristic strength is divided to obtain the design strength. See 4.4.4.

Design strength – the material strength to be used in the determination of the design resistance of a structure or part of a structure, i.e., characteristic strength divided by the material coefficient.

Resistance – capability of a structure or part of a structure to resist a loading effect.

Characteristic resistance – the value of resistance, determined on the basis of characteristic strength, which have an agreed probability of being attained by the actual structure.

Design resistance – the maximum resistance to be used in the verification of safety of a structure or part of a structure.

Relaxation – time dependent reduction of stress during state of constant strain.

Creep – time dependent increase of strain during state of constant stress.

1.2 Notation

The following general symbols are used. Other symbols are defined in the Section where they are used.

A	Ampère
A	Area
A	Accidental load (see 5.1.3)
C	Hydrodynamic coefficient
D	Deformation load (see 5.1.3)
E	Young's modulus
E	Environmental load (see 5.1.3)
F	Load in general
G	Shear modulus
H	Wave height (crest to trough)
I	Moment of inertia
L	Live load (see 5.1.3)
M	Moment in general
M	Constrained modulus of soil
N	Normal force in general

901

P	Permanent load (see 5.1.3)
P	Prestressing force
R	Resistance in general
S	Loading effect in general
T	Torsional moment
T	Temperature
T	Period
V	Shear force in general
V	Volume
V	Volt
W	Section modulus
Z	Plastic section modulus
a	Acceleration
a	Distance
b	Width
c	Cohesion
c	Cover to reinforcement
d	Diameter
d	Depth of member
e	Excentricity
f	Frequency (Hz)
f	Strength in general
f _y	Guaranteed minimum yield strength
f _{0,2}	0.2% proof stress
g	Acceleration due to gravity
h	Height
h	Water depth
h	Thickness of plates
i	Radius of gyration
k	Coefficient
l	Span; length of member
m	Moment per unit length
m	Mass
m	Average value
n	Normal force per unit length
q	Bearing capacity of soil per unit area
r	Radius
s	Standard deviation
s	Spacing
t	Time in general
v	Velocity
x	Coordinates
y	
y	
z	
z	Lever arm
α	Angle, ratio
β	Angle, ratio
γ	Weight density
γ	Partial safety coefficient
γ	Shear strain
δ	Coefficient of variation
ε	Strain
θ	Rotation
λ	Slenderness ratio
μ	Coefficient of friction
ν	Poisson's ratio
σ	Normal stress
τ	Shear stress
φ	Limiting value of angle of friction
φ	Diameter of reinforcing bar
ω	Frequency (rad/s)

The following subscripts are used:

a	Allowable
c	Concrete
c	Compression in general

d	Design value
f	Load
k	Characteristic
m	Material
r	Resistance
s	Steel, reinforcement
v	Shear
x	Coordinates
y	
y	
z	
y	yield

Example:

γ _f	load coefficient
γ _m	material coefficient
F _k	characteristic load
V _{fd}	design shear force
V _{rd}	design shear resistance

1.3 System of Dimensions

1.3.1 All plans, calculations and drawings should have one system of dimensions.

1.3.2 The SI units are used in these Rules. (Ref. International standard: ISO 1000.)

Table 1.1 Basic SI-units

Symbol	Name
m	meter
kg	kilogram
s	second
A	ampère
K	kelvin
mol	mol
Cd	candela

Table 1.2 Derived units normally used

Symbol	Name	Definition	Unit for:
A	ampère	basic unit	electric current
Hz	Hertz	cycles/s	frequency
J	joule	J = N · m	energy
K, °C	centigrade	°C = K	temperature
kg	kilogram	basic unit	mass
m	meter	basic unit	length
N	newton	N = kg m/s ²	force
kN	kilo newton	N · 10 ³	force
MN	mega newton	N · 10 ⁶	force
Pa	pascal	N/m ²	stress, pressure
kPa	kilopascal	kN/m ²	stress, pressure
MPa*	megapascal	MN/m ² = N/mm ²	stress, pressure
V	volt	V = W/A = kg m ² /(s ³ A)	electric potential
W	watt	W = J/s = kg m ² /s ³	power

* [MPa ≈ 10,2 kgf/cm² ≈ 145 psi]

SECTION 2 GENERAL REGULATIONS

2.1 General

2.1.1 Application

2.1.1.1 These Rules apply to the design, construction and installation of offshore structures (see 1.1) for which a DnV Certificate of Approval is requested. The Rules apply to structures built in steel or reinforced concrete. Other materials will be considered in each case.

2.1.1.2 The Rules do not apply to special components such as manrated underwater chambers, and need not be applied to structures or structural components which are not essential for structural integrity.

2.1.2 Amendments

2.1.2.1 Amendments to the Rules may be made at any time and may also be applicable to structures which have already been approved by DnV, see 2.1.2.3.

2.1.2.2 Unless otherwise decided, the amendments are to come into force six months after they are adopted. In special cases, DnV will consider an increase of the above mentioned time period.

2.1.2.3 Application of amendments to structures already approved, or to structures in the process of approval, will be limited to cases where it is judged essential to the structural integrity. If amended requirements concerning construction, materials, dimensions, etc. are to be made applicable to structures already approved, necessitating reanalysis of the structure and evaluation of reinforcement requirements, this will be clearly stated in the amendments.

2.1.3 Alternative Design Methods

2.1.3.1 DnV will consider alternative methods of design to those given in these Rules as acceptable, provided a standard of safety and serviceability equivalent to that of these Rules is documented.

2.1.4 Assumptions

2.1.4.1 The Rules assume that the design of a structure is carried out by qualified engineers, that the construction, transportation, and installation are carried out by contractors having the required skill and experience and that adequate quality control is carried out.

2.1.4.2 The Rules assume that the actual conditions of use of the structure during its design life do not depart significantly from the conditions for which the structure is designed. See also Section 11.

2.1.4.3 The Rules assume that the structure may be retrieved or may be required removed at end of service. For waters where removal of the structure is required at end of service, this shall be accounted for in design. (See 1.1).

2.2 Certificate of Approval

2.2.1 Issuance of Certificate

2.2.1.1 Upon request DnV is prepared to issue a Certificate of Approval for an offshore structure found to be constructed, transported and installed in accordance with these Rules.

2.2.1.2 The Certificate of Approval will be issued upon satisfactory completion of the installation of the structure and it will contain,

- a description of the structure as installed and its functions
- the geographical location and orientation of the structure
- a statement that the structure has been designed and constructed in accordance with these Rules under the surveillance of DnV.

2.2.1.3 The Certificate of Approval will normally be issued for a period of maximum 5 years, and will be renewed provided the requirements for maintenance of the Certificate of Approval are fulfilled. See Section 11.

2.2.1.4 The Certificate of Approval will cover the conditions of use of the structure.

2.2.2 Withdrawal of Certificate

2.2.2.1 DnV can withdraw the Certificate of Approval if the Owner does not comply with his duty to request surveys and to give information, his obligations in connection with the survey, or if he does not rectify defects in accordance with the requirements of DnV. See Section 11.

2.2.2.2 The withdrawal may be made conditional in that it will come into effect only if the Owner, within a stipulated time, has not rectified the conditions leading to the withdrawal.

2.2.2.3 If the conditions leading to withdrawal of the Certificate of Approval no longer exist, DnV may upon request reinstate the Certificate. As a condition hereto, DnV can demand that the structure be subjected to a survey or certain specified improvements.

2.3 Documentation

2.3.1 Submission of plans, information and calculations

2.3.1.1 The Owner is to submit to DnV, before commencement of construction or installation, whichever is relevant, documentation covering the following three types of information;

- description (drawings and specifications) of the structure, including all protective systems, so that its strength, durability and performance may be evaluated,

- description of the environment and loadings, to the extent deemed necessary for determination of required strength and serviceability,
- calculations and evaluations made in order to prove that the proposed structure satisfies the requirements to strength, durability and performance.

For more detailed listings, see Appendix J.

2.3.1.2 All written evidence is to be selfcontained or fully referenced. The documentation is to demonstrate that the different aspects as outlined in these Rules have been adequately considered.

2.3.2 Operations manuals

2.3.2.1 Operations manuals for special constructional operations, transportation, installation and the operation of the structure shall be submitted for approval in due time before commencement of the operation to be considered. See 5.2.2.3 and Section 10.

2.3.3 Filing of documentation

2.3.3.1 It is the Owner's responsibility to keep complete files of all documentation relevant to structural safety and durability.

2.3.3.2 The documentation covered by 2.3.1 is to be included in the file. In addition, inspection reports from construction, installation, testing and surveys are to be included. See Section 11. Such documentation is to be made available to DnV upon request.

2.4 Surveillance

2.4.1 General

2.4.1.1 By surveillance is meant the work carried out by DnV in order to ensure that the structure is constructed and installed in accordance with these Rules. This work comprises approval of drawings, procedures and specifications, and inspection during construction, transportation and installation. The surveillance of DnV is additional to,

and not a replacement of the quality control carried out by the contractor or manufacturer.

2.4.1.2 If found necessary instrumentation of the structure may be required for monitoring of special conditions related to loads or response during construction, transportation, installation and operation.

2.4.2 Surveillance during construction

2.4.2.1 The contractor is to provide access to the structure and the necessary assistance required for carrying out the inspection work.

2.4.2.2 When a structure is constructed under the surveillance of DnV, DnV will examine;

- that the dimensions of the structure comply with the Rule requirements and the approved plans, and that the prescribed materials are used,
- that the materials and the protection systems which are used have been tested in accordance with the Rule requirements,
- that the work is carried out in compliance with the Rule requirements and to the satisfaction of DnV, and in accordance with normal good practice,
- that satisfactory tests are carried out to the extent and in the manner prescribed in the Rules.

2.4.3 Surveillance during transportation and installation

2.4.3.1 Surveillance during transportation will normally be required. See 10.3.

2.4.3.2 The installation is to take place under the surveillance of DnV, in accordance with approved plans and specifications. See 10.4.

2.4.4 Surveillance during operation

2.4.4.1 The structure is subject to inspection and surveys in accordance with these Rules.

2.4.4.2 Surveys for maintenance of Certificate of Approval are defined in Section 11.

SECTION 3 ENVIRONMENTAL CONDITIONS

3.1 General

3.1.1 Definitions

Hindcasting: Re-construction of environmental conditions based on barometric pressure measurements and/or wind field charts.

Short-term: A period of time sufficiently short to ensure that environmental conditions are stationary in a statistical sense.

Long-term: A period of time during which the environmental conditions are non-stationary.

Sustained wind speed: The average wind speed during a specified time interval equal to or greater than one minute.

Gust wind speed: The average wind speed during a specified time interval of less than one minute.

Most probable largest: The value of an environmental parameter with peak probability density in the extreme value distribution for a given probability level in the initial distribution.

Recurrence period: The average time period between two consecutive exceedances of the most probable largest value of an environmental parameter.

Significant wave height: The average of the one third highest waves in a short-term stationary wave record.

3.1.2 Notation

The following notation is used throughout this section:

H = crest-to-trough wave height (m)
 H_s = significant wave height (m)
 T = period of a regular wave (s)
 T_p = period of peak spectral density (s)

3.2 Environmental phenomena

3.2.1 All environmental phenomena which may influence the design are to be considered. Such phenomena are wind, waves, current, ice, temperature, tide, marine fouling, and earthquake.

3.2.2 For seabed and soil conditions to be considered, see 9.2.

3.2.3 Salinity and biological activity are to be considered in the evaluation of marine fouling and in the choice of corrosion protection systems, see 3.5.7 and 6.3 respectively.

3.3 Acceptable data

3.3.1 The environmental conditions are to be described using adequate data for the areas in which the structure is to be constructed, transported and installed.

3.3.2 Data supplied by generally recognized meteorologists and oceanographers will normally be accepted as the basis for design. Background information on data procurement and derivation is to be submitted on DnV's request.

3.3.3 The various environmental factors are to be described by characteristic parameters which are relevant in evaluation of the effects on the structure.

3.4 Statistical methods

3.4.1 Statistical methods are to be used in describing environmental parameters which are of a random nature. Proper care is to be exercised in deriving such parameters in a statistically valid manner, and generally accepted methods are to be used.

3.4.2 The long-term variation of environmental phenomena such as wind, waves and current is to be described by recognized statistical distributions relevant to the environmental parameter considered. In the assessment of extreme values recognized extrapolation techniques are to be used.

3.4.3 Hindcasting techniques may be used to describe the environment provided the validity of the model is fully documented.

3.4.4 Directional distributions of wind, waves and current relative to the structure, assumed for the design, are subject to approval.

3.5 Description of environmental conditions

3.5.1 Wind

3.5.1.1 Wind conditions to be considered for design may be described either by statistical or deterministic methods. The validity of the procedures used is to be documented.

3.5.1.2 Wind speed statistics are to be used as the basis for a description of the long-term wind conditions. The long-term distributions should preferably be based on statistical data for the same averaging periods of wind speed which are used for the determination of loads. If data is available for other averaging periods only, such data may be converted by applying appropriate gust factors.

3.5.1.3 Extreme values of gust and sustained wind speeds are to be expressed in terms of most probable largest values with their corresponding recurrence periods.

3.5.1.4 The wind speed at a height 10 meters above the still water level is to be used as a reference for both sustained and gust wind speeds.

3.5.1.5 In the absence of more accurate data, the sustained and gust wind speeds at a height z meters above the still water level may be estimated in accordance with Appendix A.

3.5.2 Waves

3.5.2.1 Wave conditions may be described either by statistical or deterministic methods. The validity of the procedures used is to be documented.

3.5.2.2 The selection of suitable parameters for design purposes is in both cases to be based on the use of wave statistics or accepted hindcasting techniques.

3.5.2.3 Analytical wave power density spectra are to reflect the width and shape of typical spectra for the site considered. For open sea areas, the Pierson-Moskowitz type of spectrum will normally apply. Other spectrum formulations will be considered under special circumstances. See Appendix A.

3.5.2.4 The short-crestedness of waves in a seaway, i.e., the angular distribution of wave energy, may be taken into account. If detailed field measurements are not available a cosine squared distribution will normally be accepted. See Appendix A.

3.5.2.5 Extreme values of wave heights are to be expressed in terms of most probable largest values with their corresponding recurrence periods.

3.5.2.6 Long-term predictions are to be based on recognized techniques. A generally recognized method is given in Appendix A.

3.5.2.7 In design using deterministic procedures based on regular wave considerations, the wave is to be described by the parameters H and T. The design wave formulation used is to be valid for the problem considered.

3.5.2.8 The design waves or sea states are to be those resulting in the most unfavourable effects on the structure or structural part considered, taking into account the shape and size of the structure, water depth, etc. Consideration is to be given to the probability of occurrence of these design waves or sea states.

3.5.2.9 The wave period is to be specified in each case of application. It may be necessary to investigate the wave loads for a range of wave periods in order to ensure a sufficiently accurate determination of the maximum response. Normally, it will suffice to consider the following range of wave periods.

Deterministic approach:

$$\sqrt{6.5H} < T < \sqrt{15H}$$

Stochastic approach:

$$\sqrt{13 H_s} < T_p < \sqrt{30 H_s}$$

3.5.2.10 The wave field should be described by wave theories relevant to the conditions at the site considered.

3.5.2.11 The still water level to be used in wave load calculations for storm conditions is defined as the more unfavourable of either the highest astronomical tide level plus increase in water depth due to wind and pressure induced storm surge, or the lowest astronomical tide level. See Appendix A.

3.5.3 Current

3.5.3.1 The design current velocity is to be selected using the best statistics available.

3.5.3.2 Different components of the current are to be considered, such as tidal current, wind generated current and density current if relevant.

3.5.3.3 The variation of current over the water depth is to be considered when this is relevant. When detailed field measurements are not available, the current profile given in Appendix A may be used.

3.5.3.4 In regions where the bottom material is likely to erode, special studies of current conditions near the bottom may be required.

3.5.4 Ice

3.5.4.1 If the structure is to be located in an area where ice may develop or drift, ice conditions are to be properly considered.

3.5.4.2 Relevant statistical data on the ice conditions are to be submitted if ice hazard may exist. Sea ice conditions are to be described with particular attention to;

- concentration and distribution of ice,
- type of ice (ice floes, ice ridges, rafted ice, etc.),
- mechanical properties of ice,
- drifting speed and direction,
- thickness of ice,
- probability of encountering ice bergs.

3.5.4.3 The assumed conditions as regards icing on the structure are to be described with particular attention to concentration, distribution and thickness of ice.

3.5.4.4 The description of ice conditions should preferably be in accordance with the "World Meteorological Organization Sea Ice Nomenclature".

3.5.5 Temperature

3.5.5.1 Extreme values of high or low temperatures are to be expressed in terms of the most probable highest or lowest values with their corresponding recurrence periods.

3.5.5.2 Both air and sea temperatures are to be considered in describing the environment.

3.5.6 Tide

3.5.6.1 The assumed maximum tide is to include astronomical tide as well as wind and pressure induced storm surge. Minimum tide estimates should be based on the astronomical part only. See Appendix A.

3.5.6.2 If data directly applicable to the location in question are not available, the best estimate based on data for nearby locations may be accepted.

3.5.7 Marine fouling

3.5.7.1 The effect of marine fouling on the structure is to be considered, taking into account biological and environmental factors relevant to the site considered, such as salinity, oxygen content, pH value, current and temperature.

3.5.8 Earthquake

3.5.8.1 The effects of earthquakes are to be considered for structures to be located in areas that are determined to be seismically active.

An area is considered seismically active on the basis of previous record of earthquake activity, both in frequency of occurrence and in magnitude.

3.5.8.2 For areas where detailed information on seismic activity is generally available the seismicity of the area may be determined on the basis of such information.

3.5.8.3 For areas where detailed information on seismic activity is not generally available the seismicity is to be determined on the basis of detailed investigations, including a study of the geological history and the seismic events of the region.

5.5.8.4 If the area is determined to be seismically active and the structure will be affected by earthquake effects (see 5.3.6.2 and 5.3.6.3), an evaluation is to be made of the regional and local geology in order to determine the location and alignment of faults, epicentral and focal distances, the source mechanism for energy release and the source to site attenuation characteristics, taking into account the local soil conditions as far as these may affect the ground motion. The evaluation should consider both the design earthquake and the maximum credible earthquake. See 5.2.4.2, 5.3.6.1 and 5.3.6.2.

3.5.8.5 For structures to be located in shallow water considerations are to be made regarding the occurrence of tsunamis. See 5.3.6.3.

SECTION 4 GENERAL DESIGN REQUIREMENTS

4.1 General

4.1.1 Safety requirements

4.1.1.1 Offshore structures shall have an acceptable level of safety as regards loss of life and health, environmental pollution and major economic losses during all phases of the life of structure, i.e. construction, transportation, installation, operation and retrieval.

A structure designed, constructed and inspected in accordance with these Rules and the supplementary standards, see 4.1.3, is considered to have an adequate level of structural safety.

4.1.2 Functional requirements

4.1.2.1 Proper serviceability of a structure may require special criteria.

4.1.2.2 Functional requirements additional to those of these Rules may be specified by the Owner.

4.1.3 Supplementary standard

4.1.3.1 The Rules are to be used together with a set of recognized design standards. Standards for testing of materials, production of materials, etc., are to be those associated with the design standard used, if not otherwise agreed upon with DnV. For one installation one set of standards is to be used throughout.

4.1.3.2 At points where discrepancy may exist between the recognized standards and these Rules the latter will override. National Regulations override these Rules; see foreword.

4.1.3.3 All standards used in the design are to be presented to DnV for approval, preferably at an early stage in design. Standards that are developed for use in the country where the construction will take place are normally to be preferred, provided such standards are generally applicable. See also 4.1.3.2.

4.2 Probabilistic design

4.2.1 General

4.2.1.1 Ideally the verification of safety should be based on probabilistic methods. If a directly probabilistic method is used, the different factors governing the probability of failure is to be introduced on the basis of a thorough knowledge of their probabilistic nature. Special attention is to be paid to the statistical distribution of loads and material strengths, tolerances and uncertainties involved by the analysis.

4.2.2 Probability levels

4.2.2.1 The design method and the target probability levels are subject to approval in each case.

4.3 Working stress design

4.3.1 General

4.3.1.1 A safety verification based on working stress design using permissible stresses or usage factors, etc., may be accepted.

4.3.2 Permissible stresses

4.3.2.1 The design methods, standards, permissible stresses or usage factors to be used in design are subject to approval in each case.

4.4 Semiprobabilistic limit state design

4.4.1 General

4.4.1.1 The detailed safety requirements of these Rules are given with reference to the semi-probabilistic approach.

4.4.1.2 By this method acceptable safety is ascertained by verifying that the design loading effect will not exceed the design resistance. The design loading effect S_d is obtained on the basis of characteristic loads F_k multiplied by load coefficients γ_f . The design resistance R_d is obtained on the basis of characteristic strengths f_k divided by material coefficients γ_m .

4.4.2 Limit states

4.4.2.1 A structure or part of a structure is considered unfit for use when it reaches a particular state, called a limit state, in which it infringes one of the criteria governing its performance or use.

4.4.2.2 The limit states are categorized as follows:

- The ultimate limit states (ULS) corresponding to the maximum load carrying capacity.
- The fatigue limit states (FLS) related to the criteria associated with the effect of repeated loading.
- The limit state of progressive collapse (PLS) corresponding to a progressive collapse after damage to the structure caused by misuse or accident.
- The serviceability limit states (SLS) related to the criteria governing normal use or durability.

4.4.3 Characteristic values

4.4.3.1 For loads that may be considered as random, the characteristic value F_k is defined as the most probable largest value with a recurrence period equal to the design period. Where a reduction in load may result in a reduced safety of the structure, the characteristic value is to be taken as the most probable lowest value with a recurrence period equal to the design period. The basis for the choice

of characteristic values for different load categories is given in 5.2.

4.4.3.2 The characteristic value of strength of materials, f_k , is to be based on the 5th or the 95th percentile of the test results, whichever is the more unfavourable.

The characteristic strength of steel may be assumed to be the guaranteed minimum yield strength.

For characteristic strength of soil, see 9.3.2.

When statistical data are not available, the characteristic values may be taken from the recognized standard.

4.4.4 Load and material coefficients

4.4.4.1 The load coefficient γ_f is to take account of;

- possible unfavourable deviations of the loads from the characteristic loads, thus allowing for abnormal or unforeseen actions.
- the reduced probability that various loadings acting together will act simultaneously at their characteristic value.
- uncertainties in the assessment of loading effects as far as may be assumed independent of structural materials.

4.4.4.2 The material coefficient, γ_m , is to take account of;

- possible unfavourable deviations in strengths of materials from the characteristic values.
- possible reductions in the strength of the materials in the structure as a whole as compared with the characteristic value deduced from control test specimen.
- uncertainties inherent in the determination of the design resistance and in the determination of loading effects as far as may be assumed dependent on structural material.

Numerical values of γ_m are given in Section 6, 7 and 9 for steel structures, concrete structures, and foundations, respectively.

4.4.4.3 ULS- For checking of the ultimate limit states the following load coefficients are to be used.

Loading conditions	Load categories (see 5.1.3)				
	P	L	D	E	A
ordinary	1.3	1.3	1.0	0.7	–
extreme	1.0	1.0	1.0	1.3	–

For loading effects that are *well controlled* a reduced load coefficient $\gamma_f = 1.2$ may be used for the loads P and L instead of the value 1.3 in the construction, installation and retrieval phases.

For structures which are unmanned during storm conditions and which are not used for storage of oil or gas, a reduced load coefficient $\gamma_f = 1.15$ may be used for environmental loads instead of the value 1.3. This reduction does not apply for earthquake loads.

A load coefficient of $\gamma_f = 1.0$ is to be used for weight of soil, pore pressure, etc.

4.4.4.4 FLS- For the fatigue limit states all load coefficients may be taken equal to $\gamma_f = 1.0$. The design life is to be specified by the Owner.

4.4.4.5 PLS- The limit state of progressive collapse is to be checked for the most unfavourable combination of P, L, D, E and A. For accidental loads of impact type e.g. collision loads, dropped objects, etc., loads of type E may be ignored. For this check, which may be based on a simplified analysis, all load coefficients may be taken equal to $\gamma_f = 1.0$. Localized damage may be accepted, but is not to be disproportionate to the original cause.

4.4.4.6 SLS- For checking of the serviceability limit states, combinations of P, L, D and E are to be considered using a load coefficient $\gamma_f = 1.0$. For these limit states loads less than the characteristic values may be used as stated in the relevant parts of these Rules.

4.4.4.7 Prestress- The loading effects due to prestressing forces are in general composed of:

- a direct force acting on the prestressed section
- indirect loading effects occurring in hyperstatic structures

For direct forces, the load coefficient in the ULS is to be taken as 0.9 or 1.1, whichever is the more unfavourable. For all other limit states the load coefficient to be applied to prestressing forces is equal to 1.0.

The indirect loading effects may be considered as loading effects due to a deformation load. A load coefficient of $\gamma_f = 1.0$ may be used in all limit states. See also 4.5.1.1.

4.5 Loading effects

4.5.1 Determination of loading effects

4.5.1.1 Determination of forces, moments, stresses and displacements is to be based on accepted principles of statics, dynamics and strength of materials.

The determination of loading effects may be based on the theory of elasticity. Methods based on the theory of plasticity may be used for checking the ULS and PLS, provided their applicability is verified, and that sufficient ductility is documented.

For evaluation of ULS and PLS the effects of deformation loads may be ignored provided sufficient ductility is verified.

4.5.1.2 The analytical models used in the evaluation of loading effects and structural resistance must satisfactorily simulate the behaviour of the actual structure, including its foundations, and the relevant environments. In case of

particularly uncertain analytical models, reasonably conservative models are to be used.

4.5.1.3 In cases where non-linear effects, geometrical or material, may have significant influence on the safety of the structure these effects shall be considered.

Geometrical imperfections are to be taken into account by their most unfavourable tolerance limits.

4.5.1.4 Loading effects due to repetitive loads that may cause fatigue, are to be determined in terms of magnitude and number of cycles, i.e., stress history, by establishing a long term distribution of stress range taking into account all stress fluctuations anticipated during the design life. Dynamic effects are to be duly considered.

Local vibration due to cyclic loading, e.g., vortex shedding phenomena, are to be considered.

4.5.1.5 For loads which may be considered random the analysis may be based on deterministic methods or on statistical methods. A deterministic analysis is to be based on characteristic loads as defined in 4.4.3.1. A statistical analysis is to be based on accepted spectra, duration of extreme load periods etc. and on transfer functions for the individual load effects.

Dynamic loading effects shall be determined by use of recognized methods of analysis and realistic assumptions as regards loadings, material properties and analytical models. See Appendix G.

4.5.1.6 For anchored structures due account shall be given to the rigid body dynamic behaviour of the structure in the determination of loading effects in the structure and in its anchoring system. Non-linear effects that may be inherent in the anchoring system or may be developed as a result of large displacements of the structure are to be duly considered.

The effects of low frequency motions shall be thoroughly investigated as far as such phenomena may influence the loading effects.

4.6 Design by testing

4.6.1 Model tests may, when adequate, be used in combination with or instead of theoretical calculations. In cases of structures or details for which adequate analytical methods of analysis do not exist, tests may be required for verification of acceptable structural resistance. When it is obvious by judgement that acceptable resistance or performance exists, such model tests may be dispensed with.

4.7 General design considerations

4.7.1 General

4.7.1.1 The structure and all parts of the structure shall be designed so that displacements or vibrations will not impair proper operation of equipment or be considered disagreeable to personnel.

4.7.1.2 In the design of the structure due consideration is to be given to corrosion and corrosion protection. See 6.3.

4.7.1.3 Fixing plates, mooring rings, bollards, fenders etc. are to be designed so that a possible failure due to over-load will not result in damage of the main structure. Possible danger to personnel in case of failure of such elements is to be considered.

4.7.1.4 Stress concentrations are to be avoided as far as possible. Connections are to be designed with smooth transitions and proper alignment of elements.

4.7.1.5 Structures that may be subject to ice forces shall have a shape in the water line region that will minimize piling of drifting ice, and that will fracture the ice in a mode such that a reasonable estimate of forces is possible.

4.7.2 Protection against accidental damage

4.7.2.1 The structure is to be protected against accidental damage by the following two principles;

- reduction in damage probability
 - reduction in damage consequences.
- This applies to all phases.

4.7.2.2 The structural layout is to be planned with due consideration to the possibility for fire, explosion and other accidental damage.

4.7.2.2 Pipes and equipment, damage to which involves risk of explosions, fire or extensive pollution, are to be protected so as to minimize the risk of accidental damage. The protection may be established by providing a sheltered location, by local strengthening of the structure or by appropriate fender systems. Risers and similar equipment are to be positioned at a safe distance from boat landings, from cranes where objects may be dropped by accident, etc.

4.7.2.4 Where high pressure piping is guided through a closed compartment, the compartment shall be designed either to resist the over-pressure caused by a possible leakage or to permit release of the overpressure without damage to the structure.

4.7.2.5 If the operation of the platform requires personnel to be permanently or temporarily stationed in air-filled subsea compartments or if the safety of the platform depends on operations inside such rooms, e.g. air filled utility shaft, measures are to be taken to prevent a sudden water flooding resulting from a possible accidental damage at sea level. See also 8.2.4.

4.7.2.6 Concrete structures are to be provided with adequate lightening protection.

4.7.3 Air gap

4.7.3.1 The distance between the lowest part of the deck (structure or equipment) and the wave crest elevation should be at least 1.5 m.

In special cases a smaller distance will be considered, provided wave forces on elements within the distance 1.5 m are taken into account. Calculations of the wave pressure

are to be based on extrapolation of the design wave pressure profile.

4.7.3.2 For determination of the deck elevation the following are to be considered;

- water depths related to LAT
- tolerances in water depth measurement
- astronomical tide range
- storm surge
- crest elevation of the most probable highest wave of the design period.
- hydrodynamic interaction of structure and environment (caissons effect, suction etc.)
- initial penetration of structure into sea bed
- longterm and elastic settlement of structure
- inclination of structure
- lowering of sea floor due to pressure reduction of the oil reservoir (subsidence)

4.7.3.3 Anchored structures shall have load-line marks indicating maximum permissible draught. The load-line marks will be assigned on the basis of compliance with the requirements concerning strength and stability, and with other relevant requirements of these Rules. See Section 8.

4.7.4 Access for inspection

4.7.4.1 Where practical, access or means for inspection and repair of all structural elements should be provided. For elements impossible to inspect and repair special requirements concerning strength and durability may be introduced by DnV.

4.7.4.2 Means to simplify the maintenance of the structure and the identification of location during inspection of the installed structure are to be provided.
the installed structure are to be provided where appropriate.

SECTION 5 LOADS

5.1 General

5.1.2 All loads that may influence the dimensioning of the structure or parts of the structure are to be considered in the design. This applies for all phases of the life of the structure, (see 1.1.1).

5.1.2 The loads are to include the effects of increased dimensions and weight due to marine growth, ice accumulation etc.

5.1.3 The loads are in these Rules categorized as follows:

- P – permanent loads, see 5.2.1
- L – live loads, see 5.2.2
- D – deformation loads, see 5.2.3
- E – environmental loads, see 5.2.4
- A – accidental loads, see 5.2.5

5.2 Load Categories

5.2.1 Permanent loads

5.2.1.1 Permanent loads are gravity loads that will not be removed during the phase considered, such as:

- weight of structure in air
- weight of permanent ballast and equipment that cannot be removed
- external hydrostatic pressure of permanent nature during the phase considered

5.2.1.2 The characteristic value of a permanent load is defined as the expected average value based on accurate data of the unit weight of the material and the volume in question.

5.2.2 Live loads

5.2.2.1 Live loads are loads associated with the operation and normal use of the structure, and which may be removed during the phase considered, such as;

- stored materials, equipment and liquids, fluid pressure, etc.
- operation of cranes
- helicopters
- fendering and mooring of vessels

5.2.2.2 The characteristic values of live loads are to be determined on the basis of Owner's specifications.

5.2.2.3 The characteristic value (i.e., maximum permissible value) of live loads and the permissible combinations of such loads are to be stated in the Operations Manual. See 2.3.2.1 and 10.1.4.

5.2.2.4 Loads due to mooring of vessels shall be limited to the maximum value expected during the specified operating conditions, by use of a device (e.g. weak link) that will release the mooring forces in a controlled manner in case overloading should occur. See 4.7.1.3.

5.2.3 Deformation loads

5.2.3.1 The deformation loads are loads associated with imposed deformation, such as;

- prestressing
- temperature (including sea and air temperature)
- creep
- shrinkage
- absorption
- differential settlements

5.2.3.2 The characteristic value of a deformation load is normally evaluated on the basis of prescribed maximum and minimum values for the parameters governing its magnitude.

5.2.4 Environmental loads

5.2.4.1 Environmental loads are loads due to wind, waves, current, ice, snow, earthquake and similar environmental actions.

5.2.4.2 The characteristic value of an environmental load is normally to be established in accordance with 4.4.3.1. The design period is generally to be taken equal to 100 years for phase O.

5.2.4.3 For the phases C, T, I and R the design period is to be considered in each case taking into account location, season of the year and the consequences of the predicted values of the environmental loads being exceeded. Normally a design period equal three times the duration of the phase may be used.

5.2.4.4 Characteristic values of environmental loads to be considered for operations or phases of short duration may be based on reliable weather predictions. In such cases, the characteristic values of the environmental loads to be considered and the criteria for starting operation are subject to approval.

5.2.4.5 The combination and severity of the environmental loads used in design may be determined taking into account the probability of their simultaneous occurrence.

Loads due to earthquake normally need not be considered to act simultaneously with other environmental loads.

5.2.5 Accidental loads

5.2.5.1 Accidental loads are loads that are ill-defined with respect to intensity and frequency that may occur as a result of accident or exceptional conditions.

Examples of accidental loads are;

- collision loads
- explosion and fire
- dropped objects

- loss of internal pressure necessary for maintaining minimum required safety level
- maximum credible earthquake (see 5.3.6.1.b)

5.2.5.2 The characteristic value to be used for an accidental load is subject to approval.

5.3 Determination of environmental loads

5.3.1 General

5.3.1.1 Environmental loads are to be determined on the basis of the requirements given in Section 3 and in 5.3.

5.3.1.2 The methods used to determine the environmental loads are to be generally recognized as applicable for the type of structure considered.

5.3.1.3 The validity and correctness of the analytical procedures used for determination of environmental loads, e.g. computer programs, are to be verified to the satisfaction of DnV.

5.3.2 Wind loads

5.3.2.1 Wind loads and local pressures are to be calculated in accordance with a recognized standard. A method for calculation of wind loads and local pressures is given in Appendix B.

5.3.2.2 Data obtained from reliable and adequate model tests are recommended for determination of pressures and resulting loads on structures of complex shape.

5.3.2.3 Wind loads calculated on the basis of the 1 minute sustained wind speed is to be used in combination with maximum wave loads.

If the wind loads due to the 3 seconds gust wind acting alone are more unfavourable than the wind loads due to the 1 minute sustained wind combined with wave loads, the wind loads due to the 3 seconds gust wind are to be used.

5.3.2.4 An increase in the averaging period for the gust wind speed may be considered for large structures or structural parts for which the 3 second gust wind is not likely to act instantaneously over the complete structure or structural part considered.

5.3.2.5 Wind loads on cylinders may be divided into two types i.e.;

- static or quasistatic wind loads acting normal to the cylinder axis in the plane defined by the cylinder axis and the wind direction.
- cyclic wind loads, due to vortex shedding, acting normal to the cylinder axis in two planes; i.e. parallel and perpendicular to the wind direction. Guidance pertaining to flow induced cyclic loads is given in Appendix B.

5.3.2.6 The dynamic response from wind gustiness is to be taken into account for structures being sensitive to wind loads.

5.3.2.7 Possible increase in wind speed due to disturbances of the flow field in areas of closely spaced members is to be accounted for by use of appropriate coefficients.

5.3.3 Wave loads

5.3.3.1 Wave induced loads are to be determined by use of generally recognized methods taking proper account of water depth, size, shape and type of structure.

5.3.3.2 In the analytical determination of wave loads, the hydrodynamic coefficients used in the analysis may be determined on the basis of published data, model tests, or full scale measurements. The hydrodynamic coefficients are subject to approval.

5.3.3.3 For structures of complex shape for which analytical determination of wave loads may not yield sufficient accuracy, the wave loads are to be determined by use of reliable and adequate model tests.

5.3.3.4 The following contributions are to be considered in the determination of wave induced loads;

- potential pressure forces including the Froude-Krilov forces
- potential or viscous wave drift forces
- drag forces resulting from boundary layer effects
- impact loads.

Guidance: A special case of the potential pressure force is obtained when no diffraction effects are present, i.e. when Morison's equation is applicable. The potential pressure forces are then equal to the inertia forces which consist of the added mass forces and the Froude-Krilov forces. When diffraction effects are present, such as in the case of large volume bodies, these forces consist of the Froude-Krilov forces and the diffraction forces.

5.3.3.5 Wave induced loads on structures consisting of members with cross sectional dimensions less than approximately 1/5 of the wavelength may be calculated by use of Morison's equation, see Appendix B.

5.3.3.6 The combined effect of simultaneous drag and inertia forces is obtained by vectorial addition.

5.3.3.7 Where appropriate, account is to be taken of possible change in water particle velocity and acceleration caused by the structure interfering with the wave system.

5.3.3.8 In lieu of more exact data, the hydrodynamic coefficients used in Morison's equation may be taken in accordance with Appendix B.

5.3.3.9 Closely spaced members may cause solidification effects. In lieu of more exact data the formulae given in Appendix B may be used for selection of appropriate hydrodynamic coefficients for such cases.

5.3.3.10 For structures having characteristic dimensions which are not negligible compared to the wave length and which will influence the flow field, the determination of wave loads will normally require application of methods such as sink-source techniques or finite fluid element methods.

5.3.3.11 Hydrodynamic interaction between large immersed members of the structure are to be considered where such effects may be significant.

5.3.3.12 Impact loads from waves are to be determined according to recognized theoretical methods or according to relevant data from model tests or full scale measurements. Attention is to be paid to possible dynamic amplification of the response.

A method for calculation of impact loads is described in Appendix B.

5.3.3.13 The possibility of flow induced cyclic loads is to be considered.

5.3.4 Current loads

5.3.4.1 The current induced drag loads on immersed parts of a structure are to be taken into account.

5.3.4.2 Where Morison's equation is applicable, the effects of current may be accounted for by a vectorial addition of the orbital water particle velocity due to the waves and the steady current velocity.

5.3.4.3 The possibility of flow induced cyclic loads caused by the current is to be considered. Guidance pertaining to this phenomenon is given in Appendix B.

5.3.5 Ice loads

5.3.5.1 Determination of ice loads is to be based on statistics on the ice conditions in the area as described in 3.5.4.

5.3.5.2 Loads from laterally moving ice are to be based on relevant full scale measurements, model experiments which can be reliably scaled or on recognized theoretical methods. When determining the magnitude and direction of ice loads, considerations are to be given to the nature of ice, mechanical properties of the ice, ice structure contact area, shape of structure, direction of ice movements etc. The oscillating nature of the ice loads (build up and fracture of moving ice) is to be considered.

5.3.5.3 Where relevant, ice loads other than those caused by laterally moving ice, such as loads due to masses of ice frozen to the structure, possible impact loads during thaw of the ice, and loads due to icing are to be taken into account.

5.3.5.4 Possible increase in areas due to icing is to be considered when determining wind or wave loads acting on such areas. See 5.3.2 and 5.3.3.

5.3.6 Earthquake Loads

5.3.6.1 *General:* The effects of earthquakes are to be considered in phase O for structures to be located in seismically active areas, see 3.5.8. In special cases earthquake effects may need to be considered in phase C. Two levels of earthquake activity are normally to be considered in phase O, i.e. the design level and the exceptional level.

a) *the design level*, corresponding to the design earthquake which is defined as the most probable severest earthquake expected to occur at the site during the design period. The design earthquake is to be considered in the loading condition "extreme", see 4.4.4.

b) *the exceptional level*, corresponding to the maximum credible earthquake which could be expected to occur at the site. The maximum credible earthquake is considered as an accidental load, see 5.2.5 and 4.4.4.5.

For sites where the peak horizontal ground acceleration of the design earthquake is determined not to exceed $0.1g$, the requirements concerning the maximum credible earthquake may be ignored, upon agreement with DnV and the Owner.

Guidance: The intent of the exceptional level is to ensure that the structure has sufficient energy absorbing capacity against reaching a progressive collapse limit state during rare intense earthquake motions. Normally, the maximum credible earthquake is not taken less than twice the ground motion of the design earthquake.

5.3.6.2 *Ground motion:* The ground motions used as basis for design shall adequately represent the expected conditions at the site, both in terms of frequency content and energy distribution. See 3.5.8.

The effects of local soil conditions in amplifying or attenuating the ground motion and in altering the frequency content are to be studied in order to determine appropriate horizontal and vertical characteristic values of the ground motion.

The ground motion may be described either in terms of time histories or in terms of response spectra.

Standard spectra generally recognized as being valid for the region and the site conditions considered, may be considered when describing the ground motion.

The ground motion is normally to consist of three components (see 5.3.6.4) which are to be applied simultaneously, i.e. in the two horizontal directions and in the vertical direction.

When the response spectra method (see 5.3.6.5) is used the minimum values of ground motion in the three directions are;

- 100% in the horizontal direction (i.e. the principal axis) considered most vulnerable to the structure,
- 70% in the orthogonal horizontal direction,
- 50% in the vertical direction.

Where deemed necessary, appropriate higher percentages are to be used.

The ground motion components to be used in time history analysis are to be derived using recognized procedures.

The statistics and procedures used, and the investigations made for establishing the characteristics of the ground motion to be used as basis for design are subject to acceptance.

The characteristic values of the ground motion are subject to approval.

5.3.6.3 *Other effects:* The effects of tsunamies are to be considered for structures located in shallow water.

The effects of earthquake generated acoustic shock waves are to be considered where such effects will result in additional loads, e.g. sub-sea compartments that are not fully flooded.

5.3.6.4 *Structure analytical model:* The analytical models used for determination of earthquake response should represent the structure-soil-water system in a realistic manner as regards distribution of stiffness, mass and damping.

Assumptions made as regards nonlinear behaviour are to be carefully examined with respect material properties and structural detailing.

Normally, the dynamic characteristic of the structure and its foundation should be determined using a three dimensional analytical model. A two dimensional model may be used provided the torsional response and the response of cantilevered structures, e.g. decks on gravity structures, are properly accounted for.

Parameter studies are to be carried out where deemed necessary for proper determination of loading effects. The use of partitioned damping is recommended for parts of the structure-soil-water system having relatively large damping compared to the damping of the structure, e.g. the material and radiation damping in the soil.

5.3.6.5 Methods of analysis: The response analysis may be accomplished using any recognized method applicable for offshore structures, e.g. response spectrum methods or time history methods.

When using the response spectrum method as many modes should be considered as required to provide at least 90 percent of the total energy of all modes. A minimum of six modes with the highest energy content should be considered. Unless otherwise agreed, the maximum total response S is not to be taken less than

$$S = s_n + \sqrt{\sum s_i^2} \quad (5-1)$$

where s_n is the modal response yielding the largest contribution and s_i the individual modal response of the other modes.

When the response is carried into the inelastic range, time history methods are normally to be used.

Static equivalent methods are not to be used as the basis for design of structures for which sufficiently accurate dynamic analyses can be carried out.

Guidance: For structures for which a meaningful dynamic analysis cannot be carried out for the maximum credible earthquake, acceptable safety against progressive collapse may normally be assumed if it can be verified that the structure remains stable when subjected to a quasistatic loading that yields deformations approximately twice those of the design earthquake.

Recommendations concerning dynamic response are given in Appendix G.

5.3.6.6 Equipment response: The purpose of equipment response analysis is to determine the loads to be used in the design of the equipment support structures and the fastening arrangements, and in the checking of the safety of equipment.

The dynamic response of equipment and equipment supports is to be analyzed using recognized procedures and methods. The vertical and horizontal support accelerations should be combined in a rational manner so as to arrive at realistic loading effects.

The criteria for equipment survivability are subject to agreement with DnV and the Owner in each case.

SECTION 6 STEEL STRUCTURES

6.1 Materials

6.1.1 General

6.1.1.1 Structural materials are in general to comply with the requirements given in this subsection.

Other materials may be used provided that the material specifications are submitted for consideration and approval. Steel which may be designated as non-structural, is not considered in these Rules.

6.1.1.2 Structural steel is divided into three types, defined by their properties. The selection of steel type is directed by structural application and the consequences of a possible failure.

Special structural steel — is steel to be selected for members essential to the overall integrity of the structure and subject to particular arduous stress conditions.

Guidance: Can sections, deck to leg and column connections, cruciform joints of main girders, etc.

Primary structural steel — is steel to be selected for members participating in the overall integrity of the structure, and for other structural members of importance for the operational safety.

Guidance: Jacket legs, piles, bracings, main girders and beams in decks, riser support structures, helicopter deck, module support structures, cranes, etc.

Secondary structural steel — is steel to be selected for structural members other than special and primary structural steel members.

6.1.2 Documentation and identification

6.1.2.1 A material specification is to be prepared and submitted for approval, giving details of requirements to steel making, chemical composition, mechanical properties, mechanical testing and non-destructive testing of structural steel and steel elements.

6.1.2.2 Satisfactory documentation confirming that the chemical composition, mechanical properties and soundness of the steel comply with approved specifications is required.

6.1.2.3 Materials to be delivered as special and primary structural steel are to be furnished with test certificates, endorsed by DnV. Work certificates are acceptable for secondary structural steel.

6.1.2.4 DnV is to be given the possibility to check at the steel works that the materials are produced and tested according to approved specifications.

6.1.2.5 The materials are to be adequately marked for identification. The marking is to include the name or trade mark of the producer, steel grade, heat number, and when required, the mark of DnV.

6.1.2.6 Unidentified materials are to be rejected, unless renewed testing does verify compliance with approved specifications. Number and type of tests will be decided in each case.

6.1.3 Steel making

6.1.3.1 Steel mills, forges and foundries may be required to prove their capability of delivering products which consistently satisfy these Rules. The steel is to be made by the basic open hearth, electric furnace, LD process or by other approved processes.

6.1.3.2 High strength steel is to be fully killed. Normal strength steel may be semi-killed or fully killed. See 6.1.5.1.

6.1.3.3 Structural steels may be supplied as rolled, controlled rolled, normalized, or quenched and tempered. Steel forgings and steel castings are to be heat treated to a uniform, fine grained microstructure.

6.1.4 Chemical composition

6.1.4.1 The chemical composition of the steel is to ensure the specified mechanical properties during all probable fabrication conditions. Possible reduction of strength, ductility and toughness during forming, welding and heat treatment is to be accounted for.

6.1.4.2 For structural C-steels, C-Mn-steel and C-Mn fine grain treated steels to be welded, the ladle analysis is not to exceed the limits given in Table 6.1.

Low alloyed steels are subject to individual approval.

6.1.4.3 The chemical composition is to be determined for each heat as ladle analysis. If ladle analysis is not available, check analysis is to be performed at least twice each heat or twice each 50 tons whichever is smaller. In such cases the C- and C_E-values may be increased by 0,02% and 0,03% respectively beyond the limits specified in Table 6.1. Procedures for chemical analysis are described in Appendix C8.

6.1.5 Mechanical properties

6.1.5.1 Structural steel is defined as either normal strength steel or higher strength steel depending on the specified minimum yield strength.

Normal strength steel:	$R_{eL} < 300 \text{ Mpa}$
Higher strength steel:	$R_{eL} \geq 300 \text{ MPa}$

6.1.5.2 *Yield strength*: The minimum specified yield strength of structural steels to be welded is not to exceed 390 MPa unless specially approved.

6.1.2.5.3 *Ultimate tensile strength*: The yield to ultimate strength ratio is not to exceed 0,85.

TABLE 6.1 Chemical composition of C, C-Mn, and C-Mn fine graine treated steels

Steel classification	% C	% Mn	% Si	% P	% S	% Cu	% Mo	% Ni	% Cr	Others	CE
	max.	max.	max.	max.	max.	max.	max.	max.	max.		(2)
Special	0.20	1.60	0.50	0.04	0.03	0.35	0.08	0.40	0.20	(1)	0.45
Primary	0.22	1.60	0.50	0.04	0.04	0.35	0.08	0.40	0.20	(1)	0.47
Secondary	0.24	1.60	0.50	0.05	0.05	0.35	0.08	0.40	0.20	(1)	0.50
<p>Notes: 1) % Nb max: 0.05 % N max: 0.009 (0.015% if Al-treated)</p> <p> % V max: 0.10 % (V+Nb): max. 0.12</p> <p> % Ti max: 0.05 % (V+Nb+Ti): max. 0.15</p> <p> % Al (total): max. 0.08</p> <p>2) $CE = C + \frac{Mn}{6} + \frac{Cr+Mo+V}{5} + \frac{Cu+Ni}{15}$</p>											

TABLE 6.2 Minimum elongation

Strength level	ROUND TEST BARS A ₅	FLAT TEST BARS A ₂₀₀ t = thickness of test bar in mm						
		t ≤ 5	5 < t ≤ 10	10 < t ≤ 15	15 < t ≤ 20	20 < t ≤ 25	25 < t ≤ 35	t > 35
Normal strength steel	22%	15 %	16%	17%	18%	19%	20%	21%
Higher strength steel	21%	14%	15%	16%	17%	18%	19%	20%

6.1.5.4 *Elongation*: The required minimum elongation, A, is given in Table 6.2.

6.1.5.5 For steel castings the reduction of area, Z is not to be less than 50%.

6.1.5.6 *Lamination*: In order to screen out laminated plates special and primary structural steel is to be ultrasonic tested according to an agreed standard and acceptance level.

6.1.5.7 *Lammellar tearing*: Through thickness ductility of rolled and forged special structural steel is to be guaranteed. Minimum reduction of area, Z_T, is not to be less than 20% being the average of six test specimens when sampled and tested according to the procedure described in Appendix C8.

Such testing is recommended for primary structural steel which will be significantly strained in the thickness direction during welding.

6.1.5.8 *Fracture toughness*: In order to avoid initiation of brittle fracture, structural steels are to possess adequate fracture toughness.

For structural steels the appropriate toughness level is to be determined by Charpy V-notch testing.

The Charpy V-notch testing technique is to be used for selection of welding consumables and to establish welding procedures.

Additionally, for materials and heavy welded joints without previously documented experience from relevant applications, the fracture toughness is to be determined by fracture mechanics methods.

6.1.5.9 *Fracture mechanics*: Fracture mechanic testing is to be carried out according to agreed procedures. Extent of testing and testing conditions will be specified in each case.

The acceptable fracture toughness expressed by fracture mechanics concepts is to account for static and dynamic stresses, fabrication condition and possibility to locate and size defects during fabrication and service.

Crack Opening Displacement tests, or other agreed fracture mechanics tests, are normally to be conducted for selection of welding consumables and welding procedures for making

heavy welded joints of thickness t equal and greater than 50mm.

If COD-testing results in a minimum δ_c -value below 0,35mm in as-welded or local post weld heat treated condition, or if below 0,25mm after furnace post weld heat treatment, the defect tolerance parameter is to be calculated. The results are subject to evaluation by DnV.

Fracture mechanics testing may, after agreement, be used to determine whether adequate fracture toughness exists even if Charpy V-notch tests have failed to meet the requirements.

6.1.5.10 Charpy V-notch energy: The energy requirement depends on the specified minimum yield strength of the structural steel.

The Charpy V-notch requirements to base material, heat affected zone and weld metal are equal. The average energy absorption is not to be less than given in Figure 6.1. If the Charpy V-notch test samples are cut parallel to the principal working direction, giving KV_L -values, the minimum energy absorption required for the transverse direction, KV_T , is to be guaranteed by the steel maker. Steel castings and weld metals are to fulfill the KV_L -requirements.

One test sample consists of three specimens. No single value is to be less than 75% of the required average value. For subsize specimens the energy requirement is obtained by multiplying the requirement to standard size specimens by the applicable fraction as given in Figure 6.1.

6.1.5.11 Design temperature: The design temperature, T_D , is a reference temperature used as one of the criteria for determining the impact testing temperature for Charpy V-notch tests.

The design temperature, T_D , for parts of the structure in the atmospheric and the splash zone, is to be taken as 5°C below the most probable lowest monthly mean air temperature. For the submerged part of the structure the design temperature is to be taken as 5°C below the most probable lowest monthly mean sea water temperature. Reasonable accurate statistics based on temperature observations over several years should be used.

Figure 6.1: Average minimum Charpy V-notch energy absorption.

The design temperature may be adjusted to the nearest temperature which is a multiple of 5 (e.g. 0, +5, +10°C), but is not to exceed +10°C.

6.1.5.12 Impact testing temperature: The impact testing temperature, T , for Charpy V-notch tests depends on the structural steel type (See 6.1.1.2), design temperature, T_D , and the material thickness as directed by Table 6.3.

6.1.6 Extent of mechanical testing

6.1.6.1 Base material: From rolled tubes, plates, sections, bars etc. one (1) tensile test and one (1) Charpy V-notch impact test (3 specimens) are to be carried out for each heat. If the heat exceeds 50 tonnes, one additional set of tests is required for each 50 tonnes or parts thereof. Steel castings are to be tested individually.

Details on mechanical testing are given in Appendix C8.

6.1.6.2 Welded products: During production of welded beams, tubes, sections etc. from rolled steel having the specified material certificates, (see 6.1.2.3), weld production tests are to be taken regularly once every 50th welded product. When uniform and satisfactory quality is produced, the extent of testing may be reduced after agreement with DnV.

TABLE 6.3 Impact testing temperature

Material thickness, t mm	Special structural steel	Primary structural steel	Secondary structural steel
$t \leq 12.5$	$T = T_D$	$T = T_D$	
$12.5 < t \leq 25.5$	$T = T_D - 20$	$T = T_D$	
$25.5 < t \leq 50$	$T = T_D - 40$	$T = T_D - 20$	$T = T_D$
$t > 50$	$T = T_D - 40$	$T = T_D - 40$	$T = T_D - 20$

T = Impact testing temperature (°C)

T_D = Design temperature (°C)

Production tests are to consist of half the number of each of the tests specified for qualification of the welding procedure in question (see Table 6.8).

Production tests are to be carried out on material sampled from the heats involved.

6.1.6.3 If one or more tests give unsatisfactory results, the sample material (tube, plate, section, bar, etc.) is to be rejected. In order that the remaining products from the same heat may be accepted, two more tests of the same type are to be taken from two different tubes, plates, sections, etc., and both tests are to be satisfactory.

Should a test have failed owing to defective machining, which must be presumed to have influenced the test result, this test may be considered invalid and may be repeated.

6.1.6.4 Rejected material may be retested after heat treatment, or may be delivered as a lower grade of steel and be accepted, provided the required tests give satisfactory results for the grade in question. In either case, testing is to be carried out at least as for the initial testing.

6.1.7 Welding consumables

6.1.7.1 Welding consumables are to be of type approved standard, preferably according to DnV's List "Type Approved Products and Approved Manufacturers: Welding Consumables, Shop Primers and Welding Shops", latest revision having the appropriate designation for welding of the steel grade(s) in question.

6.1.7.2 Welding consumables are to be selected such as to produce a weldment with mechanical properties at least equal to that specified for the structural steel type in question. The weld metal is to be compatible with the base material regarding heat treatment and corrosion.

6.1.7.3 Selection of welding consumables to be used for welding of structural steel of heavy joint thickness (50mm and more), is normally to be based on fracture mechanics testing, in addition to Charpy V-notch testing, see 6.1.5.9.

6.1.8 Weldable reinforcing steel

6.1.8.1 Weldable reinforcing steels are generally to have a chemical composition complying with 6.1.4. When reinforcing steels are used as structural steel elements, their mechanical properties are generally to conform with the requirements for the structural part in question.

6.1.9 Bolts and nuts

6.1.9.1 Bolts, nuts etc. are to have chemical and mechanical properties in accordance with and be manufactured and tested to relevant ISO standards or equivalent. When such components are used as structural elements, more stringent notch toughness requirements than guaranteed by the relevant standard may be imposed. In such circumstances the elements are to possess the minimum Charpy V-notch toughness required for the structural part in question. Extent of testing will be decided in each case.

6.1.9.2 Tensile properties of structural bolts, nuts etc. are in general not to exceed ISO R 898/Property class 8.8 unless otherwise agreed.

6.1.9.3 Bolts, nuts and associated elements are to be resistant to corrosion or to be adequately protected by hot dip galvanizing, or by suitable coatings.

6.2 Design analyses and criteria

6.2.1 General

6.2.1.1 Steel structures are to be designed in accordance with Section 4 and Section 6. Loads and loading conditions considered are to be in accordance with Section 5. The more detailed regulations for strength considerations and strength criteria for steel structures are given in subsection 6.2.

6.2.1.2 The safety against brittle fracture is generally to be based on quality control procedures involving testing and inspection of materials and weldments as specified in 6.1, 6.4 and 6.5. Further, if the yield strength f_y is higher than 0,8 times the ultimate strength f_u , f_y is not to be taken higher than 0,8 f_u in the analyses.

Additionally, for materials and heavy welded joints for which experience from relevant application is not documented, the resistance to initiation of brittle fracture at relevant strain rates is to be assessed by fracture mechanic methods. The Crack Opening Displacement test is recommended, (see 6.1.5.9).

Other tests having similar capabilities to determine adequate fracture toughness may be used.

Structural details which causes local strain concentration such that the member as a whole behaves brittle must be avoided.

6.2.1.3 For the consideration of overturning and sliding i.e. the consideration of *external* equilibrium of the structure as a whole, see Section 9.

6.2.1.4 The imperfections of structural elements whose resistance is depending on the magnitude of geometrical imperfections, must be within prescribed limits corresponding to the characteristic resistance values assumed in the design.

In Appendix C some characteristic resistance values are given together with associated allowable imperfections.

6.2.2 Ultimate limit state – General

6.2.2.1 The general requirement to achieve sufficient safety against reaching the ultimate limit state may be expressed as follows:

$$S(\Sigma F_i \gamma_{fi}) \leq \frac{R_k}{\gamma_m} \cdot \frac{1}{\kappa} \quad (6-1)$$

$S(\Sigma F_i \gamma_{fi})$ design loading effect

γ_m material coefficient, to be taken as 1,15 in elastic design and 1,3 in plastic design

F_i	load
γ_{fi}	load coefficient
R_k	characteristic resistance
κ	factor depending on type of characteristic resistance. κ is normally equal to 1,0 when the characteristic resistance is proportional to the characteristic strength of the material. For other cases the value of κ is given in Table 6.5.

6.2.2.2 Calculations to verify the safety of a structure with respect to ULS may be carried out according to elastic- or where appropriate, plastic theory.

6.2.3 ULS – Elastic design

6.2.3.1 *General* In elastic design the design loading effect is determined by elastic theory. If a linear relationship between loads and loading effects can be assumed, the design loading effects may be determined by multiplying the characteristic loading effects by their respective load coefficients.

6.2.3.2 *Control of stresses* At any point of the structure the requirement given in Eq. 6-2 has to be fulfilled. In this case the requirement reads:

$$\sigma_{ed} \leq f_d = \frac{f_k}{\gamma_m} \quad (6-2)$$

f_d design strength

f_k characteristic strength, see 4.4.3.2

γ_m material coefficient = 1,15

σ_{ed} equivalent stress according to von Mises.

$$\sigma_{ed} = \sqrt{[\sigma_{xd}^2 + \sigma_{yd}^2 + \sigma_{zd}^2 - (\sigma_{xd}\sigma_{yd} + \sigma_{xd}\sigma_{zd} + \sigma_{yd}\sigma_{zd}) + 3(\tau_{xyd}^2 + \tau_{xzd}^2 + \tau_{yzd}^2)]}$$

Subscript d indicates that the stresses are design stresses, (i.e., factored stresses).

For plate and shell structures the loading effects determined from linear elastic theory will in general include local pronounced peaks. In the ULS check such peaks may be reduced to a mean value over a certain width for the section considered. This width is to be evaluated in each case according to recognized principles.

For beams and similar members where simple beam theory is applicable, the contribution to longitudinal stresses from bending moments may be calculated in accordance with Eq. 6-3.

$$\sigma_{bd} = \frac{M_{fd} \cdot y}{I \cdot 1,10} \quad (6-3)$$

M_{fd} design bending moment

y distance from the principal axis to considered point in the cross section

I moment of inertia of considered cross section

6.2.3.3 *Control of stability.* The most unfavourable buckling mode is to be considered.

For states of stress which can be defined by one single reference stress the stability requirement is:

$$S_d \leq R_d = \frac{R_k}{\gamma_m} : \frac{\psi}{\kappa} \quad (6-4)$$

S_d reference stress or stress resultant due to design loading.

R_k characteristic resistance

R_d design buckling resistance

γ_m material coefficient = 1,15

ψ factor to reflect the post buckling behaviour. Values of ψ for typical structural members are given in Table 6.4.

κ factor depending on type of structural member under consideration.
Values of κ as a function of slenderness ratio are given in Table 6.5.

For stability problems involving a state of stress which can not be defined by one single reference stress, recognized interaction formulae are to be used.

In Appendix C interaction formulae and characteristic values are given for some typical structural members and load combinations.

For stability failure modes not covered by Appendix C, or where methods and values are used which differ from those given in Appendix C, the validity of the methods and values are to be documented.

Initial imperfections in structural members are not to exceed the tolerances upon which the characteristic values are based.

Table 6.4 The Coefficient ψ

Type of structural member	Direct normal stress	Direct shear stress
Bars in pure compression	0,9	—
PLATES	redistribution possible	1,05
	redistribution not possible	0,9
SHELLS	redistribution possible	1,0
	redistribution not possible	0,9

Table 6.5 The Coefficient κ

Type of member \ $\bar{\lambda}_k$	$\bar{\lambda}_k < 0,5$ $0,5 \leq \bar{\lambda}_k \leq 1,0$ $\bar{\lambda}_k > 1,0$		
Bars & plates	1,0	$0,9 + 0,2\bar{\lambda}_k$	1,1
Shells	1,0	$0,7 + 0,6\bar{\lambda}_k$	1,3

$$\bar{\lambda}_k = \sqrt{\frac{f_y}{f_i}}$$

f_y = yield strength

f_i = critical elastic buckling resistance

6.2.4 ULS – Plastic design

6.2.4.1 Structures composed of members which can develop well-defined plastic resistances considering all relevant stresses, and maintain these resistances during the deformation which is necessary to form the mechanism may normally be designed by plastic theory. See 4.1.3.1.

6.2.4.2 The loading effects may be determined considering the formation of a plastic collapse mechanism due to the design loading. The design resistance is given by the characteristic resistance of the mechanism divided by the material coefficient, $\gamma_m = 1,3$.

6.2.4.3 The determination of the characteristic resistance is to be in accordance with recognized plastic theorems so as to avoid non conservative estimates of the safety.

6.2.4.4 Structures subjected to repeated loading are to be designed with due consideration to repeated yielding. It must be shown that the structure will shake down without developing excessive plastic deformations or fracture due to repeated yielding.

6.2.5 Fatigue limit state

6.2.5. *General.* The fatigue limit state may (as a conception) be defined as a state of "accumulated damage", due to previously experienced variable stresses, in which an additional stress cycle will cause failure.

Fatigue is in particular to be considered for constructional details where stress concentrations occur. Typically, the critical sections may be through welds or through base material close to welds.

The aim of the fatigue design is to assure adequate safety against the fatigue limit state being reached within the planned life of the structure. The specific criteria will depend on method of analysis of which two different categories exist:

- Methods based on fracture mechanics
- Methods based on fatigue tests

6.2.5.2 *Methods based on fracture mechanics.* Where appropriate, a calculation procedure based on fracture mechanics may be used.

The specific criteria will be considered in each separate case. Guidance on methods of analysis and the necessary documentation to be submitted are given in Appendix C7.

6.2.5.3 *Methods based on fatigue tests.* These methods comprise generally of the following three main steps:

- Determination of long term distribution of stress range, see 6.2.5.4.
- Selection of appropriate S-N curve (characteristic resistance), see 6.2.5.5.
- Determination of the accumulated damage, see 6.2.5.6.

6.2.5.4 *Long term distribution of stress range.* All stress fluctuations imposed during the entire life of the structure which have magnitude and number large enough to cause fatigue effects are to be taken into account when determining the long term distribution of stress range, see 4.5.1.4.

Typical causes of stress fluctuations are the direct and indirect actions (vortex shedding) of waves, current and wind, as well as live loads, machinery and cranes.

As most of the loads which contribute to fatigue are of random nature statistical considerations will normally be required for determination of the long term distribution of fatigue loading effects. Deterministic or spectral analysis may be used. The method of analysis used is subject to acceptance.

The effects of dynamic response are to be properly accounted for when determining the stress ranges unless it can be shown that the dynamic effects are negligible. Special care shall be taken to adequately determine the stress ranges in structures or members excited in the resonance range.. The amount of damping assumed in the analysis is to be conservatively estimated.

6.2.5.5 *Characteristic resistance – S-N curves.* Characteristic resistances are normally given as S-N curves, i.e., stress versus number of cycles to failure.

The S-N curve used is to be applicable for the material, construction detail and state of stress considered as well as to the surrounding environment.

The S-N curve is normally to be based on a 95% confidence limit.

In Appendix C7 failure modes for some typical construction details are classified in relation to a family of S-N curves.

6.2.5.6 *Determination of accumulated damage.* In the general case where stress fluctuations occur with varying amplitude in random order, the linear damage hypothesis (Miner's rule) may be used.

Application of the Miner's rule implies that the long term distribution of stress range is replaced by a stress histogram, consisting of a convenient number of constant amplitude stress range blocks $(\sigma_r)_i$ and a number of repetitions n_i .

The fatigue criteria then reads:

$$\sum_{i=1}^s \frac{n_i}{N_i} \leq \eta \quad (6-5)$$

where

- s number of stress blocks
 n_i number of stress cycles in stress block i
 N_i number of cycles to failure at constant stress range $(\sigma_r)_i$
 η limit damage ratio

The number of stress blocks, s , is to be large enough to ensure reasonable numerical accuracy.

The limit damage ratio η will depend on the maintainability, i.e. possibility for inspection and repair, as well as the importance of the particular construction detail considered.

Recommended values of η are given in Table 6.6.

Methods for determining the cumulative damage ratio, other than the Miner's rule will be considered in each separate case.

Table 6.6 Limit damage ratio η

Classification of construction detail	Access for inspection and repair		
	No access	Access	
	Location All zones	Location in and below splash zone	Location above splash zone
Major importance	0.10	0.3	1.0
Minor importance	0.3	1.0	1.0

6.2.6 Progressive collapse limit state

6.2.6.1 The progressive collapse limit state is to be considered for possible accidental (exceptional) loads, against which sufficient local strength cannot be provided by reasonable means, or against which increased local strength would reduce the safety against overall collapse of the structure.

6.2.6.2 The extent of the damage may either be defined, or determined on the bases of a defined "accident". When relevant, the effects of the accidental load itself, on the intact part of the structure, is to be considered. Load and material coefficients may all be taken equal to unity, i.e. all design values may be taken equal to the characteristic values.

6.2.7 Serviceability limit states

6.2.7.1 For steel structures the serviceability limit state will normally include criteria related to displacements and vibrations.

6.2.7.2 The serviceability limit states are to be checked for combinations of loads of category P, L, D and E. Unless otherwise agreed upon with DnV and the Owner, the displacements are to be evaluated for the characteristic values of the loads.

Vibrations are to be evaluated for a load pattern agreed upon by DnV and the Owner in each separate case. For load coefficients, see 4.4.4.6.

6.2.7.3 The check of the serviceability limit state is normally to be based on elastic theory.

Realistic stress strain curves are to be used for modelling interaction with nonlinear materials such as foundation soils etc. Permanent deformations associated with plastic design are to be evaluated on the basis of elasto plastic material properties, see 6.2.4.4.

6.2.7.4 Displacements may be calculated by simplified methods in which redundant forces and moments are chosen freely, provided the chosen values result in larger displacements than obtained by accurate calculations.

6.2.7.5 Vibrations are to be checked in accordance with recognized methods, see 4.5.1.5 and Appendix G.

6.2.7.6 SLS criteria will be given by the Owner. See also 4.7.1.1.

6.3 Corrosion Protection

6.3.1 General

6.3.1.1 Steel structures are to be protected against corrosion according to 6.3. For corrosion protection of concrete structures, see 7.11.

6.3.1.2 Methods, design of system, materials, fabrication and installation of the corrosion protection system for special and primary structural steel (see 6.1.1.2) are subject to approval.

Special precautions are to be taken to protect;

- steel members impossible or difficult to inspect or repair after installation.
- steel surfaces exposed to very aggressive environments (e.g. the splash zone).

6.3.2 Definitions

Splash zone: The splash zone range is defined as the astronomical tidal range plus the wave height having a probability of exceedance of 0.01. The upper limit of the splash zone is determined by assuming 65% of this wave height above HAT and the lower limit by assuming 35% below LAT.

Submerged zone: The region below the splash zone including buried parts.

Atmospheric zone: The region above the splash zone.

Internal zones: Regions of the structure which are not externally exposed. Internal zones are to be defined for each structure.

Coating: Metallic, inorganic and organic materials applied for prevention of corrosion of steel surfaces.

Cathodic protection: A technique to prevent corrosion of a metal surface by making that surface the cathode of an electrochemical cell.

Corrosion allowance: Steel thickness in excess of that needed for strength.

6.3.3 Corrosion protection systems

6.3.3.1 Steel surfaces in the splash zone are to be protected by special corrosion protection systems, normally in combination with a corrosion allowance of minimum 12mm.

6.3.3.2 Steel surfaces in the atmospheric zone are to be protected by coating.

6.3.3.3 Steel surfaces in the submerged zone are to be protected by cathodic protection with sacrificial anodes or alternatively with impressed current.

The cathodic protection system may be combined with a suitable coating. A reduction of the amount of sacrificial anodes or impressed current is acceptable for coated surfaces as compared to bare surfaces. The reduction is dependant on the type of coating and will need evaluation in each case.

6.3.3.4 Steel surfaces exposed to sea water in internal zones are normally to be protected by cathodic protection and coating.

Impressed current systems are not to be used in closed spaces or where water flow may be significantly restricted.

Steel surfaces exposed to air in internal zones are normally to be protected by coating.

Other protective systems may be accepted upon special consideration.

6.3.4 Design parameters

6.3.4.1 The following parameters for the sea water and sea bottom are to be taken into account;

- temperature
- oxygen content
- chemical composition
- resistivity
- sea currents
- pH value
- erosion
- biological activity (sulphate reducing bacteria, marine growth etc.)

If relevant data on these parameters are not available, measurements at the location are required.

6.3.4.2 The following parameter for the milieu in internal zones are to be taken into account:

- humidity
- condensation
- temperature
- properties of electrolytes
- crude oil environment
- potential corrosives
- transition zones

6.3.4.3 The steel surfaces are to be described regarding;

- physical shape
- location on the structure
- consequences of corrosion damages
- possibility of inspection and repair

6.3.5 Protection by coating

6.3.5.1 Coating system specifications are to be submitted for approval. The specifications are to include information on type of coating, trade name and documentation of performance of the coating system under actual conditions, or similar environment. If relevant information based on practical experience is not available, adequate experimental data are to be submitted. The information should include the following properties of the coating system;

- adhesion
- resistance to sea water
- service temperature, maximum and minimum limits
- resistance to ageing
- resistance to mechanical damage, e.g. impact resistance, elongation, tensile strength
- resistance to biological attack, for coating exposed to sea water
- resistance to cathodic disbondment when the coating is used in combination with cathodic protection
- compatibility of different coatings when such are combined
- reparability during construction, installation and service.

6.3.6 Coating application

6.3.6.1 A procedure specification for coating application is to be submitted for approval. The specification is to include;

- description of general application conditions at coating yard
- method and equipment for surface preparation
- ranges of temperature and relative humidity
- application methods
- time between surface preparation and first coat
- minimum, maximum dry film thickness of a single coat
- number of coats and minimum total dry film thickness
- relevant drying characteristics e.g. recoatability in relation to temperature and relative humidity
- procedure for repair of damaged coating
- methods of inspection

901

6.3.6.2 Surface preparation and application of coating are to be carried out when the surface temperature is more than 3°C above the dew point or when the relative humidity of the air is below 90% or as recommended by the coating manufacturer.

6.3.6.3 The application process is to be inspected and inspection reports are to be available upon request from DnV. The report is to include;

- acceptance criteria according to the approved specification
- surface preparation data
- temperature and humidity measurements
- number of coats and total dry film thickness
- adhesion data
- holiday detection

6.3.7 Protection by sacrificial anodes

6.3.7.1 Design specifications are to be submitted for approval. The specifications are to include information on;

- area to be protected
- electrically connected systems
- current density requirement
- anode design, weight, distribution and total number
- anode material and manufacturer
- calculations of the effectiveness of the system
- anode framework and installation
- monitoring system

6.3.7.2 The cathodic protection system is to deliver sufficient current to maintain the potentials given in Table 6.7 — at all points within the structure.

6.3.7.3 The area of bare steel to be protected is to be specified. For coated surfaces the area of bare steel to be protected is to be taken as a percentage of the total area determined from experience of coating damages and coating resistance.

6.3.7.4 The current density requirement is to be based on the environmental conditions either from experience under similar conditions or from measurements (see 6.3.4.1).

6.3.7.5 The possibilities of stray currents in connection with nearby structures are to be evaluated. In areas where stray currents are suspected, appropriate tests are to be conducted. Detrimental effects of stray currents are to be avoided by applying general preventive methods.

Guidance: Stray currents may be avoided by means of a metallic conductor connected to the return (negative) side of the stray current source, or by counteraction of the effect of stray current by means of cathodic protection or removal or relocation of the stray current source.

Special attention should be paid to stray currents caused by welding during construction and to the reinforcement of concrete structures.

6.3.7.6 Electrically connected systems which may cause current drainage are to be included in the design of the cathodic protection system. Special attention shall be paid to current drainage to the reinforcement of concrete structures, see 7.11.2.

6.3.7.7 A cathodic protection system by sacrificial anodes is to be designed to maintain the required potential during the design life of the structure. The design may be based on a shorter period if reinstallation of anodes is planned.

6.3.7.8 The driving potential and the electrochemical efficiency of the sacrificial anodes are to be documented by appropriate tests. The manufacturer may be required to prove his capability of delivering anodes which consistently satisfy the actual specifications.

Material certificates for anodes are to state at least;

- the manufacturer
- the specified chemical composition
- the actual chemical analysis
- the charge number

6.3.7.9 The anodes are to be located so as to give a uniform current distribution to the steel structure.

The current output from the anodes is to be determined from the driving potential and circuit resistance or from tests measurements.

Table 6.7 Potential (volts) for cathodic protection of steel structures

Metal	Reference electrode		
	Cu/CuSO ₄	Ag/AgCl	Zn
Steel in aerobic environment			
a) positive limit	- 0,85	- 0,80	+ 0,25
b) negative limit	- 1,10	- 1,05	+ 0,00
Steel in anaerobic environment			
a) positive limit	- 0,95	- 0,90	+ 0,15
b) negative limit	- 1,10	- 1,05	+ 0,00
Very high strength steel (ultimate tensile strength > 800 N/mm ²)			
a) positive limit	- 0,85	- 0,80	+ 0,25
b) negative limit	- 1,00	- 0,95	+ 0,10

6.3.7.10 The anode lifetime L is to be determined as follows:

$$L = \frac{W \cdot u}{E \cdot I}$$

- L effective lifetime of the anodes in years
 W net mass of the anodes in kg
 u utilization factor determined by the amount of anode material consumed when the remaining anode material cannot deliver the current required
 E consumption rate of the anode in kg/A·year
 I mean current output during the lifetime in A

The maximum values for the utilization factor are;

- slender anodes: 0,9
 other shapes: 0,8

6.3.7.11 The anode core is to be designed to support the anode during all constructional and operational phases, e.g. transportation, pile driving etc.

6.3.7.12 A permanent cathodic protection monitoring system for measuring of the potential is to be installed at locations where inspection is impractical.

6.3.7.13 Adequate electrical connection between sacrificial anodes and the steel structure is to be assured. Welded connection is preferred.

Anodes are to be positioned with due regard to protection of joints. Direct attachment at areas of high stress levels is to be avoided. All welding of anodes to structural members is to follow qualified welding procedures established for fabrication of the actual member, see 6.4.

6.3.7.14 The surfaces of sacrificial anodes are to be examined 100% visually. The anode surface is to be free from coating and cracks affecting the anode efficiency. Attachment welds for anodes are to be inspected and tested in accordance with the requirements of 6.5, for secondary steel structures.

6.3.8 Protection by impressed current

6.3.8.1 The conditions to be taken into account for impressed current systems are the same as for sacrificial anode systems given in 6.3.7.2 through 6.3.7.6.

6.3.8.2 A design specification is to be submitted for approval. The specification is to provide information on the following items;

- area to be protected
- electrically connected systems
- current density requirement
- general arrangement
- anodes, anode shields, rectifiers, cables, cable connections and electrical circuiting
- monitoring system

6.3.8.3 The impressed current anodes are to be located and shielded to give a uniform current distribution to the steel surface.

Special precautions are to be given to interaction phenomena with the reinforcement of concrete structures, see 7.11.2.

6.3.8.4 Due consideration is to be given to detrimental effects of chlorine, especially if combined with hydrogen caused by overprotection.

6.3.8.5 A permanent cathodic protection monitoring system for measuring of the potential is required.

6.3.8.6 Testing of the power source is to be carried out to ensure adequate electrical connection and that no damage has occurred during installation.

The cables and connections are to be carefully inspected to detect insulation defects. Defects are to be properly repaired.

Impressed current anodes are to be inspected to ensure that the anode material and size are in accordance with specification.

6.3.8.7 All equipment, cables etc. are to be approved for use in the respective hazard zones.

6.3.9 Testing of effectiveness of systems

6.3.9.1 Testing is to be carried out after each cathodic protection system is put into operation to ensure that the steel potential is within the required range. This testing is to be carried out within;

- one year for sacrificial anode systems
- one month for impressed current systems

6.3.9.2 Test equipment, procedure for, and extent of potential measurements are to be approved.

6.3.9.3 Determination of the potential is to be made with the protective current applied.

The reference electrode is to be located as close as possible to the selected surface point to be measured.

6.4 Fabrication and Construction

6.4.1 General

6.4.1.1 Subsection 6.4 contains technical conditions for fabrication and construction of steel structures.

6.4.1.2 A specification containing the main aspects of fabrication and construction is to be submitted for approval.

6.4.1.3 The fabricator is to organize a system for quality control involving competent personnel with defined responsibilities covering all aspects of quality control.

6.4.1.4 Fabrication and construction is to be in accordance with approved specifications. All defects and deficiencies are to be corrected before the structural part is coated or made inaccessible.

6.4.2 Welding procedure specifications

6.4.2.1 Welding procedure specifications are to be prepared, and submitted for review, detailing steel grades, joint/groove design, thickness range, welding process, welding consumables, welding parameters, principal welding position, preheating/working temperature and post weld heat treatment.

6.4.3 Welding procedure qualification

6.4.3.1 The fabricator is to document the ability to produce weldments of specified quality. Such documentation is to be presented prior to welding of special and primary structural steel, as well as prior to welding of secondary structural steel of thickness above 25,5 mm.

To the discretion of DnV welding procedure qualification tests may be replaced by production tests. (See 6.4.11)

6.4.3.2 The qualification program specified herein is applicable for manual metal arc, gas metal arc with solid or fluxcoated electrode and submerged arc welding. Other welding processes are subject to special approval. Additional requirements for underwater welding are given in 6.4.12.

6.4.3.3 The qualification tests are to be witnessed by DnV and conducted under actual or simulated conditions, based upon the welding procedure specification. Materials with carbon content and carbon equivalent value in the upper compositional range should be selected for the test assembly.

6.4.3.4 The qualification of welding procedures is to be based upon non-destructive testing and mechanical testing. Type and number of tests are specified in Table 6.8.

Mechanical testing and sampling of test specimens are detailed in Appendix C8.

6.4.3.5 The welding procedure is qualified when the soundness and mechanical properties comply with the requirements specified in 6.4.3.6 through 6.4.3.12.

6.4.3.6 *Non-destructive testing:* The soundness is to comply with 6.5.6.

6.4.3.7 *Tensile tests:* The ultimate tensile strength of the welded joint is to be at least equal to the minimum specified ultimate tensile strength for the steel grade in question.

6.4.3.8 *Bend tests:* After bending to an angle of minimum 180°, no defects extending more than 3 mm in any direction are to appear. Minor defects at the specimen edges may be disregarded.

6.4.3.9 *Charpy V-notch tests:* The average and minimum Charpy V-notch energy recorded for each specified position is to comply with 6.1.5.10 and 6.1.5.12.

6.4.3.10 *Hardness tests:* The maximum hardness at any part across the weldment is not to exceed 325 HV5. A lower hardness level may be required if structural members will be exposed to environments which may cause stress corrosion.

6.4.3.11 *Macrosection:* The welded joint is to show a regular profile with smooth transitions to the base material and without significant undercuts or excessive reinforcement. Cracks or lack of fusion are not acceptable. Porosity, and slag inclusions are to comply with 6.5.6.

6.4.3.12 *Fracture mechanics tests:* Regarding fracture toughness of heavy welded joints, see 6.1.5.9.

Table 6.8 Qualification of welding procedures – Type and number of tests

Joint configuration	Joint thickness (mm)	Non-destructive testing (100%) ²⁾	Mechanical testing ¹⁾					Fracture mechanic tests
			Tensile tests	Bend tests ³⁾	Charpy V-notch tests ⁴⁾⁵⁾	Hardness/plates	Hardness/tubes	
Buttwelds (Tubes and plates)	t < 50	X-ray	2	2	4 samples	1	2	–
	t ≥ 50	UT+MP	2	2	6 samples	1	2	See 6.1.5.9
T-joints (plates)	t < 50	UT+MP	–	–	4 samples	1	–	–
	t ≥ 50	UT+MP	–	–	6 samples	1	–	See 6.1.5.9
Tubular joints	t < 50	UT+MP	–	–	4 samples	–	2	–
	t ≥ 50	UT+MP	–	–	6 samples	–	–	See 6.1.5.9
Fillet welds	All	MP	–	–	–	2	2	–

Notes:

- 1) If the fabricator decides to use welding consumables or combination of such not contained in the list of type approved consumables, see 6.1.7.1, additional mechanical tests may be required.
- 2) X-ray = radiographic testing, UT = ultrasonic testing, MP = magnetic particle testing.
- 3) Bend tests, are to consist of 1 face and 1 root bend specimen for $t \leq 20$ mm and 2 side bend specimens for $t > 20$ mm.
- 4) Impact testing is to be carried out with the notch positioned in the center of the weld, on the fusion line (50 % weld metal, 50 % HAZ), 2 mm from the f.l. and 5 mm from the f.l. Specimens are to be sampled 2 mm below the base material at the capping side. If more welding consumables or several welding processes are applied for the same joint, impact testing is to be carried out for the related regions of the welded joint.
- 5) For welded joints having thickness $t \geq 50$ mm, additional impact testing is required in the root region with the notch in center of the weld metal and on the fusion line.

6.4.4 Validity of welding procedures

6.4.4.1 Qualification of a welding procedure is restricted to the fabricator and yard/barge etc. where the test weld was produced.

6.4.4.2 A qualified welding procedure is to be used within the limitations of the essential variables, see 6.4.5. If not production tests have been carried out within two years since the qualification date, requalification is required.

6.4.5 Limitations of essential variables for welding

6.4.5.1 The changes set forth in 6.4.5.2 and 6.4.5.3 are to be considered essential and are in general to initiate a new procedure qualification test unless otherwise agreed. When a combination of welding processes is used, the variables applicable to each process shall apply.

6.4.5.2 Essential variables for welding above water are;

Materials: Change of material grade, type and composition significantly affecting weldability and mechanical properties.

Thickness: Change of material thickness beyond plus and minus 25 %, unless the test material thickness is selected in compliance with Table 6.9.

Table 6.9 Qualified thickness range.

Thickness of test plate t (mm)	Qualified thickness range (mm)
15-20	$t \leq 25.5$
35-40	$25.5 < t \leq 50$
60-75	$50 < t \leq 90$
≥ 90	$t \geq 90$

Diameter: Change of diameter from OD > 300 mm to OD ≤ 300 mm.

Joint configuration: Change from butt welds to T-joints and tubular joints, and vice versa.

Groove design: Change from double side welding to single side welding, change of included angle more than 15° , and change of specified root face and root gap significantly affecting penetration and fusion.

Welding process: Any change.

Welding consumables: Change to a non-specified electrode/wire size or to a non-hydrogen controlled consumable, or any change of brand and combination when impact testing is required at a testing temperature $T \leq -10^\circ\text{C}$.

Welding positions: Change from one principal welding position to another, unless complying with Table 6.10.

Table 6.10 Qualified principal positions

Test weld		Qualified positions		
Joint configuration	Principal positions	Butt welds Plates	Tubes	Fillet welds Plates/Tubes
Plates/ butt weld ¹⁾²⁾	2G+3G	All	All ¹⁾²⁾	—
	1G	1G	1G	—
	2G	1G,2G,4G	1G,2G	—
	3G	3G	—	—
	4G	1G,4G	1G	—
Tubes/ butt welds ¹⁾²⁾	2G+5G=6G	All	All ²⁾	—
	1G	1G	1G	—
	2G	1G,2G,4G	1G,2G	—
	5G	All	1G+5G	—
Fillet welds ¹⁾²⁾	2F+3F	—	—	All
	1F	—	—	1F
	2F	—	—	1F,2F,4F
	3F	—	—	3F
	4F	—	—	1F,4F

Notes: 1) Tubes OD ≥ 600 mm are considered equivalent to plates

2) Tubular joints are to be qualified separately.

Welding parameters: Change beyond ± 15 per cent each on mean voltage and mean current, and beyond ± 10 per cent on travel speed.

Gas metal arc characteristics: Change from spray arc to short arc or pulsed arc, or vice versa.

Gas shielding: Change of specified gas mixtures, composition and flow rate.

Preheating/working temperature: Change $\pm 25^\circ\text{C}$ beyond specified minimum and maximum preheating/working temperature range.

Post weld heat treatment: Change beyond specified temperature range, soaking time, cooling/heating rates and temperature gradient.

6.4.5.3 Essential variables for underwater welding in addition to those specified in 6.4.5.2 are:

Welding conditions: Change from dry welding to wet welding and vice versa.

Welding consumables: Any change.

Welding parameters: Change beyond ± 10 per cent on mean voltage, or current or travel speed.

Polarity/type of current: Any change.

Water depth: Change in water depth/working pressure beyond agreed range.

6.4.6 Welder Qualification

6.4.6.1 Manual welding is to be performed by qualified welders. Performance tests are to be conducted regularly.

6.4.6.2 When a welder has been employed by a new

fabricator, or has interrupted welding for more than 6 months, a new qualification test is normally to be conducted.

6.4.6.3 Welding operators using the submerged arc welding process need in general not pass performance tests, but are to mark their welds for later identification.

Welding operators using mechanized gas metal arc- and fluxcored arc welding processes are to be qualified. Performance tests are to be conducted regularly.

6.4.6.4 Conditions for qualification of welding personnel are detailed in Appendix C8.

6.4.7 Welding consumables

6.4.7.1 Welding consumables are to be as specified in the qualified welding procedures.

6.4.7.2 Generally manual welding of all higher strength steel and normal strength steel with carbon equivalent $CE \geq 0.41$ (see 6.1.4.2), is to be carried out with low hydrogen consumables designated HH and H according to the International Association of Classification Societies.

6.4.7.3 For special structural steel and repair welding, only extra low hydrogen electrodes are to be used (i.e. max. hydrogen 5 ml per 100 gram weld metal, verified by designation HH).

6.4.7.4 Welding consumables are to be supplied in sealed moisture proof containers. Storage and handling are to be in accordance with Table 6.11, unless otherwise agreed upon. Consumables which have been contaminated by moisture, rust, oil, grease, dirt etc. are to be discarded. Any rebaking of low hydrogen consumables is to be carried out in accordance with the manufacturer's instructions.

Table 6.11 Storage and handling of welding consumables

Type of consumable	Storage of hermetically sealed containers	Storage of opened containers	Storage of consumables withdrawn for use
Coated electrodes – low hydrogen type – Rutile, acid types	20–30°C ¹⁾ 20–30°C ¹⁾	150–250°C $\geq 70^\circ\text{C}$	70–100°C ²⁾ 3)
Flux cored wire – low hydrogen type – other types	20–30°C ¹⁾ 20–30°C ¹⁾	150–250°C $\geq 70^\circ\text{C}$	2) 3)
Flux for submerged arc welding	20–30°C ¹⁾	$\geq 70^\circ\text{C}$	3)

Notes:

- 1) The temperature should exceed ambient by $+ 5^\circ\text{C}$.
- 2) When withdrawn for use, low hydrogen consumables are to be kept in heated containers, and used within 2 hours unless low rates of moisture pick-up is documented.
- 3) To be handled according to the manufacturer's instructions.

6.4.8 Preparation for, and performance of welding

6.4.8.1 A system for material identification during all stages of fabrication and construction is to be used.

6.4.8.2 Forming of plates and tubes is to be carried out according to a specification outlining the successive and controlled steps. Cold forming resulting in more than 2% permanent deformation, is normally to initiate either stress relieving or strain ageing tests, with retesting of mechanical properties of base material and weldments.

Hot forming is normally to be carried out at a temperature not exceeding 600°C, unless subsequent heat treatment is carried out restoring uniform microstructure and mechanical properties.

The specified mechanical properties are to be fulfilled in the final condition.

6.4.8.3 Surfaces to be welded are to be free from mill scale, slag, rust, grease, paint, etc. Edges are to have a smooth and uniform surface.

6.4.8.4 No welding is to be performed when the surfaces are humid. Suitable protection is to be arranged when welding is performed during inclement weather conditions. The groove is to be dry at the time of welding and at a temperature of minimum + 5°C. Moisture is to be removed by preheating.

6.4.8.5 The fit-up is to be checked before welding. Misalignment between parallel members is not to exceed 10 %, max. 3 mm.

6.4.8.6 If the thickness of abutting members differ more than 3 mm, the thicker member is to be tapered by machining or grinding to a slope of not less than 1 : 4.

6.4.8.7 Tack welding, seal welding and welding of temporary attachments is to be performed with qualified welding procedures.

6.4.8.8 Each welding pass and the final weld is to be deslagged and thoroughly cleaned.

Table 6.12 Minimum preheating and working/interpass temperature, °C, (1)

Carbon equivalent (CE) ²⁾	Maximum thickness at weld area		
	t ≤ 20 mm	20 < t ≤ 30 mm	t > 30 mm
CE ≤ 0.41	5	5	75
CE ≤ 0.43	5	50	100
CE ≤ 0.45	50	100	125
CE ≤ 0.47	100	125	150
CE ≤ 0.50	125	150	175

Notes:

1) Other temperatures may be accepted when the actual chemical composition and the welding procedure is given.

2) $CE = C + \frac{Mn}{6} + \frac{Cr + Mo + V}{5} + \frac{Cu + Ni}{15}$ (ladle analysis)

6.4.8.9 The minimum preheating and working/interpass temperatures are given in Table 6.12.

The working/interpass temperature is normally not to exceed the maximum temperature as recorded during the welding procedure test, and restricted to max. 250°C.

6.4.8.10 The reinforcement of the weld is to have a regular finish and is to merge smoothly into the base material without significant undercutting. The height of weld reinforcement is not to exceed 3 mm for material thickness $t \leq 12.5$ mm, and max. 4 mm for greater thicknesses.

6.4.8.11 Welds which are essentially perpendicular to the direction of applied fluctuating stresses in members important to the structural integrity, are normally to be of full penetration type, and if possible, welded from both sides. Dressing of welds by grinding may be required.

6.4.8.12 Grinding of welds with the intent of increasing the fatigue life and/or reduce the probability of brittle fracture is to be carried out according to agreed specifications.

6.4.8.13 The use of permanent steel backing strips is permitted when properly accounted for in the design analysis. Ceramic and inert backing strips may be used when being of approved type, see 6.1.7.1. A test weld for the intended application is to be produced and subjected to mechanical testing agreed upon in each case.

6.4.8.14 Temporary cut outs are to be made of sufficient size allowing sound replacement. Corners of cut outs are to be given appropriate radius minimizing the local stress concentration.

6.4.8.15 Fillet welds for sealing purposes are to have a leg length minimum 5 mm.

6.4.9 Repairs

6.4.9.1 General: Defects may be rectified by grinding, machining or welding. Welds of insufficient strength, ductility or notch toughness are to be completely removed prior to repair. The mechanical properties of repair welds are to satisfy the minimum specified properties of the steel in question.

Repair welding in the same area may be carried out twice. Further repairs are subject to DnV's consent.

6.4.9.2 A repair welding specification is to be prepared. In addition to the details mentioned in 6.4.2.1 the method for removal of defects, preparation of weld area and subsequent non-destructive testing as well as minimum and maximum repair length/depth are to be specified.

6.4.9.3 The use of arc-air gouging is to be followed by grinding, removing the affected material.

6.4.9.4 Whenever a discontinuity is removed, the gouged and ground area is to be examined by magnetic particle testing or other suitable method to ensure complete removal.

6.4.9.5 Repair welding is to use extra low hydrogen welding consumables applying an appropriate preheating and working/interpass temperature. Generally the preheating

and working temperature when making shallow and local repairs is to be raised 25°C above the level used for production welding, however, not less than 100°C. (See Table 6.12). The working temperature is to be maintained until the repair has been completed. To ensure sound repair welds, the single repair length is not to be shorter than approx. 100 mm.

6.4.9.6 Repair of base material: The maximum repair depth of rolled steel and steel forgings is normally to be limited to 20 % of the nominal thickness. For steel castings the maximum repair depth is to be restricted to 75 % of the nominal thickness. Casting defects are to be repaired after homogenization treatment.

Subject to DnV's consent, minor discontinuities may be removed by grinding or machining, blending the gouged area smoothly into the surrounding material.

When repair welding is carried out on steel supplied in a heat treated condition, reheat treatment may be required. Steel castings and forgings are to be post weld heat treated after repair welding.

6.4.9.7 Repair of welded joints: There are no restriction on the size of defects in the weld which may be repaired by welding. Long defects may be require repaired in several steps to avoid overloading or cracking. Each repair step is to be controlled so as not to cause plastic deformation on the remaining material when removing the defect.

Repair welding of post weld heat treated joints is normally to initiate a new heat treatment.

Frequent and extensive repairs are to initiate review, and if necessary, requalification of the welding procedures, or the welding personnel involved.

6.4.10 Heat treatment

6.4.10.1 General: Heat treating is to be performed in accordance with a procedure specification detailing heating and cooling rates, temperature gradients, soaking temperature range and time, heating facilities, insulation, control devices and recording equipment. The specification is to be submitted.

6.4.10.2 The temperature distribution throughout heating furnaces is to be controlled within a range of $\pm 15^\circ\text{C}$.

6.4.10.3 Stress relieving: Stress relieving of cold worked materials and weldments (see 6.4.8.2) is to be carried out according to conditions as specified for post weld heat treatment, see 6.4.10.5 through 6.4.10.10.

6.4.10.4 Post weld heat treatment: Post weld heat treatment is generally required for structural welds of joint thickness 50 mm and greater, unless adequate fracture toughness can be documented in the as welded conditions. (See 6.1.5.9). For restrained joints of complicated design, post weld heat treatment may be required for smaller thicknesses.

6.4.10.5 Post weld heat treatment of C-steels, C-Mn steels and C-Mn fine grain treated steels is to be performed at a soaking temperature in the range 550–600°C, for a time of

2 minutes per mm thickness. Soaking temperature for low-alloyed steel is to be decided in each case.

6.4.10.6 The temperature difference between the outside and the inside surface during soaking is not to exceed 30°C within the heated area. Double sided heating is to be applied as far as possible.

6.4.10.7 Heating and cooling is to be carried out in a manner which prevents cracking, and distortions outside the dimensional tolerances. The temperature difference along lines or planes of symmetry is normally not to exceed 30°C when the material temperature is above 300°C.

6.4.10.8 The heat treatment cycle is to be recorded using thermocouples equally spaced externally, and whenever possible internally, throughout the heated region. Heat treatment records are to be submitted.

6.4.10.9 Post weld heat treatment is, wherever possible, to be carried out in an enclosing furnace. Where it is impractical to heat treat the whole structure in a closed furnace, local heat treatment may be adopted subject to DnV consent.

6.4.10.10 When local post weld heat treatment is selected, a region extending minimum 3 times the material thickness on either side of the weld is to be kept at the specified temperature. At the edge of insulated area, on either side of the weld, the temperature is to be maximum 300°C.

6.4.11 Production tests

6.4.11.1 During fabrication and construction production tests for quality control may be asked for. Number and type of tests will be specified in each case.

Production tests may, when agreed upon with DnV, replace welding procedure qualification tests.

6.4.12 Tolerances

6.4.12.1 Tolerances on dimensions during fabrication and construction are to be specified in detail and complied with.

6.4.12.2 These tolerances are not to exceed the values assumed in the design analysis, see 6.2.1.4.

6.4.13 Underwater welding

6.4.13.1 Underwater welding may be used for construction and repair.

Underwater welding is generally to be carried out in a large chamber from which the water has been evacuated (habitat welding) using a low hydrogen welding process.

Underwater wet welding, characterized by the arc working in the water or in a small gas-filled confinement, is normally restricted to minor repair work in comparatively shallow water.

6.4.13.2 A detailed welding procedure specification is to be established and submitted for review. In addition to the

information asked for in 6.4.2.1 the maximum and minimum water depth, the gas composition the maximum humidity level, the temperature fluctuations and pressure inside the habitat or confinement is to be specified.

6.4.13.3 The welding procedure is to be qualified by conducting a simulated test at the actual site of welding or at a testing facility. The test is to be carried out at maximum water depth or at similar conditions as for the underwater welding operation.

6.4.13.5 Qualification of welding procedures for underwater welding is to follow the scheme given for welding above water, see 6.4.3. If the fabricator can not document previous experience of similar work, extended testing may be required.

6.4.13.6 Limitations of a qualified procedure: In addition to the essential variables specified for welding above water (see 6.4.5.2) the essential variables of 6.4.5.3 apply.

6.4.13.7 Qualification of underwater welders: Only welders trained for welding above water are permitted to qualify for underwater welding. See Appendix C8.

6.4.13.8 Each welder is to be qualified for welding the complete joint. The applicability of underwater welders qualification will be evaluated by DnV in each case.

6.4.13.9 When the welder has been employed by a new fabricator/contractor, or has interrupted welding more than 3 months, a new performance test is to be conducted unless otherwise agreed. Requalification is to be carried out regularly.

6.4.13.10 Storage of electrodes: Electrodes to be used for underwater welding are to be stored as described in 6.4.7.4.

6.4.13.11 Transferring and handling of electrodes: A procedure for transferring of electrodes from the sealed containers and through the water into the welding habitat is to be submitted for approval. The electrodes are to be baked at a temperature advised by the manufacturer, prior to transferring into canisters. The canisters are to be filled with a dry inert gas at a pressure exceeding the habitat pressure by 1 bar.

Electrodes in the welding habitat are to be kept in heated containers at a temperature 70° to 100°C. The exposure time is not to exceed 2 hours.

6.4.13.12 Production test welds: Prior to commencing the actual welding, test welds are to be produced to check that all systems are properly functioning and resulting in sound welds.

Production test welds are to be prepared at the actual site of welding in a manner which, as far as possible, reproduces the actual welding conditions. Number and positions of test coupons will be specified by DnV.

6.4.13.13 The production test welds are to be visually inspected and non-destructive tested using agreed methods and procedures prior to the actual welding. The production test welds are to be subject to mechanical testing. Number and type of tests will be specified in each case.

6.4.13.14 Non-destructive testing: The permanent welds are to be visually inspected and non-destructive tested. Methods and extent of testing will be evaluated in each case. The finished welds are to comply with the soundness specified for the structural part.

All non-destructive testing is to be carried out by competent operators following qualified or accepted procedures, see 6.5.

6.4.14 Corrosion protection

6.4.14.1 Surface preparation and coating application are to be carried out in accordance with the approved specification, see 6.3.6.1 and 6.3.6.2.

6.4.14.2 Sacrificial anodes are to be installed according to the approved specification, see 6.3.7.1, 6.3.7.8 and 6.3.7.13.

6.4.14.3 Impressed current systems are to be installed according to the approved specification, see 6.3.8.2–3 and 6.3.8.6.

6.5 Inspection and testing

6.5.1 Welding inspection

6.5.1.1 Welds are to be subjected to visual inspection and non-destructive testing as fabrication and construction proceeds. Final non-destructive testing is normally to be carried out not earlier than 48 hours after completion of the welds in question. When post weld heat treatment is performed, the final non-destructive testing is normally to be carried out when all heat treatments have been completed.

6.5.1.2 All welds are to be visually inspected full length. All welds participating in the overall integrity of the structure and which will become inaccessible or very difficult to inspect in service, are to be non-destructive tested full length.

All other welds, unless otherwise agreed, are to be non-destructive tested to an extent as indicated in Table 6.13. The percentages refer to total length of weld for each structural assembly in question.

6.5.1.3 Ultrasonic testing may be substituted by radiography and visa versa, when considered suitable in agreement with DnV, (apart from cases where both methods are required).

6.5.1.4 When gas metal arc welding is applied, ultrasonic – and magnetic particle testing is normally required in addition to radiographic testing.

6.5.1.5 The non-destructive testing is particularly to cover intersection of butt welds, cruciform joints and other areas where the stress level is high, as well as start and stop points of automatically welded seams.

6.5.1.6 Areas which have been strained in the thickness direction by welding, are to be ultrasonically tested for lamellar tearing.

6.5.1.7 If non-destructive testing reveals defects which indicate unacceptable weld quality, the Surveyor may require increased extent of testing, until the specified overall quality level has been re-established.

If severe defects (i.e. cracks and other planar defects, excessive slaglines and cluster porosities) occur repeatedly, all welds made with the same welding procedure during the period in question, are to be tested full length.

6.5.1.8 The Surveyor shall have the right of being final judge in assessment of weld quality.

6.5.1.8 All non-destructive testing is to be properly documented and identified in such a way that the tested areas may be easily retraced during fabrication and construction, and after completed installation of the structure.

6.5.2 Selection of method for non-destructive testing of welds

6.5.2.1 Methods for non-destructive testing are to be chosen with due regard to the conditions influencing the sensitivity of the methods.

Appropriate methods will be evaluated in each case.

6.5.3 Radiographic testing of welds

6.5.3.1 A procedure specification for the radiographic testing is to be established, which is at least to include the following information:

- Joint configuration and dimensions.
- Radiation source (X-rays or gamma rays. If gamma rays; type of isotope).

- Technique. (Equipment rating in voltage or curie, external or internal equipment.)
- Geometric relationships. (Source focal spot size, film-focus distance, object-film distance, radiation angle with respect to weld and film.)
- Film type. (Trade name and designation.)
- Intensifying screens. (Front and/or back, material, thickness.)
- Exposure conditions. (kV, mA min, mCi min.)
- Processing. (Developing time/temperature, stop-bath, fixation, washing, drying, etc.)
- Image Quality Indicator sensitivities in percent of the wall thickness, based on source and film side indicators respectively.
- Density. (The density of the radiographs measured on the sound weld metal and adjacent base material images.)
- Film coverage. (Film lengths within limits given in 6.5.3.4).

6.5.3.2 The radiographic procedure is to be qualified by making two radiographic exposures of a welded joint with the same or typical configuration and dimensions, and of material equal to or similar to that which is to be used in the structure.

Image Quality Indicators of the wire type and of required number (according to the recommendations of document IIW/IIS-62-60) are to be placed on both the film side and the source side.

Table 6.13 Minimum extent of non-destructive testing – structural welds

Steel classification ¹⁾	Type of connection	Visual inspection	Welds always in ²⁾ atmospheric zone			Welds always in ²⁾ splash or submerged zone		
			Radiography	Ultrasonic	Magnetic particle	Radiography	Ultrasonic	Magnetic particle ⁶⁾
Special	Buttwelds ³⁾	100%	10%	100%	20%	20%	100%	100%
	T-joints ³⁾		—	—	100%	—	100%	100%
	Fillet welds		—	—	100%	—	—	100%
Primary	Buttwelds ³⁾	100%	10%	10–20% ⁴⁾	10%	10%	20%	20%
	T-joints ³⁾		—	10–20% ⁴⁾	20%	—	20%	100%
	Fillet welds		—	—	20%	—	—	100%
Secondary	Buttwelds ³⁾	100%	spot ⁵⁾	spot	spot	spot	spot	spot
	T-joints ³⁾		—	spot	spot	—	spot	5%
	Fillet welds		—	—	spot	—	—	5%

- Notes:
- 1) Classification of structural steels is defined in 6.1.1.
 - 2) Atmospheric, splash and submerged zones are defined in 6.3.2.
 - 3) Applies to all full penetration welds, and partial penetration welds with weld metal cross section of more than 12,5mm.
 - 4) 10% testing applies to welded joints which are mainly subjected to static loading. 20% testing applies to welded joints which are exposed to significant fluctuating load.
 - 5) "Spot" means 0–5% to the Surveyor's discretion.
 - 6) Magnetic particle testing to be applied for both external and internal surfaces, as accessible.

921

The image quality indicators are to be clearly identified, and the sensitivity of the source side indicator is to be equal to or better than the requirements given in Figure 6.2. (During production radiography, in cases where the source side is inaccessible, only film side indicators are required.)

Exposed radiographs are to have an average H & D density at the sound weld metal image of 1,8–2,5.

6.5.3.3 Radiographers are to be fully capable of performing a satisfactory operational test using the qualified radiographic procedure.

6.5.3.4 For production radiography, only approved radiographic procedures are to be used.

If the panorama technique is used to include 100 percent of a tubular girth weld in one exposure, a minimum of three penetrameters are to be equally spaced around the circumference.

If the multiple exposure technique is used, at least one penetrometer is to be recorded on each film.

The maximum acceptable film lengths are limited by a 6 percent increase of the wall thickness in the beam direction.

All films are to be clearly marked to identify the proper weld, and so that any discontinuities can be quickly and accurately located. DnV may specify the identification system.

6.5.3.5 The radiographers are to report the weld quality assessment of all radiographs. The report is to indicate if the weld quality meets the requirements of 6.5.6, which defects have been judged unacceptable, and the number of repairs made to meet the requirements.

6.5.4 Ultrasonic testing of welds

6.5.4.1 The equipment used for ultrasonic testing is to:

- be applicable for the pulse echo technique and for the double-probe technique
- cover as a minimum the frequency range from 2–6 MHz
- have a flat screen accessible from the front for direct plotting of reference curves
- allow echos with amplitudes of 5 percent of full screen amplitude to be clearly detectable under test conditions
- include straight beam transducers, and angle beam transducers of 45°, 60°, 70° and 80°.

6.5.4.2 A procedure specification for the ultrasonic testing is to be established, which is at least to include the following information:

- Type of instrument
- Type of transducers
- Frequencies
- Calibration details
- Surface requirements
- Type of couplants
- Scanning techniques
- Recording details
- Reference to applicable welding procedures

6.5.4.3 The ultrasonic testing procedure may be required qualified through a procedure qualification test.

The test is to be performed under normal working conditions in the presence of a Surveyor.

$$\text{IQI sensitivity} = \frac{\text{diameter of the smallest wire still visible} \times 100}{\text{thickness of the weld}} \quad (\text{percent})$$

Figure 6.2 Required IQI sensitivity. – Source side penetrometer

Note: For production radiography; sensitivity readings based on film side penetrameters are to be judged as per results from the procedure qualification.

The test pieces are to be available as reference during the inspection work.

For stationary testing equipment, the procedure test is to be performed on test pieces containing artificial defects of types which the testing procedure is intended to detect.

For portable equipment, reference blocks as described in Figure 6.3 will normally be considered satisfactory as test pieces. Whenever groove geometry, welding method or other factors may cause special problems in flaw detection, Preparation of special test pieces may be required.

L = length of reference block given by probe angle and material range to be covered.

T = thickness of reference block.

B = width of reference block, minimum 40 mm.

D = Diameter or drilled hole.

P = Position of drilled hole.

Actual wall thickness t in mm	Thickness of ref. block T in mm	Position of drilled hole P in mm	Diameter of drilled hole D in mm
up to 25	20 or t	T/2	2,4
above 25 up to 50	38 or t	T/4	3,2
above 50 up to 100	75 or t	T/4	4,8

The hole diameter may be required reduced when groove geometry and/or welding process give reasons to expect special types of defects, giving small reflections.

Figure 6.3 Blocks for construction of reference curves

6.5.4.4 Calibration of the ultrasonic equipment is to be carried out whenever it has been out of function for any reason including on/off, and whenever there is any doubts concerning proper functioning of the equipment.

For stationary testing equipment, the test pieces described in 6.5.4.3 may also be used as calibration references. Other calibration references are to be evaluated in each case. It will be the responsibility of the manufacturer/inspection agency to provide complete information as a basis for such evaluation.

For portable testing equipment the IIW/ISO calibration block is to be used for calibration of range and for angle determination. The V2 calibration block according to DIN 54122 may be used for calibration of range only.

For evaluation of flaw indications, a reference curve is to be established. The curve shall be plotted on the instrument screen.

A reference block is to be used for gain calibration and construction of reference curves. The reference block is to be manufactured from the actual production material and have dimensions according to Figure 6.3.

As shown in Figure 6.4, the sound path from point A to the reference reflector is not to be less than 0,6 N where N is the nearfield length of the probe.

The echo height from position A is to be maximized, and the gain control regulated so that the echo height is 75 percent of full screen height. This gain setting is called the *primary gain* and is to be recorded. Without altering this gain setting, the maximized echo-heights from points B and C are to be plotted on the screen. The *reference curve* is now to be drawn as a smooth line through the three points. Curves being respectively 20 percent and 50 percent of the reference curve are also to be constructed.

The primary gain is to be corrected for differences in surface character and attenuation between the reference block and the actual work piece by means of the double probe technique. See Figure 6.5. The gain correction necessitated by such difference is to be max. 6 dB.

Figure 6.4 Construction of reference curves

Figure 6.5 Attenuation and surface correction.
Double probe technique

6.5.4.5 The ultrasonic operators are to be capable of:

- calibrating the equipment
- performing a satisfactory operational test under production conditions
- interpreting the screen display
- evaluating size and location of reflectors

6.5.4.6 For ultrasonic testing, the contact surface is to be clean and smooth, i.e. free from dirt, scale, rust, weld spatter, etc. which may influence the results of the testing.

6.5.4.7 The weld is normally to be examined from at least two sides as shown in Figures 6.6 and 6.7.

For defect detection, the corrected primary gain (according to 6.5.4.4) is to be increased by 6 dB.

No defect size evaluation is permitted at this increased gain level.

All echos which exceed 20 percent of the reference curve, when examining at the increased gain level (i.e. corrected reference gain level + 6 dB), are to be subjected to defect size evaluation.

The defects are to be investigated by maximizing the echos with different angle probes and by rotating the probes.

For dimensional evaluation, either the "20 dB-drop" method or the "half-value-drop" method is to be used.

6.5.4.8 The ultrasonic operators are to report all defects from which the echo exceeds 50 percent of the reference curve. The report is to show if the weld quality meets the requirements of 6.5.6, and the number of repairs made to meet the requirements.

Figure 6.6 Probe movement for testing of butt welds

Figure 6.7 Detection of transverse cracks

9th

6.5.5 Magnetic particle testing of welds

6.5.5.1 The equipment used for magnetic particle testing is to establish a field strength between 2400 A/m (300 e) and 4000 A/m (500 e). This needs not to be proven by measurement in case of yoke, coil or prod magnetizing, provided the following requirements are met:

- AC electromagnetic yokes are to have a lifting power of at least 5 kp and a pole spacing of 75–100 mm.
- DC electro- or permanent magnetic yokes are to have a lifting power of at least 20 kp and a pole spacing of 75–100 mm.
- The coil magnetizing current is to be chosen depending on the number of turns on the coil. The ratio between the ampere-turns and the diameter of the pipe/work piece to be tested is to be 8–16 ampere-turns per mm.
- For prod magnetizing, alternating or half-wave rectified magnetizing current is to be used. For sections of thickness 20 mm or more, the prod spacing is to be less than 300 mm, and the current is to be 4–5 A per mm prod spacing. For sections of thickness less than 20 mm, the current is to be 3,5–4,5 per mm prod spacing.

6.5.5.2 A procedure specification for the magnetic particle testing is to be established, which is at least to include the following information:

- Materials and dimensions
- Type of magnetization
- Type of equipment
- Surface preparation
- Wet or dry method
- Make and type of magnetic particles and contrast paint
- Magnetizing current. (For prod magnetizing, the prod type and spacing is to be stated.)
- Demagnetization
- Description of examination technique

6.5.5.3 No special procedure qualification test is required. The procedure is considered qualified based on approval of the testing procedure specification.

6.5.5.4 Operators performing magnetic particle testing are to be capable of performing a satisfactory operational test, using the test method and technique which is to be applied in production.

6.5.5.5 The surface of the parts subjected to test is to be dry and clean, free from dirt, grease, oil, lint, scale, welding flux etc. which may interfere with the examination.

To ensure detection of discontinuities having axes in any direction, the examination is to be performed with the magnetic field shifted in at least two directions on each area (90° turned).

Non-fluorescent wet or dry particles are to provide adequate contrast with the background of the surface being examined.

Examination with fluorescent magnetic particles is to be

conducted in a darkened area using filtered ultraviolet radiation with wave lengths within the range of 3200–3800 Å.

Magnetic particle examination is not to be performed on parts with surface temperature exceeding 300°C (570°F).

Wet magnetic particle examination is not to be performed on parts with surface temperature exceeding 60°C (140°F).

Care should be taken to avoid local heating of the test surface. Prods tipped with lead, or "soft prods" are recommended.

Arc strikes and burn marks are to be ground out and inspected.

6.5.5.6 The magnetic particle examination operators are to report all surface defects as detected. The report is to show if the weld quality meets the requirements of 6.5.6 and the number of repairs made to meet the requirements.

6.5.6 Standards of acceptability

6.5.6.1 The soundness of welds is to comply with the standards of acceptability as set forth in 6.5.6.2 through 6.5.6.7, unless otherwise is specifically agreed.

The given limits may, however, in certain cases be restricted or relaxed to DnV's discretion, depending on factors such as; significance of the particular joints to the integrity of the structure, ratio of static/dynamic loading, length of defective area versus total length of weld, distance of defect from edge of plate (end of weld) etc.

Also, defects exceeding the given limits may after agreement be assessed on the basis of fracture mechanical testing, or by relevant previously documented experience.

Defect assessment based on fitness for purpose criteria is to account for both local stress conditions, and limitations of the non-destructive testing methods to evaluate location and size of defects during fabrication, construction and service of the structure.

6.5.6.2 *Radiographic testing:* In general, welds which are shown to contain defects exceeding the limits given in Tables 6.14 and 6.15 are to be repaired and re-radiographed.

6.5.6.3 Since radiography gives two dimensional results only, the Surveyor may reject welds which appear to meet the limits, if the depth of the defect may be detrimental to the efficiency of the joint.

6.5.6.4 *Ultrasonic testing:* In general, if ultrasonic testing as per 6.5.4.7 reveals defects of any length from which the echo height exceeds the reference curve, the area is to be repaired and re-examined.

If only one side of the weld is accessible for testing, all indications giving echos which exceed 50 percent of the reference curve are to be repaired and re-examined.

6.5.6.5 Since ultrasonic testing in principle detects reflectors in the material, all indications are to be considered as the most dangerous type of defect until otherwise proved.

6.5.6.6 When supplementary non-destructive testing or mechanical sampling of production welds proves that the defects in question are porosity, slag inclusions, slag lines or incomplete penetration, repair is required only when the dimensions of the defects exceed the limits as per 6.5.6.2.

6.5.6.7 *Magnetic particle testing*: In general, welds which are shown to have surface defects exceeding the limits given in tables 6.14 and 6.15 are to be repaired and re-examined.

Table 6.14 Acceptance Limits for Weld Defects – Non-destructive Testing for Special- and Primary steel Structures

Type of defect	Size limits	Note*)
INTERNAL DEFECTS:		
Porosity	<p><i>Scattered porosity</i>: Max. 1 percent by project area. Largest pore dimension $t/8$, max. 2mm.</p> <p><i>Cluster porosity</i>: Max. 3 percent by projected area. Largest pore dimension $t/16$, max. 1mm.</p> <p>Porosity on line is not to penetrate the weld surface.</p>	1
Slag inclusions	<p><i>Isolated slag</i>: Length $\leq t/3$, width $\leq t/8$, max. 2mm.</p> <p><i>Slag lines</i>: Length $\leq 2 \cdot t$, max. 50mm, width $\leq 1,5\text{mm}$.</p> <p>The width of each of parallel slag lines (wagon track) is not to exceed 1mm.</p>	2, 3, 4
Lack of fusion or Incomplete penetration	<p>Length $\leq t$, max. 25mm</p> <p>If ultrasonics prove the defect not to exceed the reference curve, length $\leq 50\text{mm}$.</p>	2, 3, 4
Cracks	Not acceptable	5
SURFACE DEFECTS:		
Lack of fusion or Incomplete penetration	Not acceptable	
Undercut	Not acceptable	
Cracks	Not acceptable	5

*) See bottom of page 38.

Table 6.15 Acceptance Limits for Weld Defects – Non-destructive Testing for Secondary Steel Structures

Type of defect	Size limits	Note
INTERNAL DEFECTS:		
Porosity	<p><i>Scattered porosity:</i> Max. 3 percent by projected area. Largest pore dimension $\leq t/4$, max. 4mm.</p> <p><i>Cluster porosity:</i> Max. 10 percent by projected area. Largest pore dimension $\leq t/8$, max. 2mm.</p> <p>Porosity on line is not to penetrate the weld surface.</p>	1
Slag inclusions	<p><i>Isolated slag:</i> Length $\leq t/2$, width $\leq t/4$, max. 4mm.</p> <p><i>Slag lines:</i> Length $\leq 4 \cdot t$, max. 100mm. Width ≤ 2mm.</p> <p>The width of each of parallel slag lines (wagon track) is not to exceed 1,5mm.</p>	2, 3, 4
Lack of fusion or Incomplete penetration	<p>Length $\leq 2 \cdot t$, max. 50mm.</p> <p>If ultrasonics proves the defect not to exceed the reference curve, length ≤ 100mm.</p>	2, 3, 4
Cracks	Not acceptable	5
SURFACE DEFECTS:		
Lack of fusion or Incomplete penetration	Length $\leq t/2$, max. 10mm	2, 3, 7
Undercut	Shallow undercut of max. 0,3mm depth may be accepted regardless of length provided it's shape and degree of notch effect is not considered detrimental by the Surveyor.	3, 6, 7
Cracks	Not acceptable	5

NOTES TO THE ACCEPTANCE LIMITS

- 1) See porosity chart Figure 6.8. When the extent of porosity or slag inclusions may mask for detection of other defects, supplementary radiographic or ultrasonic examination is required.
- 2) If elongated defects are situated on line and the distance between them is less than the length of the longest indication, the defects are to be evaluated as one continuous defect.
- 3) Any accumulations of slag inclusions, incomplete penetration, misalignment or undercut are to be judged as the most serious of the defects in question.
- 4) Not more than one time the defect limits as per notes 2 and 3 within any continuous length of weld which equals five times the length of the defected area.
- 5) Repeated occurrence of cracks should initiate more extensive non-destructive testing of the joints and revision of the welding procedure.
- 6) The depth is to be measured by mechanical means.
- 7) Severe corrosive environment may necessitate more stringent requirements to be adopted.

1mm PORE DIAMETER

10 PER CENT

3 PER CENT

1 PER CENT

2mm PORE DIAMETER

10 PER CENT

3 PER CENT

4mm PORE DIAMETER

10 PER CENT

Figure 6.8 Typical distribution of porosity by projected area

986

6.5.7 Inspection of corrosion protection systems.

6.5.7.1 Coating systems are to be inspected and tested for conformance with specification, as per 6.3.6.3.

6.5.7.2 Sacrificial anodes are to be inspected and tested during manufacture, as per 6.3.7.8.

6.5.7.3 The attachments for sacrificial anodes are considered as secondary structural steel and the welds are to be inspected and tested accordingly, (see Table 6.13).

6.5.7.4 Testing of effectiveness of cathodic protection systems is to be carried out in accordance with 6.3.9.1 through 6.3.9.3.

SECTION 7

CONCRETE STRUCTURES

7.1 General

7.1.1 Notation

7.1.1.1 In addition to the definitions and notations given in Section 1 the following symbols have been used throughout Section 7.

b	width of section
h	overall depth of section
d	effective depth of section
e	eccentricity
ϕ	diameter of reinforcing bar
c	cover to reinforcement
x	depth of compression zone
A_c	gross area of concrete section
A_s	area of longitudinal reinforcement
A_{sv}	area of transverse reinforcement
ρ	reinforcement ratio = A_s/A_c
I_c	second moment of area of concrete section about the principal axis
W_c	elastic section modulus of concrete section
f_{sk}	characteristic strength of reinforcement
f_{sr}	design strength of reinforcement
f_{sy}	yield strength of reinforcement
$f_{0.2}$	0,2 % proof stress of reinforcement
$\Delta\sigma_s$	variation in stress in prestressing reinforcement with reference to the stress at zero strain in concrete
f_{ck}	characteristic compressive strength of concrete
f_{cr}	design compressive strength of concrete
f_{vk}	characteristic shear strength of concrete
f_{vr}	design shear strength of concrete
f_{tk}	characteristic tensile strength of concrete
f_{tr}	design tensile strength of concrete
P	prestressing force

In addition to those given in Section 1 the following subscripts are used:

c: concrete, compressive
s: reinforcement
v: shear
t: tensile

Other symbols are defined in the text.

7.2 Materials

7.2.1 General

7.2.1.1 Specifications or certificates for materials to be used in construction are to be submitted to DnV for approval. It is to be documented that the properties of materials under consideration are adequate for the intended purpose.

7.2.1.2 Materials are to be clearly marked for identification. Incompletely identified materials are normally to be rejected.

7.2.1.3 DnV may require appropriate tests to be carried out to demonstrate that the materials have properties suited for the proposed construction procedure.

7.2.2 Concrete constituents

7.2.2.1 *Cement*: The following types of cement are normally acceptable: Ordinary, Modified, Rapid hardening, Low-heat, Sulphate resistant, Blastfurnace or Pozzolanic Portland Cements (ASTM-types I, II, III, IV, IS and IP).

Different types of cement are normally not to be mixed.

The content of tricalciumaluminate (C_3A) in the cement is to be related to the risk of sulphate attack on the concrete and the reinforcement.

Guidance: See Appendix D1 for testing of cement.

7.2.2.2 *Water*: Water is to be free from contamination in amounts likely to harm the reinforcement or the concrete.

7.2.2.3 *Aggregates*: Aggregates shall have sufficient strength and durability.

Aggregates containing potentially reactive or deleterious constituents (e.g. certain reactive siliceous or carbonaceous mineral constituents, salts, sulphates, clay, silt, fine dust, excessively flat or long particles, organic matter or other impurities) shall not be used.

Aggregates shall be properly graded.

7.2.2.4 *Admixtures*: The use of admixtures is subject to approval by DnV.

When more than one admixture is used in the same concrete mix, it is to be documented that the admixtures are compatible. Calcium chloride ($CaCl_2$) is not to be used.

Certificates for admixtures are not to be more than two years old when presented to DnV for approval.

The minimum required documentation is described in Appendix D2.

7.2.3 Properties of concrete

7.2.3.1 To give the structural concrete sufficient durability against chemical and physical attack, and to protect the reinforcement, the coefficient of permeability of the concrete should preferably not exceed 10^{-12} m/s. Guidance on methods of testing permeability is given in Appendix D3.

This low permeability may normally be obtained by employing means such as;

— selection of sound, dense aggregates

- proper grading of fine and coarse aggregates
- use of rich mixes with a minimum cement content of 300 kg/m³
- use of low water-cement ratio, preferably less than 0,40, but not exceeding 0,45
- good concreting practice and good workmanship (including precautions against segregation, adequate workability, proper handling, transporting, placing and consolidation).

7.2.3.2 In the splash zone the cement content is not to be less than 400 kg/m³.

7.2.3.3 Steps are to be taken to ensure that shrinkage, heat of hydration, lifting of slipforms and similar effects do not cause surface cracking which adversely affects the performance or durability of the structure.

7.2.3.4 The total amount of chlorides in the fresh concrete, calculated as free calcium chloride, is not to exceed 0,3 % of the weight of cement.

7.2.3.5 Parts of the structure that may be subject to freezing and thawing are to have adequate frost resistance. This requirement may be considered to be satisfied if the air content in fresh concrete made with natural aggregates is at least 3 % for a maximum particle size of 40 mm, or at least 5 % for a maximum particle size of 20 mm. The air pores should be evenly distributed, with a calculated spacing factor not exceeding 0,25 mm.

7.2.4 Properties of grout for prestressing tendons

7.2.4.1 Grout is normally to be composed of Ordinary Portland cement, fresh potable water and admixtures. Aggregates may be used in large ducts with sufficient free area.

7.2.4.2 The minimum characteristic compressive strength at 28 days is to be 30 MPa found from tests on cylinders with a diameter to height ratio of 1 : 2.

7.2.4.4 The total amount of chlorides in grout, calculated as free calcium chloride, is not to exceed 0,05 % of the weight of cement.

7.2.4.5 Separation of water from cement paste (bleeding) at 20°C is not to exceed 2% by volume three hours after mixing. The separated water is to be reabsorbed after 24 hours.

7.2.4.6 The plastic shrinkage of grout is not to exceed 2 %.

7.2.4.7 The total free volume expansion of grout is to be limited to 10 %.

7.2.5 Reinforcement

7.2.5.1 *Normal reinforcement:* Normal reinforcing steel shall satisfy the requirements of the recognized standard. The following items shall normally be included in the documentation submitted;

- manufacturing process
- minimum guaranteed yield strength or 0.2 % proof stress

- margin of ultimate strength over yield or proof stress
- stress-strain curves
- tensile elongation at maximum stress
- bend and rebend properties
- bond properties
- fatigue properties, where relevant.

7.2.5.2 *Weldable reinforcement:* Reinforcing steel to be welded is to comply with the requirements concerning chemical composition given in 6.1.4 unless otherwise agreed.

7.2.5.3 *Prestressing reinforcement:* Prestressing tendons may be in the form of wires, bars, strands or cables.

Due attention should be paid to the risk of brittle fracture of high tensile bars.

In addition to the general requirements of 7.2.5.1 the following documentation for each type of prestressing steel and system is to be submitted;

- chemical composition of steel
- resistance against stress corrosion
- fatigue properties, if applicable
- fracture toughness, if applicable
- test data on relaxation
- adequacy of anchorages and splices
- parameters, based on statistical data, governing losses of prestress due to losses in anchorages and due to friction in ducts.

7.2.6 Other materials

7.2.6.1 The adequacy of materials such as epoxies, special mortars etc. is to be verified by procedure tests under site conditions.

7.2.6.2 It is to be documented that these materials possess the long- and short-term mechanical, physical and chemical properties required to ensure proper durability and acceptable safety of the structure.

7.3 Design parameters for concrete

7.3.1 Strength

7.3.1.1 *Compressive strength:* The 28 days characteristic strength f_{ck} found from 150 x 300 mm cylindrical specimens tested in accordance with RILEM recommendation CPC4 is the basis for determination of the compressive strength of concrete. (See 4.4.3.2 for definition of characteristic strength).

An increase in the characteristic strength with time, above the 28 days strength, may be taken into account. The increase assumed should be based on well established experience and verified by tests.

In cases where structural parts will be subjected to loads earlier than 28 days, the design strength is to be based on the characteristic strength corresponding to the actual age.

For determination of resistance, an idealized parabolic/rectangular stress-strain diagram as shown in Figure 7.1 is to be used.

Figure 7.1 Stress-strain relationship for concrete to be used for determination of resistance.

Other diagrams may be used provided the results obtained either agree sufficiently well with those obtained from the above diagram or are always on the safe side.

7.3.1.2 Tensile strength: An estimate of the tensile strength of concrete may be derived from the characteristic compressive strength. The values used for design should normally be confirmed by tests.

Guidance: See Appendix D4.

7.3.1.3 Shear strength: Components of shear strength are given in 7.6.5.

7.3.1.4 Bond strength: The values for bond strength are to be in accordance with the recognized standard. See also 7.6.8.1.

7.3.2 Elastic parameters

7.3.2.1 The short term modulus of elasticity E_c may be taken from the recognized standard. When the materials to be used in construction are known, the actual modulus of elasticity should be determined by tests in accordance with RILEM CPC 8, and the design checked and revised where necessary.

7.3.2.2 Variation of E_c with strain-rate may be taken into account where appropriate.

7.3.2.3 Poisson's ratio may be taken as 0.2.

7.3.2.4 The influence of creep, shrinkage and thermal effects is to be taken into account where appropriate.

7.4 Design parameters for reinforcement

7.4.1 Strength

7.4.1.1 The characteristic strength of normal reinforcement is the guaranteed minimum yield strength.

For high strength steel without a distinct yield point the 0.2 % proof stress is to be used.

7.4.1.2 For determination of resistance, a characteristic stress-strain curve typical for the actual type of steel is to be used. The design stress-strain curve is derived from the characteristic curve as shown in Figure 7.2.

Figure 7.2 Stress-strain relationship for reinforcement to be used for determination of resistance.

7.4.2 Elastic parameters

7.4.2.1 The modulus of elasticity E_s for normal reinforcement may be taken as $2.1 \cdot 10^5$ MPa.

7.4.2.2 For prestressing reinforcement, the design values of the modulus of elasticity, relaxation and friction properties should be in accordance with values guaranteed by the manufacturer.

7.5 Loading effects

7.5.1 General

7.5.1.1 The general principles for determination of loading effects given in Section 4 are valid for concrete structures.

7.5.2 Analytical models

7.5.2.1 The analytical model may normally be based on linear elastic theory.

Where cracking, creep or other causes may lead to significant redistribution of the loading effects, this redistribution is to be duly considered.

7.5.2.2 The effect of water under high pressure penetrating into possible cracks is to be considered.

7.5.2.3 For plate and shell structures the loading effects determined from linear elastic theory will in general include pronounced peaks. Such peaks may be reduced to a mean value over a certain width of the section considered. This width is to be evaluated in each case and each limit state according to recognized principles.

7.5.3 Yield line theory

7.5.3.1 Yield line theory may be used as the basis for design in the ULS and PLS provided the following conditions are satisfied;

- the load carrying capacity will be governed by a ductile mode of failure
- second order effects will be negligible
- the plastic hinges along the yield lines will allow sufficient rotation.

Compliance with the above requirements is to be verified by recognized methods.

7.5.4 Effects of deformation loads

7.5.4.1 The loading effects may be calculated using linear theory of elasticity. Reduction in the loading effects due to cracking should in general be considered, and is to be considered where the deformation loads may act favourably.

Guidance: See Appendix D5.

7.6 Ultimate limit state

7.6.1 General

7.6.1.1 The requirements given in 7.6.3 through 7.6.7 are in general applicable to structural members where the ratio between the effective depth of the member and the distance between the points of zero bending moment is less than 0,5. If this ratio is greater than 0,5, assumptions relevant to other types of structural members such as deep beams, corbels etc. should be applied.

7.6.1.2 Whenever geometrical imperfections may effect the load carrying capacity significantly, construction tolerances are to be specified by the designer and introduced in the calculations with their most unfavourable limits. If the specified tolerances are exceeded during construction, measured values of imperfections are to be used.

7.6.1.3 The determination of structural resistance as outlined in 7.6 is based on the uniaxial design strength of concrete. An increase in strength due to biaxial or triaxial stress may be allowed for, if adequately documented.

7.6.2 Material coefficients

7.6.2.1 The material coefficient for concrete is $\gamma_m = 1,5$.

A value of $\gamma_m = 1,4$ may be used provided the following conditions are satisfied;

- the laboratory strength testing shows a coefficient of variation less than 0,1
- the fabrication control verifies that a uniform and satisfactory concrete quality has been obtained in the structure.

7.6.2.2 The material coefficient for reinforcement is $\gamma_m = 1,15$.

7.6.3 Resistance against bending moment and axial force

7.6.3.1 The structural resistance of a concrete section subject to bending and axial force is to be determined on the following assumptions;

- plane sections remain plane
- the tensile strength of the concrete is neglected

- the stress – strain relationships for concrete and reinforcement are those given in Figure 7.1 and Figure 7.2.

7.6.3.2 The maximum resistance of a reinforced concrete section against axial loads is to be limited to

$$N_r = 0,85 \cdot (0,85 \cdot f_{cr} \cdot A_c + f_{sr} \cdot A_s) \quad (7-1)$$

7.6.4 Structural instability

7.6.4.1 *General:* Structures for which second order effects cannot be neglected are to be designed for the combined effects of the loads and the associated displacements of the structure.

The effects of geometrical imperfections and of non-linear material properties are to be considered.

The design of neighbouring elements is to take account of the possible second order effects transmitted at the connections.

7.6.4.2 *Basic calculation principles:* The displacements are to be calculated using realistic moment-curvature relationships. The effects of creep and cracking are to be considered where appropriate.

In the deformed state, full correspondence shall exist between strains and displacements, and between section forces and loadings.

The determination of sectional resistance is to be based on the stress-strain relationships given in 7.3 and 7.4.

7.6.4.3 *Approximate methods:* As a completely correct non-linear analysis of reinforced concrete is rather comprehensive and difficult, it will often be necessary to use simplified methods.

A simplified method will in general be considered acceptable if it can be proved that, for a certain acceptable state of deformation, the design loading effects will not exceed the corresponding design resistances.

Guidance: See Appendix D6.

7.6.5 Shear resistance

7.6.5.1 *General:* The recommendations given in 7.6.5 are based on the principle of addition of component resistances to determine the total shear resistance. This method has proved valid for shear forces combined with moderate bending moments and axial forces. For simultaneously occurring high bending moments and axial forces, the method may give inaccurate results and should be used with care, see Appendix D7. The formulas given are limited to beam and shell elements loaded and supported in such a way that any tensile forces applied perpendicular to the element plane are taken by extra reinforcement properly anchored.

Alternatively to the recommendations given in 7.6.5.2 through 7.6.5.5 the load carrying capacity may be determined from an analytical model using a failure criterion for the biaxial state of stress in the compression zone. The

analytical model should represent a realistic state of stress and the critical mode of failure. The validity of the method and the chosen failure criterion is to be documented.

Guidance: See Appendix D7.

7.6.5.2 Components of shear resistance: The total shear resistance, V_r , is expressed as the sum of the following components:

$$V_r = V_{cr} + V_{pr} + V_{sr} \quad (7-2)$$

where

V_{cr} is the shear resistance due to the concrete and the longitudinal reinforcement.

V_{pr} is the shear resistance due to prestress or axial force.

V_{sr} is the shear resistance provided by shear reinforcement.

The total shear resistance is not to be taken greater than

$$V_{r,max} = 0,25 \cdot f_{cr} \cdot b \cdot d \quad (7-3)$$

When checking the maximum resistance, the short span effect according to 7.6.5.5 is not to be considered.

7.6.5.3 The component V_{cr} : The shear resistance due to the concrete and the main longitudinal reinforcement is expressed by:

$$V_{cr} = f_{vr} \cdot b \cdot d \quad (7-4)$$

where

$$f_{vr} = \frac{0,12\sqrt{f_{ck}}}{\gamma_m} \cdot \xi \cdot (1 + 50\rho) \leq \frac{0,25\sqrt{f_{ck}}}{\gamma_m} \quad (7-5)$$

where

$\xi = 1,6 - d, (d \text{ in m}). \xi$ is not to be taken less than 1.0.

$\rho = A_s/b \cdot d$, but not greater than 0,02.

7.6.5.4 The component V_{pr} : The shear resistance due to a compressive axial force or a prestressing force is:

$$V_{pr} = \frac{M_o}{M_{fd}} \cdot V_{fd} \quad (7-6)$$

where M_o is the applied moment that combined with the axial force and prestress would give zero concrete stress at the extreme fibre. V_{fd} and M_{fd} are the design loading effects at the section considered.

M_o and M_{fd} are to be evaluated about the principal axis of the homogeneous section, see Figure 7.3.

N_{fd} and P_{fd} are not to be introduced with values exceeding $0,5 f_{cr} A_c$.

Figure 7.3 Principles for assessment of M_o .

The sum $V_{cr} + V_{pr}$ is not to exceed

$$\frac{0,25\sqrt{f_{ck}}}{\gamma_m} bd + 0,2 N_{fd}$$

The decrease in the shear resistance due to an axial tensile force is expressed as

$$V_{pr} = -2 \cdot \left| \frac{M_o}{M_{fd}} \right| \cdot V_{fd} \quad (7-7)$$

The sum $V_{cr} + V_{pr}$ should not be introduced in the calculations with negative values.

The effect of deformation loads on M_{fd} , V_{fd} and N_{fd} should be critically considered when calculating V_{pr} .

7.6.5.5 Short span effect: The favourable arch effect associated with direct loads near the support may be calculated by recognized methods.

For liquid pressure, which also may act in the cracks, the short span effect should be neglected.

Guidance: Appendix D7.

7.6.5.6 Minimum shear reinforcement: At intersections between structural elements with considerable stress concentrations, and where transfer of shear forces is essential for the integrity of the structure, transverse reinforcement not less than

$$A_{sv} = 0,02 \frac{f_{cr}}{f_{sr}} bd \quad (7-8)$$

is to be provided.

7.6.6 Membrane shear resistance

7.6.6.1 Resistance against membrane shear forces in plates and shells is to be determined by recognized methods based on equilibrium considerations. The tensile strength of concrete is to be neglected.

Guidance: See Appendix D7.

7.6.7 Torsional resistance

7.6.7.1 Torsional resistance is to be determined by recognized methods. If equilibrium of beam and frame members can be established without considering transfer of torsional moments, the check of the torsional resistance may be omitted.

7.6.8 Resistance against bond and anchorage failure

7.6.8.1 *General:* Resistance against bond and anchorage failure is to be determined by recognized methods. Both local bond and anchorage bond are to be investigated.

In zones of reduced bond, e.g. where gravitational settling of the concrete may reduce the compaction around the reinforcement, the design bond strength is not to be taken higher than 70 % of the value for good bond zones.

Due attention is to be paid to the state of stress in the anchorage zone. Adequate bond resistance is to be assured by transverse reinforcement, stirrups, spirals, hooks or mechanical anchorages.

7.6.8.2 *Post tensioning anchorages:* Anchorages are to be designed for the ultimate strength of the tendon. The anchorage unit is to be designed so that transfer of forces to the surrounding concrete is possible without damage to the concrete. Documentation verifying the adequacy of the anchorage unit is to be submitted.

7.6.8.3 *Anchorage zone:* The design of anchorage zones is to be in accordance with recognized methods. Reinforcement is to be provided where required to prevent bursting or splitting.

The design strength of such reinforcement is to be limited to 250 MPa.

7.7 Fatigue limit state

7.7.1 Material strength under fatigue loading

7.7.1.1 The material strength under fatigue loading is to be represented by characteristic S-N curves determined from the 5th percentile of the test results.

7.7.1.2 The design S-N curves are obtained by dividing the S-value of the characteristic S-N curves by the material coefficient γ_m . The values of the material coefficients will depend on the accuracy of the calculation procedure and are to be agreed upon.

7.7.2 Cumulative fatigue damage

7.7.2.1 The cumulative damage to the structure caused by different fatigue loadings is to be included in the analysis by accepted methods taking into account the special nature of the load, see Appendix D8 and 4.5.1.4.

7.7.3 Structural aspects

7.7.3.1 The geometrical layout of structural elements and reinforcement should be such as to minimize the possibility,

of fatigue failure. Ductility should be assured by confinement of the concrete by appropriate reinforcement.

7.7.3.2 Submerged members that are essential for the integrity of the structure and are subjected to loadings that may cause fatigue are to be designed without membrane tension for any load combination of P, L, D and E. Edge stresses due to bending is to be limited so that no cracking occurs. Where creep effects may cause transfer of compressive stress from the concrete to the reinforcement such effects are to be accounted for in the determination of concrete stresses.

7.8 Progressive collapse limit state

7.8.1 General

7.8.1.1 The analytical model should reflect as accurately as possible the behaviour of the structure under an accidental load. Depending on the type of structure and the nature of the accidental load, the analytical model may be based on elastic or plastic theory, or on yield line theory, see 7.5.3.

7.8.1.2 The determination of structural resistance may be based on the stress-strain relationships given in 7.3 and 7.4.

7.8.1.3 The material coefficients are to be taken equal to:

For concrete : $\gamma_m = 1.1$
For reinforcement : $\gamma_m = 1.0$

7.8.1.4 The possibilities and effects of rupture of critical sections are to be examined critically. If the rupture of a section may cause a catastrophic collapse, the section or member should, if possible, be designed so that a possible failure will develop in a ductile manner.

7.9 Serviceability limit state

7.9.1 General

7.9.1.1 For concrete structures the serviceability limit state will normally include criteria related to

- control of cracking
- control of displacements and motions

7.9.1.2 The calculation of concrete and steel stresses may normally be based on the assumption of a cracked section and linear stress-strain relationship for the concrete and the reinforcement. In cases where the calculated concrete stresses are greater than $0.6 f_{ck}$, a more realistic stress-strain relationship for concrete should be considered.

7.9.1.3 The serviceability criteria for structural members of temporary use, are to be agreed upon with DnV in each case.

7.9.2 Control of cracking

7.9.2.1 Cracking of the concrete is to be limited so that it will not impair the function or the durability of the structure.

7.9.2.2 Members subjected to predominantly static loads, not causing tensile stresses calculated for a homogeneous section, may be considered as uncracked. Nominal reinforcement in accordance with the recognized standard is to be provided.

7.9.2.3 To obtain satisfactory crack distribution in members not satisfying the conditions given in 7.9.2.2, the area of reinforcement at one face of the member is not to be less than

$$A_s = \frac{f_{tm} + w}{f_{sp}} \cdot b \cdot d_e \quad (7-9)$$

where

f_{tm} – mean tensile strength of concrete.
 f_{sp} – proportional limit for reinforcement
 w – waterpressure in cracks
 d_e – effective tension zone = $1,5 \cdot c + 10 \cdot \phi$

d_e is not to be taken less than $0,2 \cdot h$ and not greater than $0,5 \cdot (h - x)$.

The maximum spacing between reinforcing bars is 200 mm for the principal reinforcement and 300 mm for the secondary reinforcement.

7.9.2.4 The control of cracking may be based either on calculation of stresses in the reinforcement or on calculation of crack widths.

The degree of cracking may be considered acceptable if the calculated steel stresses in the reinforcement are limited to the values given in 7.9.3 and requirements regarding minimum reinforcement are satisfied.

7.9.2.5 If control of cracking is based on calculation of crack widths, the limiting values and the calculation procedure are to be agreed upon with DnV in each case.

7.9.2.6 Special attention is to be paid to the effect of differing directions of the principal tensile stresses and the main reinforcement.

7.9.3 Limitation of stresses

7.9.3.1 Unless otherwise agreed upon with DnV, the design of structural members is to satisfy the criteria given in Table 7.1.

Table 7.1 SLS-Allowable stresses

Design phase	Loading condition	Allowable stresses (MPa)	
		σ_s	$\Delta\sigma_s$
C, T and I	a ¹⁾	220 ²⁾	120 ²⁾
O	a ¹⁾ b ³⁾	160 0,8 f_{sy}	80

- 1) Loading condition a): Combination of the load categories P, L, D and E; E being taken as 50% of the characteristic value for the design phase considered, excluding earthquake effects.
- 2) For short term loads of categories P, L and D, 30% increase in stresses is allowed.
- 3) Loading condition b): As loading condition a): but E being taken as 100% of the characteristic values.

7.9.3.2 In parts of structures prestressed in one direction only, the stresses in reinforcement transverse and adjacent to prestressing tendons should be limited to $\Delta\sigma_s$.

7.9.3.3 The stresses in the prestressing steel are not to exceed

$$0,80 f_{0,2} \quad (0,80 f_{sy})$$

except during stressing of tendons where the allowable stresses may be increased to

$$0,85 f_{0,2} \quad (0,85 f_{sy})$$

provided that it is documented that the steel will not be damaged and the stressing force is measured directly with calibrated equipment.

7.9.4 Additional requirements

7.9.4.1 Members subjected to a transverse hydrostatic pressure difference are to be designed with a permanent compression zone not less than the larger of 0,25 h and the values given in Table 7.2.

Table 7.2 Depth of compression zone versus pressure difference

Pressure difference (kN/m ²)	Depth of compression zone (mm)
< 150	100
> 150	200

The above requirements apply for the operation phase, loading condition a).

7.9.4.2 Oil containment structures with an ambient internal oil pressure greater than or equal to the ambient external water pressure (including pressure fluctuations due to waves) are to be designed with a minimum membrane compressive stress ($\sigma_m = N/A$) equal to 0,5 MPa for the operation phase, loading condition a) unless other constructional arrangements, e.g. special barriers, are used to prevent oil leakage.

7.10 Constructional arrangements

7.10.1 Normal reinforcement

7.10.1.1 Spacing and placement of the reinforcing bars are to be in accordance with the requirements of the recog-

nized standard. Special attention is to be given to the need for placing tolerances in heavily reinforced structures.

7.10.1.2 Bending, anchoring and splicing of reinforcing bars are to satisfy the requirements of the recognized standard, unless otherwise specified by DnV. Adequate transfer length and transverse reinforcement are to be provided in the anchorage and splicing zones. See 7.6.8.

7.10.1.3 The following splices in reinforcement may be used;

- mechanical splices (couplers)
- welded splices
- end-bearing splices for compression bars
- lap splices

In general splices should be staggered and placed in regions with low stresses. Due attention is to be paid to the state of stress in the zone of splicing (stresses of static and dynamic nature, transverse tensile or compressive stresses etc.)

7.10.1.4 Deformed, high bond bars may be bundled in contact to ensure the quality of casting in areas with congested reinforcement. Special consideration should be paid to the possibility of water channels along the reinforcing bars. For watertight structures normally not more than 4 bars are to be bundled at any section including the splices.

7.10.2 Prestressing tendons

7.10.2.1 The spacing and placement of ducts and anchor plates are to be in accordance with the requirements of the recognized standard and the specifications from the manufacturer unless, otherwise agreed upon with DnV.

7.10.2.2 Ducts are normally to be rigid or semi-rigid steel pipes. Watertight splices or sleeves are to be used. Vents are to be provided at all high points in the duct profile.

7.10.3 Concrete cover

7.10.3.1 For normal reinforcement the concrete cover is not to be less than

- 40 mm in the atmospheric zone, not subject to severe splashing.
- 50 mm for all other parts of the structure.

In addition, the cover is not to be less than 1,5 times the nominal maximum size of the aggregate.

7.10.3.2 For prestressing tendons the cover to ducts is not to be less than twice the values given in 7.10.3.1.

7.10.3.3 Special considerations are to be given to cover for members that may be subject to fire.

7.11 Corrosion protection

7.11.1 Reinforcement and fully embedded steel

7.11.1.1 Reinforcing steel, prestressing steel, or other fully embedded steel in concrete structures is to be protected

against corrosion. Concrete cover in compliance with 7.10.3 is normally considered to provide adequate protection against corrosion in marine environment.

7.11.1.2 If special means of corrosion protection of the reinforcement are used, e.g. coating, galvanizing or cathodic protection, relevant specifications according to 6.3 are to be submitted for approval. Due consideration is to be given to the possibility of harmful effects on other parts of the structure.

7.11.1.3 Combinations of prestressing steels of different qualities that may cause risk of galvanic corrosion are to be avoided.

7.11.2 Embedded steel with exposed surfaces

7.11.2.1 All steel members not embedded in concrete or grout are to be considered as exposed steel structures and protected according to 6.3.

7.11.2.2 In the design of cathodic protection systems for steel exposed to sea water and in electrical contact with reinforcement, allowance is to be made for current drainage to the reinforcement (see 6.3.7.5).

Guidance: A current density of 0,5 – 1 mA/m² for the outer reinforcement layer is normally sufficient.

7.11.2.3 Current drainage may occur via the reinforcement (see 6.3.7.5). Steel of no structural importance, e.g. plates of temporary use, is also to be taken into account.

7.11.2.4 Sacrificial anodes are recommended for protection of steel exposed to sea water.

7.11.2.5 For impressed current systems it is to be documented that no harmful effects will occur. In addition to the requirements of 6.3.8 due consideration is to be given to the possibilities of

- local overprotection of reinforcement which may lead to reduced bond
- attack on concrete or steel by chlorine or acids derived from chlorine.

7.11.2.6 Adequate sealing of concrete around embedment plates or steel fixing items, pipe sleeves, etc. is required to prevent ingress of sea water to the reinforcement. Sealing is to be carried out after completion of welding operations. Specifications of sealing materials and application procedures are to be submitted for approval.

7.12 Construction

7.12.1 Tolerances

7.2.1.1 Construction tolerances are to be specified on drawings and other relevant technical documents.

7.12.1.2 Construction tolerances are to be given for at least the following;

- geometry of cross sections
- overall geometry, including deviation from theoretical shape and out-of-alignment

- placing of ordinary and prestressing reinforcement including ducts and anchorages
- embedded items.

7.12.2 Construction joints

7.12.2.1 The position of construction joints and the procedures for treatment and cleaning are to be specified on the drawings.

7.12.3 Reinforcement

7.12.3.1 *General:* The surface of reinforcement is to be free from substances that may adversely affect the steel or concrete or reduce the bond.

Prestressing steel and anchorages are to be protected during storage and handling against mechanical damage and corrosion.

7.12.3.2 *Placing:* The supports for reinforcement are to be of such material, shape and strength that the reinforcement can be maintained in its correct position, and that the protection of the reinforcement is not impaired.

7.12.3.3 *Bending:* Reinforcing steel is normally to be bent cold to the specified shape in one operation. Rebending or heat-bending of reinforcing steel is not permitted unless specified on drawings or agreed upon with DnV.

7.12.3.4 *Welding:* Welding of reinforcement is to be carried out by qualified welders using a low hydrogen process. Use of the gas metal arc welding process is to be limited to conditions where the weld area is fully sheltered from draught and wind. Prior to welding of reinforcement, a welding procedure is to be submitted for approval. Procedure tests may be required. For welding of steel see also 6.4.

7.12.3.5 *Post-tensioning tendons:* Precautions are to be taken to prevent intrusion of debris or water into the ducts. Protruding ends of tendons are to be protected against damage.

7.12.4 Mixing and placing of concrete

7.12.4.1 *Concrete constituents:* Materials which have been stored or handled in such a way that their quality may have been impaired are not to be used.

Aggregates of different types and gradings are to be stored separately.

The quantity of mixing water is to be adjusted according to the water content of the aggregates.

The maximum batch-weight tolerances shall be in accordance with the recognized standard.

7.12.4.2 *Placing:* The concrete is to be placed as soon as possible after mixing, and in any case well before the initial set. The methods used for transport, placing and compacting concrete are to preserve its uniformity and avoid segregation.

7.12.5 Concreting under adverse conditions

7.12.5.1 In cold weather, the formwork and reinforcement are to be free from ice and snow before concrete is placed.

7.12.5.2 The temperature of concrete during placing is to be at least + 5°C. Until hardening has reached a maturity stage corresponding to 3 days at + 10°C, the temperature of the concrete is to be kept above + 2°C.

7.12.5.3 In hot weather and when casting thick sections, precautions are to be taken to keep the temperature of the concrete at an acceptable level. The maximum temperature is to be specified by the designer.

7.12.6 Concreting under water

7.12.6.1 Specifications of materials and work procedures are to be submitted to DnV for approval before work begins.

7.12.7 Curing of concrete

7.12.7.1 The concrete is to be protected against drying out for a period of at least two weeks.

7.12.7.2 Documentation of the adequacy of the proposed curing method may be required.

7.12.8 Stressing of tendons

7.12.8.1 Stressing of tendons is not to be carried out before the concrete in the structure has reached the required strength, as specified by the designer.

7.12.8.2 Prestressing jacks and instrumentation are to be calibrated prior to stressing operations and at agreed intervals during such operations, or on request by DnV.

7.12.8.3 The stressing operations are to be in accordance with the programme and specifications given by the designer. Forces and elongations are to be measured and compared with calculated values. If the measured values are not within specified tolerances, agreed procedures are to be followed.

7.12.9 Grouting of tendons

7.12.9.1 Grouting operations are to be carried out in accordance with grouting procedure specifications accepted by DnV. In special cases e.g. grouting of long vertical tendons, where previous experience is limited, procedure tests may be required to verify the adequacy of the grout mix and the grouting procedure.

7.12.9.2 Precautions are to be taken to minimize bleeding effects. See 7.2.4.5.

7.12.9.3 The maximum time between mixing and pumping of grout is to be such that any expansion of the grout takes place after injection.

Until injected, the grout is to be continuously agitated.

7.12.9.4 The duct should be sealed off under pressure until the grout has set.

7.12.9.5 In cold weather, the grout is to be prevented from freezing. During grouting and the first two days thereafter the temperature in the structure is not to fall below + 5°C unless otherwise agreed with DnV.

7.12.10 Repair work

7.12.10.1 Prior to repair work a detailed procedure is to be submitted.

7.12.10.2 Tests of procedure and repair materials under site conditions may be required.

7.13 Testing of materials and inspection

7.13.1 General

7.13.1.1 Materials shall be tested by recognized laboratories. Methods for testing of materials are to be in accordance with the recognized standards. Special tests where no standard methods are available are subject to approval.

7.13.1.2 The organization plan of testing, inspection, reporting of results, etc. for the construction site is subject to acceptance. The organization of quality control and inspection shall be independent.

7.13.2 Testing of concrete constituents

7.13.2.1 *Cement*: Cements which have been tested by the manufacturer and certified to satisfy these Rules are also to be tested by an independent laboratory when required by DnV.

Guidance: See Appendix D1.

7.13.2.2 *Water*: Water to be used in concrete is to be tested every 4 months during construction or when deemed necessary.

7.13.2.3 *Aggregates*: The following properties of aggregates for concrete are to be determined before use;

- particle size distribution (grading) including silt content
- content of organic matter
- density and specific gravity
- strength in concrete or mortar
- potential reactivity with alkalis in cement
- petrographical composition and properties that may affect the durability of the concrete.

Testing of aggregates is to be carried out at regular intervals during concrete production. The frequency of testing is to be determined taking the quality and uniformity of supply and the concrete production volume into account.

7.13.2.4 *Admixtures*: Admixtures to be used in concrete are to be tested under site conditions to verify that these

products will yield the required effects, without impairing the other properties required.

Guidance: See Appendix D2.

7.13.3 Testing of concrete

7.13.3.2 Prior to start of construction, the following are to be documented;

- mix proportions and the resulting consistence, bleeding and air content
- setting times and strength development
- modulus of elasticity in compression
- permeability of hardened concrete. See 7.2.3.1
- durability in accordance with relevant environmental exposure. See 7.2.3.1 through 7.2.3.5.

7.13.3.3 During production, concrete is to be tested regularly for strength, permeability, air content and density, as given in Table 7.3.

Table 7.3 Frequency of production testing of concrete

Parameter	Frequency
strength	One sample per shift, and normally not less than one sample for every commenced 100 m ³
permeability	at every change of constituent materials or mix proportions
air content and consistence	three times per shift, or whenever a strength sample is taken
density	once per shift

Each sample for strength testing, taken from one batch at the form after transportation, shall comprise 4 test specimens.

7.13.3.4 Until the uniformity of the concrete has been demonstrated higher rates of testing may be required. During continuous production, rates of testing may be reduced as agreed upon with DnV.

7.13.4 Testing of concrete in the structure

7.13.4.1 The quality of concrete in the structure may be verified by tests on drilled or sawn cores from the structure or by non-destructive testing.

The extent, location and method for such testing are to be agreed upon with DnV in each case.

Guidance: See Appendix D9.

7.13.4.2 By comparison of test results, a relationship is to be established between the results of the in-situ tests and the results from standard specimens tested in accordance with these Rules.

7.13.4.3 The calibration of equipment for non-destructive testing is to be submitted for approval.

7.13.5 Testing of grout for prestressing tendons

7.13.5.1 Grout for injection in ducts for prestressing tendons is to be tested for viscosity, density, expansion and strength, as given in Table 7.4.

Table 7.4 Frequency of testing of grout

Parameter	Frequency
viscosity	every 3 hours
density	every 3 hours
expansion and bleeding	once per shift
compressive strength	once per shift
setting time	once per shift

7.13.6 Testing of reinforcing steel

7.13.6.1 Reinforcing steel is normally to be delivered with work certificates. Certificates endorsed by DnV may be required.

Spot checks taken at the site may be required on random samples, and tested by a recognized testing laboratory.

7.13.6.2 All welds in reinforcement are to be inspected visually.

The type and frequency of destructive or non-destructive testing of welded reinforcement are subject to acceptance by DnV. Impact testing is normally not required. See also 6.4.

7.13.6.3 Where deemed necessary DnV may require additional testing of component parts of prestressing systems.

7.13.6.4 Testing of mechanical splices shall comprise;

- before production begins, 3 tensile tests on splices made under site conditions
- during production, testing of one splice in every hundred.

7.13.7 Testing of repair materials

7.13.7.1 The extent of testing of repair materials is to be agreed upon with DnV in each case.

SECTION 8

HYDROSTATIC STABILITY, WATERTIGHT INTEGRITY AND ANCHORING

8.1 General

8.1.1 The general requirements concerning hydrostatic stability, watertight integrity and anchoring given in Section 8 apply to phase O for structures designed to remain permanently anchored offshore, such as conventionally anchored buoys or platforms, tension leg platforms, articulated tower structures etc. For the phases C, T and I, the requirements given in section 10 apply.

8.1.2 Anchored offshore structures are to have load line marks indicating maximum permissible draught. See 4.7.3.3.

8.2 Hydrostatic stability

8.2.1 General

8.2.1.1 The Operations Manual is to include information, related to the stability requirements of subsection 8.2. The extent of the information is to be sufficient to give the responsible personnel the guidance necessary to ensure sufficient stability under all expected conditions.

8.2.1.2 In particular, instructions with regard to termination of the normal operating modes, and appropriate measures to be taken in deteriorating weather conditions, are to be included in the Operations Manual.

8.2.1.3 Relevant data such as curves showing draught versus displacement, centre of buoyancy, waterplane areas, centroid of waterplanes, moment of inertia of waterplanes, position of metacentre above base line, trimming and heeling unit moments, and displacement per unit immersion (tonnes/cm) are to be submitted.

Capacity data of all tanks, including position of centre of gravity and free surface correction are to be submitted.

8.2.1.4 Calculations related to the following matters are to be submitted,

- stability
- damage stability and floatability
- determination of weight and centre of gravity based on inclining test
- possible effects of icing on the stability.

8.2.2 Inclining tests and weight determination

8.2.2.1 When the construction of the hull is completed, inclining tests are to be undertaken in order to establish the position of the centre of gravity. Further, the light weight is to be determined.

8.2.2.2 The tests are to be carried out under the surveillance of a DnV Surveyor. A report is to be submitted for acceptance.

8.2.2.3 The tests are to be carried out using the following procedure;

- the inclining angle should be of the order of 2°

- the angles are to be measured by at least two pendulums
- the draught is to be such that the waterline intersects the unit in a wallsided area
- if water is used to achieve sufficient inclining moment, the tanks involved are to be manually sounded during transfer of water. Care is to be taken to avoid trapping air in the piping system
- the effects of external forces due to wind, waves, moorings, anchors, tugs, cranes, etc. are to be considered during the test and in the report.

8.2.3 Intact stability requirements

8.2.3.1 Proof of sufficient stability is to be established for all relevant loading conditions.

8.2.3.2 Conventionally moored structures are to meet the requirements of 8.2.3.3 through 8.2.3.7.

8.2.3.3 Statical stability curves are to be calculated for heeling axes parallel to the unit's two main axes in the horizontal plane. When there is reason to believe that stability about any other heeling axis may be critical, statical stability curves referred to this axis are to be calculated.

8.2.3.4 Wind heeling moment curves are normally to be calculated for wind directions parallel to the unit's two main axes in the horizontal plane. When there is reason to believe that any other wind direction is more unfavourable, wind heeling moment curves referred to this direction are to be calculated.

8.2.3.5 The wind heeling moment curves are to be calculated using a recognized method. The sustained wind speed, $V_s(100)$ is to be applied, (i.e. the 100 year value).

Guidance: A method for computing the wind heeling moments is given in Appendix E.

8.2.3.6 The initial metacentric height after correction for free surface effects is not to be less than 0,3m.

8.2.3.7 The statical stability curves (see 8.2.3.3) and the wind heeling moment curves (see 8.2.3.4 and 8.2.3.5) are to be plotted in the same diagram and shown in the Operations Manual. The areas under the statical stability curve and the wind heeling moment curve are to be calculated up to an angle of heel which is the least of;

- the angle of heel corresponding to the second intercept of the two curves,
- the angle of heel at which flooding of buoyant spaces starts.

This area for the statical stability curve is not to be less than 1,4 times the corresponding area for the wind heeling moment curve. For structures with a small waterline area a factor of 1,3 may be used instead of 1,4, upon agreement with DnV.

8.2.3.8 Tension leg and articulated tower structures, or other structures having constructional features which render the requirements of 8.2.3.2 inapplicable, will be specially considered.

8.2.3.9 For structures to which vessels may be moored, stability calculations are to take into account the simultaneous effects of;

- anchor forces
- mooring forces from the vessel
- wind forces corresponding to the maximum wind velocity assumed to occur when the vessel is moored to the structure, see 5.2.2.4.

8.2.4 Subdivision and damage stability requirements

8.2.4.1 The requirements on subdivision and damage stability given in 8.2.4 require consideration of the following two types of flooding;

- a) Accidental flooding as a result of any possible leakage.
- b) Flooding as a result of damage, e.g. collision etc. Damage areas to be considered are described in 8.2.4.3 through 8.2.4.7.

8.2.4.2 Proof of sufficient reserve buoyancy and stability is to be established for all relevant loading conditions after accidental flooding of any one compartment that can possibly be flooded, or after flooding as a result of damage.

Compartments located outside the region of damage described in 8.2.4.3 through 8.2.4.7 may be considered as not floodable, provided they are not located adjacent to the sea or the weather deck.

8.2.4.3 Damage is assumed to occur in a zone which is bounded by two horizontal planes normally positioned 5 meters above and 3 meters below the waterline in question.

8.2.4.4 For all types of unit, damage is assumed to occur in the shell plating of any one compartment, leaving watertight subdivision bulkheads intact. If any parts of two subdivision bulkheads are spaced less than 2,3 meters apart, one of the bulkheads is to be considered as non-existent.

8.2.4.5 The horizontal penetration of damage is to be taken as 1,5 meters inboard from the shell plating.

8.2.4.6 Cylinders are assumed to be penetrated radially a distance equal to 1,5 meters. The circumferential extent of damage is assumed to be $\pi D/6$, where D is the diameter of the cylinder. The damage is assumed to occur at any point at the cylinder surface, except at positions where it is obvious that damage cannot take place.

8.2.4.7 The vertical extent of damage is to be taken as 2,3 meters in the case of vertical or horizontal members such as columns or lower hulls. For barge type units, the vertical extent of damage is to be from bottom shell to upper deck.

8.2.4.8 Realistic permeabilities of flooded spaces are to be used. For empty spaces a permeability of 0,98 is to be used, while in pump rooms, machinery spaces etc. a value of 0,85

is considered appropriate. Allowance for liquid in partially filled tanks may be made by considering the specific gravity of the liquid in relation to that of sea water.

8.2.4.9 For the initial conditions given under 8.2.4.2 the unit is assumed to be simultaneously exposed to the overturning effect of a constant, nominal wind speed of $0,5 V_{s(100)}$ (see 8.2.3.5) acting in the direction in which the unit will heel/trim as a result of flooding of the compartment considered. The resulting still water equilibrium conditions are to comply with the requirements of 8.2.4.10.

8.2.4.10. The requirements to still water equilibrium are;

- a) The final waterline in the still water equilibrium condition after flooding, taking into account sinkage, trim and heel, is to be below the lower edge of any opening through which progressive flooding may take place. Openings, the lower edge of which is not to be submerged, include air pipes (regardless of closing appliances), ventilators, ventilation intakes and outlets, non-watertight hatches and doors. Openings such as manholes, watertight hatches, watertight doors, side scuttles of the non-opening type may be submerged.
- b) The metacentric height in the still water equilibrium condition without the effect of any wind heeling moment is to be at least 0,30 meters.

8.2.4.11 In the event pipes, ducts, tunnels, etc. are located within the extent of damage penetration, arrangements are to be made to avoid flooding beyond the limits assumed for the various damage cases.

8.2.4.12 For the damage conditions, ballasting instructions describing proper procedures to be followed in order to reduce trim/heel, are to be included in the operations manual. In addition, such instructions are to be posted in the control centre of the unit in an intelligible form, preferably in visual combination with the manoeuvre arrangement of valves and pumps.

8.2.4.13 Tension leg and articulated tower structures, or other similar structures, are to remain afloat with sufficient freeboard to preclude progressive flooding with any one compartment open to the sea and simultaneously subjected to a wind force corresponding to a wind speed of $0,5 V_{s(100)}$ (see 8.2.3.5).

8.2.4.14 Failure of moorings may have an adverse effect on the hydrostatic stability of the structure. It is to be verified that sufficient stability and buoyancy exist to keep the structure in an upright position after one or more of the moorings may have failed.

8.3 Watertight integrity

8.3.1 General

8.3.1.1 The number of openings in watertight bulkheads and decks is to be kept to a minimum compatible with the design and proper working of the structure. Where penetrations of watertight decks and bulkheads are necessary for

access, piping, ventilation, electrical cables, etc., arrangements are to be made to maintain the watertight integrity.

8.3.1.2 Where valves are provided at watertight boundaries to provide watertight integrity, these valves are to be capable of being operated from the bulkhead deck or weather deck, pump room or other normally manned space. Valve position indicators are to be provided at the remote control station.

8.3.2 Watertight doors and hatches

8.3.2.1 Watertight doors and hatches are to be remotely controlled from a central position above the bulkhead deck and are also to be operable locally from each side of the bulkhead or deck. Indicators are to be provided at the central position to indicate whether the doors are open or closed.

8.3.2.2 The requirements of 8.2.3.1 regarding remote controls may be dispensed with, provided an alarm system (e.g. light signals) is arranged showing personnel, both locally and at a central position, whether the doors and hatches in question are open or closed. A sign is to be placed on such doors and hatches to the effect that they are not to be left open.

8.4 Anchoring

8.4.1 Anchors

8.4.1.1 Anchors to be used for mooring of anchored structures are normally to be gravity anchors or pile anchors.

8.4.1.2 The design resistance of an anchor is to be determined in accordance with the requirements of Section 9. The effects of repeated loads shall be accounted for in the determination of the design resistance. If practical, verification of the design resistance of an anchor may also be based on tests.

8.4.1.3 The design of steel anchors shall satisfy the requirements of Section 6.

The design of reinforced concrete anchors shall satisfy the requirements of Section 7.

8.4.2 Anchor lines

8.4.2.1 Anchor lines may consist of chain cable, steel wire, fibre ropes or a combination of these.

8.4.2.2 The quality of chain cables, steel wire or fibre ropes to be used for anchor lines shall satisfy a standard generally recognized for offshore application.

8.4.2.3 The following properties of anchor lines are normally to be documented:

- ultimate strength
- guaranteed minimum yield strength
- load-elongation characteristics
- fatigue resistance
- durability in sea water
- notch toughness

8.4.2.4 The determination of loading effects in the anchoring system is to satisfy the relevant requirement of 4.5.

8.4.2.5 The fatigue life of anchor lines is to be determined with due consideration of possible local vibrations, longitudinal and transverse, in addition to the primary loadings.

8.4.2.6 The requirements regarding safety of anchor lines will depend on the type of anchor line used. The design resistances to be used as the basis for design in ULS and FLS are to be established in accordance with the principles given in 4.4.3.2 and 4.4.4.2, and are subject to approval in each case.

8.4.2.7 Anchor lines are to be replaceable. A program for replacement of the anchor lines is to be given in the Operations Manual.

8.4.3 Mechanical joints

8.4.3.1 Criteria pertinent to the design of mechanical joints used for anchoring of structures, such as articulated towers, are subject to agreement in each case.

SECTION 9 FOUNDATIONS

9.1 General

9.1.1 Application

9.1.1.1 This Section applies to pile foundations and gravity type foundations.

9.1.1.2 The design of foundations is to consider the strength and deformations of the foundation structure as well as the strength and deformations of the foundation soils. This Section covers the foundation soils and the soil reactions on the foundation structure. Design of the foundation structure itself is covered by Sections 4, 5, 6 and 7.

9.1.2 Notation

The following symbols are used in this Section:

A'	Effective foundation area
A_p	Gross end area of pile
A_{si}	Shaft area of pile in layer i
F_v	Vertical load
K_v	Coefficient of earth pressure
R_p	End resistance of pile
R_s	Accumulated skin resistance along pile shaft
c	Effective cohesion
c_u	Undrained shear strength
f_l	Limiting value of unit skin friction along pile shaft
f_{si}	Average unit skin friction along pile shaft in layer i
$\bar{p}_o$	Average effective overburden pressure within layer i
q_l	Limiting value of unit end resistance of pile
q_p	Unit end resistance of pile
γ_{mc}	Material coefficient, index c referring to soil cohesion (c' or c_u)
γ_{mf}	Material coefficient, index f referring to soil friction ($\tan\phi'$)
τ_d	Design shear strength
τ_{mob}	Average mobilized design shear stress
σ'	Effective normal stress
$\tan\phi'$	Coefficient of friction of soil
$\tan\delta$	Average coefficient of friction between soil and pile within layer i

9.2 Site investigations

9.2.1 General

9.2.1.1 Design of foundations is to be based on information from the actual site. The extent of the site investigations is to be in accordance with type, size and importance of the structure, and with uniformity of soil and sea bed conditions.

9.2.1.2 The choice of methods and extent of site investigations as described in 9.2.4 and 9.2.5 are to be compatible with the geological conditions in the area.

9.2.1.3 In selecting the size of the target area to be investigated, sufficient tolerances are to be included to account for;

- errors in positioning during site investigations
- errors in navigation equipment used for installation
- realistic tolerances in placement of platform.

9.2.1.4 The results from site investigations are to be submitted to DnV. Such reports are to include;

- information on when and by whom the investigation has been carried out
- comprehensive description of equipment and procedures used for field and laboratory investigations
- results of such investigations
- critical examination of possible sources of error or limitations in the applicability of the results.

9.2.2 Bottom topography

9.2.2.1 A survey of the sea bottom topography is to be carried out for all structures.

9.2.2.2 For gravity structures the required accuracy for measured differential elevations is normally in the order of $\pm 0.1m$.

9.2.2.3 For piled structures the accuracy for measured differential elevations is to be considered in each case.

9.2.2.4 Possible sand waves and sea bed movements are to be thoroughly investigated.

9.2.2.5 In addition to surveys giving quantitative description of the bottom topography, a scanning survey may be required in cases where obstructions such as boulders or other items (anchors, debris, etc.) may impair a safe installation of the structure.

9.2.3 Site geology

9.2.3.1 An engineering geology study is to be carried out as part of the site investigation. The study is to be based on available information on geology, soil conditions, bottom topography, etc., in the general area.

9.2.3.2 The purpose of such study is both to establish that the methods and extent of other site investigations as described in 9.2.4 and 9.2.5 are adequate, considering the geological conditions in the area, and to correlate the general area geology with the particular site formations and their behaviour.

9.2.3.3 The study is also to contain an evaluation of the seismic risk in the area, see 3.5.8.

9.2.4 Soil exploration

9.2.4.1 The site investigation is to be sufficiently extensive to reveal all soil and rock deposits of importance to the

foundation of the structure. The investigation is to extend to an area and a depth where the possible existence of weak formations will not influence the safety of the structure.

9.2.4.2 The soil exploration may be carried out by a combination of the following principal methods;

- geophysical methods
- in situ tests
- borings with sampling for laboratory testing.

9.2.4.3 Geophysical methods alone will not be accepted as a basis for foundation design.

9.2.5 Geotechnical properties

9.2.5.1 The field and laboratory investigations are to provide the following types of geotechnical data for all important layers;

- data for classification and description of the deposit
- parameters for use in geotechnical calculations.

9.2.5.2 The investigations are to provide all data necessary for analyses as described in 9.3 through 9.6.

9.3 General design requirements

9.3.1 General

9.3.1.1 The limit state method of design is recommended for both pile and gravity type foundations, using load coefficients according to 4.4.4 and material coefficients as specified in 9.4.2, 9.5.5 and 9.6.4. The characteristic strength of the soil is to be assessed according to 9.3.2. Other design methods may be used; see 2.1.3, 4.2 and 4.3.

9.3.1.2 The application of the safety requirements as specified in this Section is to prevent total failure of the foundations and local overstressing of isolated members of the base structure. Safety against excessive deformations is to be calculated independently.

9.3.1.3 All analyses are to be carried out with assumptions regarding scour compatible to the requirements of 9.4.4.

9.3.1.4 The calculations are to cover both the installation and operation conditions. The uncertainties in such calculations are to be specified.

9.3.2 Characteristic properties of soil

9.3.2.1 The characteristic properties of soil are to be determined with reasonable accuracy for all layers of importance.

9.3.2.2 The characteristic property in each different layer is to be taken as the conservatively assessed mean value based on the results from;

- in situ tests
- laboratory test

taking into account the stress conditions during testing and the actual stress conditions in the layer considered.

9.3.2.3 In selecting characteristic values considerations are to be given to the particular type of analysis for which the value is to be used, i.e. whether a conservative calculation requires a large or a small characteristic value. Correspondingly larger conservatism is to be applied in the assessment of characteristic values if the number of determinations is small or the scatter is large.

9.3.3 Effects of repeated loadings

9.3.3.1 The effects of repeated loadings on the soil properties are to be considered in all calculations where relevant.

9.3.3.2 The effects of wave induced forces are to be investigated for the following conditions;

- a design storm during the installation phase and the consolidation period
- the 100-year storm (short term effect)
- the long term cumulative effect of several storms, including the 100-year storm.

Realistic assumptions regarding duration and intensity of the storm are to be made.

9.3.3.3 In seismic areas where the structure-foundation system may be subjected to earthquake forces the deteriorating effects on the soil properties due to repeated loading have to be evaluated for the local conditions and considered in the design where relevant.

9.3.3.4 For all soils repeated shear stress application may lead to a gradual increase in pore pressure. Such pore pressure build-up which may reduce the shear strength of the soil is to be accounted for in the design.

9.3.4 Stability

9.3.4.1 The stability of the soil is to be evaluated by one of the following methods;

- effective stress stability analysis based on effective strength parameters of the soil and realistic estimates of the pore water pressures in the soil. This method of stability analysis requires laboratory shear tests with pore pressure measurements.
- total stress stability analysis based on total shear strength values determined from representative soil samples, which, as closely as practically feasible, are to be subjected to the same stress conditions as the corresponding elements in the soil.

The test results are preferably to be interpreted by means of stress paths.

9.3.5 Settlements and displacements

9.3.5.1 The analyses are in general to include calculations of;

- initial, consolidation and secondary settlements
- differential settlements

- permanent (long term) horizontal displacements
- dynamic motions due to repeated loadings.

9.3.5.2 Displacements of the structure as well as its foundation soils are to be evaluated to give a basis for the design of piles, conductors, risers, etc. connected to the structure.

9.3.5.3 Due to possible lateral variations in foundation conditions within the foundation area, and preferred direction of environmental forces, the platform may experience differential settlements. The calculated tilt of the platform is not to exceed the tolerable platform tilt according to the serviceability requirements.

9.3.5.4 The subsidence of the sea bottom due to possible pressure reduction in the producing reservoir is to be estimated.

9.3.5.5 Settlements and displacements are to be calculated in the serviceability limit state for loads of categories P, L and E as defined in 5.1.3, see also 4.4.4.

9.3.6 Soil-structure interaction

9.3.6.1 The evaluation of sectional forces and moments as well as dynamic motions in the structure is to be based on an integrated analysis of the soil-structure interaction. The analysis is to be based on realistic assumptions regarding soil stiffness and transfer to the soil of loads from structural members being seated on or penetrating into the sea bottom. Variation of foundation deposits in the horizontal directions of importance for the actual distribution of the soil reactions is to be considered in the design.

9.4 Stability of sea bottom

9.4.1 Slope stability

9.4.1.1 If the structure is located on or near a slope, the risk for slope failure is to be analysed. Such analysis is to cover;

- natural slopes
- slopes during and after installation of the structure
- probable future changes of the existing slopes as foreseeable at the time of design.

The effect of wave loads on the sea bottom is to be included in the analysis when such loads are unfavourable.

9.4.1.2 Particularly careful analyses are to be carried out if the soil deposits include one of the following types of soils;

- soft to very soft clays
- loose deposits of silt or sand where "flow slides" or "turbidity currents" may develop.

9.4.1.3 If the structure is located in a seismic region, the effects of earthquakes on the stability of the sea bottom is to be included in the analyses.

9.4.2 Safety against slope failure

9.4.2.1 The safety against slope failure is to be analysed according to 9.4.1 using material coefficients $\gamma_{mf} = 1.2$ and $\gamma_{mc} = 1.3$. A load coefficient $\gamma_f = 1.0$ is to be used on soil unit weight.

9.4.3 Hydraulic stability

9.4.3.1 The possibility of failure due to hydraulic instability is to be considered where soils susceptible to erosion or softening are present.

9.4.3.2 An investigation of hydraulic stability is to assess the risk for;

- softening of the soil and consequent reduction of bearing capacity due to hydraulic gradients and seepage forces
- formation of piping channels with accompanying internal erosion in the soil
- surface erosion in local areas under the foundation due to hydraulic pressure variations resulting from environmental loads.

9.4.4 Scour and scour protection

9.4.4.1 The risk for scour around the foundation of a structure is always to be taken into account unless it can be proved that the foundation soils are not subject to scour for the expected range of water particle velocities.

9.4.4.2 The effect of scour may be accounted for according to one of the following principles;

- adequate means for scour protection are placed around the structure as early as possible after installation. The placement is to be completed prior to onset of the first stormy season
- the foundation is designed for a condition where all materials which are not scour resistant are assumed to be removed after installation of the structure
- the sea bed next to platform is kept under close surveillance and means for preventing further scour can be placed in a short time after detection of significant scour.

9.4.3.3 Materials placed on the sea bed to protect against removal of underlaying erosive deposits are to;

- cover the sea bed where the currents can cause erosion
- have a thickness and weight sufficient not to be removed
- prevent underlaying soils to escape
- permit such pore pressures as may be generated in the underlaying soils to drain freely through the placed material.

9.5 Design of pile foundations

9.5.1 General

9.5.1.1 The design of pile foundations is to satisfy the requirements of Sections 6, 7 and 9.

9.5.1.2 The pile resistance may be assessed based on total or effective stress analysis depending on which analysis best represents the actual conditions.

9.5.1.3 In calculating the pile resistance the effects of pile installation method is to be considered.

9.5.1.4 The pile resistance may be determined according to one or preferably a combination of the following methods;

- load testing of piles
- static pile formulae
- dynamic pile formulae (driven piles only)
- semi-empirical methods based on in situ tests.

9.5.1.5 Dynamic pile formulae, herein understood as those based on the wave propagation theory, are not accepted as the only method for determination of pile resistance.

9.5.1.6 If load testing to failure of full-scale offshore piles is not practical, instrumentation and measurement of load deflection characteristics at various points on a test pile may allow extrapolation from loads in the testing range.

9.5.1.7 Where grout is relied upon to transfer loads from one pile element to another or from the pile elements to the foundation soil, the surfaces are to be free from rust scale etc. that can reduce the capacity of load transfer. Furthermore the grout itself is to have stress-strain characteristics permitting the transfer of such loads. For pile installation operations including grouting procedures, see 10.4.5.

9.5.2 Resistance of piles in compression

9.5.2.1 The pile resistance, R , is composed of two parts, one part being the accumulated skin resistance, R_s , and the other part the end resistance, R_p ;

$$R = R_s + R_p = \sum f_{si} A_{si} + q_p A_p \quad (9-1)$$

where

f_{si} average unit skin friction along pile shaft in layer i
 A_{si} shaft area of pile in layer i
 q_p unit end resistance
 A_p gross end area of pile

9.5.2.2 For piles in mainly cohesive soils, the unit skin friction, f_{si} , is to be taken equal to or smaller than the undrained shear strength of undisturbed clay within the actual layer. The degree of reduction depends on the nature and strength of clay, method of installation, time effects, geometry and dimensions of pile and other factors.

9.5.2.3 The unit end resistance, q_p , of piles in mainly cohesive soils may be taken as 9 times the undrained shear strength of the soil near the pile point.

9.5.2.4 For piles in mainly cohesionless soils the unit skin friction in layer i , neglecting the pile-soil adhesion, may be taken as;

$$f_{si} = K \bar{p}_o \tan \delta \quad (9-2)$$

where

K — average coefficient of earth pressure on pile shaft within layer i
 $\bar{p}_o$ — average effective overburden pressure within layer i
 $\tan \delta$ — average coefficient of friction between the soil and the pile element considered.

The pile-soil adhesion is, for design purposes, normally negligible.

9.5.2.5 Realistic estimates of the parameters in Eg. 9-2 are to be made, taking into account the fact that a limiting value, f_{li} , may be approached for long piles. This limiting value, which is dependent on soil conditions, method of pile installation etc. is normally not to be taken larger than 100 kPa. In case of calcareous sands special considerations are required.

9.5.2.6 The unit end resistance, q_p , of piles in mainly cohesionless soils may be calculated by means of conventional bearing capacity theory, taking into account the limiting value, q_l , which may be approached for long piles. This limiting value is normally not to be taken larger than 10MPa.

9.5.2.7 The calculation of end resistance of open-ended pipe piles in any soil deposit is to take into account the resistance of an internal plug which may limit the end resistance of the pile.

9.5.2.8 Guidance for calculation of pile resistance using static pile formulae is given in Appendix F2.

9.5.2.9 The end resistance of piles to rock will depend on the type of rock and of pile, and on the method of pile installation. Based on these factors, the pile resistance is to be considered in each case.

9.5.2.10 The additional stresses introduced in the pile due to settlements in the surrounding soil are to be evaluated in the design where relevant.

9.5.3 Resistance of piles in tension

9.5.3.1 For piles in cohesionless soils the pile-soil friction is normally to be less for piles in tension than for piles in compression.

9.5.3.2 For piles in cohesive soils the pile-soil friction may be equal in tension and in compression.

9.5.3.3 The contribution from end resistance is normally to be assumed equal to zero for all soils.

9.5.3.4 For piles with an increased base diameter the resistance is to be based on the shaft resistance or on the resistance of the base. The two contributions are, however, not to be assumed to act simultaneously at the lower part of the pile.

9.5.4 Resistance of laterally loaded piles

9.5.4.1 Laterally loaded piles may be analysed on the basis of realistic stress-strain curves for soil and pile. The pile deflections induced by the combination of lateral and axial loads may be large enough to develop inelastic behaviour of the soil.

9.5.4.2 The lateral resistance of a pile or pile group may in the ultimate limit state and the progressive collapse limit state be based on the theory of plasticity provided the conditions of 6.2.4 are satisfied. The calculations are then to be based on the assumption that the lateral deformations of the pile are sufficiently large to plastify the soil completely.

9.5.4.3 Guidance for calculation of the resistance of laterally loaded piles is given in Appendix F3.

9.5.5 Safety requirements for pile foundations

9.5.5.1 The safety requirement for pile foundations is;

$$S_d \leq R_d \quad (9-3)$$

where

S_d - design loading effect
 R_d - design resistance of pile.

9.5.5.2 When the pile resistance is calculated from a static or dynamic pile formulae the following material coefficients are to be used;

Effective stress analysis:

- $\gamma_{mf} = 1.2$ on the characteristic value of unit skin friction (f_{si}) and the characteristic limiting value of unit skin friction (f_l), see 9.5.2.5.
- $\gamma_{mf} = 1.1$ on the characteristic value of the coefficient of soil friction ($\tan\phi'$) used in the calculation of the unit end bearing capacity, see 9.5.2.6.
- $\gamma_{mf} = 1.3$ on the characteristic limiting value of unit end bearing capacity (q_l), see 9.5.2.6.

Total stress analysis:

- $\gamma_{mc} = 1.3$ on the characteristic values of
 - unit skin friction (f_{si}), see 9.5.2.2
 - undrained shear strength used to calculate the end bearing capacity, see 9.5.2.3.

9.5.5.3 When laterally loaded piles are analysed according to 9.5.4, the following material coefficients are to be used;

- $\gamma_{mf} = 1.2$ for an effective stress analysis
- $\gamma_{mc} = 1.3$ for a total stress analysis

9.5.6 Group effects

9.5.6.1 For pile groups the interaction effect on individual piles is to be considered for axial as well as for lateral resistance and stiffness.

9.5.6.2 Axial capacity of pile groups may be smaller or larger than the sum of capacities of the individual piles.

depending on the combined effect of factors such as pile spacing, type and strength of soils, pile installation method, etc. Such factors are always to be considered in connection with the evaluation of the pile group resistance.

9.5.6.3 In the evaluation of resistance and stiffness of a pile group consideration is to be given to the effect of imperfect installation procedure, such as reduction of the distance between piles at a depth below mudline due to deviations from parallelism of pile axis, etc.

9.6 Design of gravity type foundations

9.6.1 General

9.6.1.1 The analyses of gravity type foundations are to be carried out according to the requirements given in 9.3 and 9.6.

9.6.1.2 The ultimate limit state is to be considered for the possible failure modes described in 9.4 and 9.6.2, i.e. stability of the foundation, including bearing capacity, with due account to hydraulic effects.

9.6.1.3 The serviceability limit state, i.e. settlements and displacements, is to be considered as described in 9.3.5.

9.6.2 Stability of foundations

9.6.2.1 The risk of shear failure below the base of the structure is to be investigated for all gravity type foundations. Such investigation is to cover sliding along any potential rupture surface with special consideration to the effect of soft layers.

9.6.2.2 The stability analyses, see 9.3.4 and 9.6.4, are to verify that the resistance of the soil is sufficient to resist the most unfavourable combination of loads.

9.6.2.3 The calculations are to be carried out for fully drained, partially drained or undrained conditions, depending on which analysis best represents the actual conditions.

9.6.2.4 If the shear strength of the soil in the undrained condition is shown to be higher than the corresponding strength in the drained condition, the use of the latter is acceptable in lieu of a more realistic analysis.

9.6.2.5 When the analyses are carried out for drained conditions or based on undrained shear strength of clay, and where soil conditions are uniform an analysis of the safety against a deep-seated failure based on bearing capacity formula is acceptable. Bearing capacity formulae are included in Appendix F1. See also 9.6.4.4. The bearing capacity formulae may also be used for non-uniform soil conditions, provided that the characteristic soil properties are selected to give a result on the conservative side.

9.6.2.6 For structures where skirts, dowels, etc. transfer loads to the foundation soil, the contributions of these members to the bearing capacity and lateral resistance are to be analysed.

9.6.3 Soil reaction on foundation structure

9.6.3.1 The reaction of the soil is to be accounted for in the design of the foundation structure.

9.6.3.2 The distribution of such soil reactions against structural members being seated on or penetrating into the sea bottom are to be estimated from conservatively assessed distributions of strength and deformation properties of the foundation soil.

9.6.3.3 The assumed distribution of soil reactions is to be based on the results of a sea bottom survey, giving due consideration to the effects of deviations from a plane surface, the stress-strain properties of the soil, and the geometry of the base of the structure. Local stiffening of the soil associated with negative skin friction on conductors, etc., penetrating the soil is to be accounted for where relevant. For the calculation of local soil reaction stresses on base structure reference is made to the guidelines given in Appendix F5.

9.6.3.4 Due to inhomogeneities in the foundation soil the penetration resistance may vary across the foundation area. Reasonable variations are to be accounted for when designing the ballasting system. See also 10.4.

9.6.3.5 The penetration resistance of skirts, dowels and other projecting objects during installation phase may be calculated according to the guidelines given in Appendix F4.

9.6.4 Safety requirements for gravity type foundations

9.6.4.1 The requirement for stability of gravity type foundation is;

$$\tau_{mob} \leq \tau_d \quad (9-4)$$

where

τ_{mob} — design loading effect (average mobilized design shear stress in the soil)
 τ_d — design shear strength of the soil.

9.6.4.2 If the stability analysis is carried out in terms of effective stresses τ_d is equal to;

$$\tau_d = \frac{c'}{\gamma_{mc}} + \sigma' \frac{\tan \phi'}{\gamma_{mf}} \quad (9-5)$$

where

c' — effective cohesion
 σ' — effective normal stress
 $\tan \phi'$ — characteristic coefficient of friction of soil
 $\gamma_{mf} = 1.2$
 $\gamma_{mc} = 1.3$

9.6.4.3 If the stability analysis is carried out in terms of total stresses τ_d is equal to;

$$\tau_d = \frac{c_u}{\gamma_{mc}} \quad (9-6)$$

where

c_u — characteristic undrained shear strength
 $\gamma_{mc} = 1.3$

9.6.4.4 If the stability of the foundation is calculated by means of a bearing capacity formula, the requirement for stability is;

$$\frac{F_v \gamma_f}{A'} \leq q_d \quad (9-7)$$

where

F_v — characteristic vertical load compatible with the loading condition under consideration
 A' — effective foundation area to be consistent with the bearing capacity formula used
 γ_f — load coefficient, see 4.4.4
 q_d — design bearing capacity, i.e. bearing capacity calculated for the design shear strength defined in Eqs. (9.5) and (9.6).

9.6.4.5 For structures founded on two or more separate footings, the safety against overturning is to be investigated for the extreme loading condition. The moments are to be calculated about the most unfavourable axis through the centre of one or two footings. The design overturning moment is to be less than the design stabilizing moment.

9.6.4.6 The penetration resistance of dowels and skirts is to be calculated based on a realistic range of soil strength parameters using material coefficients $\gamma_{mc} = \gamma_{mf} = 1.0$. Conservative values are to be used in the design. For requirements to the ballasting system, see 10.4.4.

9.6.4.7 The local soil reaction stresses against the base structure are to be calculated based on rational methods of analysis using the highest expected values of strength parameters and material coefficients $\gamma_{mc} = \gamma_{mf} = 1.0$. See also 4.5.1.2.

9.6.5 Dynamic soil properties

9.6.5.1 Dynamic analysis of a gravity structure is to consider the effects of soil-structure interaction, see 9.3.6. In general, modelling of the foundation soil using the continuum approach (or the elastic half-space method) is acceptable.

9.6.5.2 Due account is to be taken of the non-linearities in the soil stress-strain relationships for calculation of spring constants.

9.6.5.3 Parametric studies to investigate the influence of uncertainties in the choice of soil properties such as the strain-dependent shear modulus and damping ratio are to be carried out. Internal soil damping, radiation damping and the effect of soil layering is to be accounted for in a rational manner. See Appendix G for guidance.

9.6.6 Filling of voids

9.6.6.1 Filling of the voids between the platform structure and sea bed may be necessary to assure sufficient stability of the platform.

9.6.6.2 Loading effects due to filling pressures and heat of hydration are to be within acceptable limits.

9.6.6.3 The material used are to be capable of retaining sufficient strength during the lifetime of the platform considering all relevant forms of breakdown such as;

- chemical breakdown
- mechanical breakdown
- pore pressure build-up due to repeated loading, placement problems such as incomplete mixing, dilution etc.

9.6.7 Jack-up platform foundations

9.6.7.1 The design requirements given in Section 9 for gravity type foundations may be made applicable for jack-up platform foundations.

9.6.7.2 Preloading of the jack-up platform foundation in lieu of a complete foundation analysis based on comprehensive site investigations may be considered, provided that;

- the critical loading condition expressed in terms of shear stress mobilization in the foundation soil is exceeded during preloading with 30% or more
- the preload is sustained a time period estimated to be long enough to allow excess pore pressures to dissipate
- the platform elevation can be corrected for possible settlements of the foundation during operation

- it can be shown that the strength of the soil is not critically reduced due to the effects of repeated loading
- scour is considered according to 9.4.4
- the stability of the sea bottom is satisfactory.

9.7 Supervision during installation

9.7.1 General

9.7.1.1 The Owner is to establish a system for supervision of the installation in order to demonstrate that the work is carried out according to the design assumptions. Requirements concerning installation of piled and gravity structures are given in 10.4.

9.7.2 Conductor installation

9.7.2.1 The installation of conductors beneath a platform is to be properly planned and executed to avoid a reduction of the level of safety against failure of the structure itself as well as disturbance of the foundation soils. If conductors are installed through towers or cells with lower hydraulic head inside than outside, this pressure difference is generally not permitted to be applied directly to the foundation soils.

100
200

91

SECTION 10 MARINE OPERATIONS

10.1 General

10.1.1 Application

10.1.1.1 Section 10 applies to all marine operations necessary for the construction, transportation, and installation of an offshore structure, to the extent such operations may influence the safety of the structure or parts thereof.

10.1.1.2 As the requirements given in Section 10 cover various types of structures and many different types of operations, the application of the various paragraphs is to be considered in relation to the actual type of structure and to the complexity of the operations to be performed.

10.1.1.3 New concepts and solutions not adequately covered in this section, will be considered in each case.

10.1.2 Assumptions

10.1.2.1 It is assumed that all marine operations are conducted by competent personnel and that the operation planning is based on experience and sound engineering practice.

10.1.2.2 These Rules assume that conditions during the actual operations do not depart from those assumed.

10.1.3 Surveillance

10.1.3.1 Marine operations are to be carried out in accordance with approved procedures and under the surveillance of DnV.

10.1.4 Permissible loadings

10.1.4.1 All loadings on the structure during marine operations are to be within the limits specified in the Operations Manual. See 10.1.7.

10.1.4.2 Loads during marine operations are to be determined in accordance with the principles given in Section 5.

10.1.4.3 Loading effects are not to exceed the limits given by the requirements concerning structural resistance and serviceability. (See Sections 4, 6 and 7.)

10.1.4.4 The structural strength and behaviour of any floating unit supporting the structure are to be analysed as far as they may influence the support conditions of the structure.

10.1.5. Hydrostatic stability

10.1.5.1 Proof of sufficient stability and reserve buoyancy is to be established for all stages of marine operations.

10.1.5.2 The following requirements are to be met;

- the metacentric height (GM) corrected for free surface and effect of possible air cushion is to be at least 1 m.
- the heel due to extreme wind, towing and mooring loads should not exceed 5 degrees. The wind velocity to be used in the calculations is to be selected in accordance with Section 5.
- the floating structure is to withstand accidental, rapid increase in loading during transfer of heavy loads, unless special precautions are taken.
- the structure is to remain afloat in stable equilibrium with sufficient freeboard to preclude progressive flooding with any one compartment open to the sea.

These requirements may be dispensed with in special cases provided adequate, approved precautions are taken to maintain the same degree of safety.

10.1.5.3 Inclining tests are to be performed prior to all marine operations where stability may be critical. Such inclining tests are to be performed in accordance with 8.2.2.

10.1.5.4 Structures supported on floating bases will be specially considered in each case. However, relevant requirements of 8.2 apply.

10.1.6 Electrical and mechanical systems

10.1.6.1 The structure is to be equipped with all the systems necessary to maintain complete control of the structure during marine operations.

10.1.6.2 Depending on the complexity of the operation, its duration and the structure itself, a separate study may be required to determine the systems required for safe operation. The study is to include normal operations as well as emergency situations. Normally, the following systems are to be considered;

- main power supply
- emergency power supply
- electrical distribution
- machinery control systems
- valve control systems
- instrumentation systems
- bilge and ballast arrangements
- compressed air systems
- fire fighting systems
- communication systems

10.1.6.3 The systems are to be designed, built, installed and tested in accordance with relevant sections of DnV Rules for the Construction and Classification of Steel Ships or other recognized codes or standards.

10.1.6.4 All systems and equipment involved are to be tested shortly before the start of an operation. Such commissioning tests are to demonstrate that the systems are sufficiently reliable, and have the necessary capacities.

10.1.7 Documentation

10.1.7.1 For general requirements to documentation, see 2.3.

10.1.7.2 *Marine operations manuals*: Prior to commencement of any marine operation the details of the operation are to be fully described in operation manuals. These manuals are to cover all aspects of importance for normal operations as well as emergency situations. Generally the following aspects are to be considered;

- organization and communication
- systems and equipment involved (see 10.1.6)
- limitations imposed by environmental conditions (see 10.1.4)
- limitations imposed by structural resistance (see 10.1.4)
- limitations imposed by stability considerations (see 10.1.5)
- operational procedures.

10.1.7.3 *Marine operations records*: During a marine operation the actual procedures used and observations made are to be recorded. Where deviations from approved procedures or expected behaviour occur, the implications are to be analysed and included in the operations records together with the relevant conclusions.

10.2 Construction afloat

10.2.1 General

10.2.1.1 Subsection 10.2 covers marine operations necessary to provide a safe and stable base for construction activities afloat. A construction base may consist of parts of the platform structure itself and/or support structures such as barges, pontoons etc.

10.2.2 Mooring systems

10.2.2.1 The mooring system includes all arrangements necessary to keep the structure in its planned position during construction afloat. The mooring system is to be designed for all relevant loads, see section 5.

10.2.2.2 The weak link principle is to be applied when designing the mooring system, see 4.7.1.3.

10.2.3 Instrumentation systems

10.2.3.1 For general requirements, see 10.1.6.

10.2.3.2 For proper control of the structure during construction afloat it may be necessary to make use of instrumentation to monitor;

- loads or deformations
- environmental conditions
- ballast and stability conditions
- heel, trim and draft.

10.2.3.3 Essential instruments are to be duplicated. If dependent on electric power, the standby power source is to be emergency batteries.

10.2.3.4 All instruments required by 10.2.3.2 are to be tested and calibrated to the satisfaction of DnV prior to start of operation.

10.2.4 Special installation equipment

10.2.4.1 Systems and equipment used during special operations such as deck mating, installation of modules etc., are to be specified. Such specifications are to be sufficiently detailed to permit complete assessment of operational feasibility and loads imposed on the structure.

10.2.4.2 To allow evaluation and approval of the special equipment, the following documentation is to be submitted to DnV;

- description of the equipment
- general lay-out drawings
- strength calculations
- material specifications
- fabrication and installation specifications.

10.3 Transportation

10.3.1 General

10.3.1.1 Subsection 10.3 covers all operations necessary to move the platform structure or major structural parts from the onshore place of fabrication/assembly to the final position. For lifting operations see 10.5.3.

10.3.1.2 The following are to be considered; the transported structure, the sea fastening arrangements, the floating units, the towing arrangements, and any special arrangements involved in the operations.

10.3.1.3 For requirements regarding instrumentation systems, see 10.1.6 and 10.2.3.

10.3.2 Transfer operations

10.3.2.1 A transfer operation includes all the activities necessary to move a structure from one support condition to another. Such transfer operations may be performed by means of lifting, pushing, pulling or ballasting/deballasting of floating units.

10.3.2.2 If the transfer operation involves barges or other floating units, proper mooring systems are to be arranged to provide stable bases for the operation and to achieve the necessary positioning accuracy of the units.

10.3.2.3 The tolerances on supports, skidways etc., are to be specified so that the structure in no phase of the transfer operation is supported in such a way that it may be overstressed.

10.3.2.4 For barges or other floating units forming supports for the structure, a flotation study is to be carried out to verify that the support conditions are satisfactory at all stages.

10.3.3 Towing operations

10.3.3.1 The motions and motion responses of the towed unit are to be analysed. The environmental conditions and loads are to be determined in accordance with Sections 3 and 5 respectively.

10.3.3.2 The towing arrangements and the towing force (required bollard pull of tugs) are to be sufficient to ensure proper control and speed of the towed unit in:

- adverse sea conditions
- adverse currents
- restricted waters.

10.3.3.3 The towing arrangement is to be so designed that failure will not occur in the towed unit itself (weak link principle).

10.3.3.4 The towing route is to be chosen so that adequate bottom clearance and sea room are achieved during the towing operations. Attention is to be paid to navigational accuracy, motion characteristics of the unit and possible heel/trim effects of towing forces, static wind force, ballasting etc.

10.3.3.5 Arrangements for reliable weather forecastings prior to and during the towing operations are to be provided. Weather criteria for starting operations will be evaluated in each case.

10.4 Installation

10.4.1 General

10.4.1.1 Subsection 10.4 covers the operations necessary for installing the structure at its final position. Such operations are positioning, setting, fixing etc. of the structure.

10.4.1.2 If installation operations can cause overloading of structural members or of the foundation, relevant effects of such loading are to be monitored and controlled.

10.4.1.3 Installation instrumentation: For general requirements on instrumentation systems, see 10.1.6 and 10.2.3. Instrumentation employed for control of the structure during installation may include devices for measurements of draft, penetration/settlement, inclination, ballast levels, navigational parameters and environmental conditions.

10.4.2 Launching and upending

10.4.2.1 When a structure is to be launched from a barge, the launch barge is to be specifically equipped for this type of operation. Launchways and rocker-arm arrangements are to be considered with respect to suitability and structural strength.

10.4.2.2 The launching operation is to be planned so that loads imposed on the structure during the launch are within acceptable limits. Parameters to be specially considered are;

- freeboard of launch barge
- trim angle of launch barge
- amount of buoyancy
- position of buoyancy tanks.

10.4.2.3 The launch prepared structure is to be designed with sufficient net buoyancy to compensate for possible inaccuracies in determination of weights and buoyancy.

10.4.2.4 It is to be verified that the structure will behave in a stable manner during the launch dive and the upending operation, and that sufficient bottom clearance is assured at all stages.

10.4.2.5 Buoyancy tanks, supports, and other intermediate equipment are to have adequate structural strength to withstand forces imposed during the launching and upending operations. Buoyancy tanks are to be closely surveyed for imperfections which could influence their structural resistance.

10.4.3 Positioning and submergence

10.4.3.1 The structure is to be placed within the investigated area as defined in 9.2.1.3. If the sea bed has been specially prepared the maximum tolerances in positioning are dictated by the extent and the nature of the preparations.

10.4.3.2 The structure is to be lowered in a controlled manner. Due care is to be taken in assessing the inaccuracies inherent in water depth, sea bed topography, and obstructions. Sudden or large motions during touch down are to be avoided.

10.4.3.3 For requirements regarding ballasting see 10.4.4.

10.4.4 Penetration and leveling

10.4.4.1 The ballast system is to provide ballasting rates permitting safe descent and penetration. The ballasting process is to be reversible during critical stages.

10.4.4.2 The structure is to be capable of providing sufficient ballasting capacity to overcome maximum expected penetration resistance to reach required penetration depth. As the local penetration resistance can vary across the foundation site, eccentric ballasting may be necessary to keep the platform inclination within specified limits.

10.4.4.3 The loading caused by the various ballast configurations during platform installation is to be within the limits given in 10.1.4.

10.4.5 Pile installation

10.4.5.1 Pile installation operations are to be properly planned and executed to avoid reduction in the load carrying capacity of the various soil formations.

10.4.5.2 The piles are to be installed in a sequence providing adequate stability to the structure in all phases of installation.

10.4.5.3 Energy input to the pile and the corresponding pile set are to be recorded during pile driving operations.

10.4.5.4 Jetting is usually acceptable only inside the pile casing to a depth not affecting the soil at the pile tip. Below

the tip of the pile casing only controlled drilling with carefully selected drilling fluid is to be permitted.

10.4.5.5 The placement of grout is to be carefully planned. The grout is to have pumpability and setting time consistent with the actual placement operations. The grout viscosity, density and bleeding properties are to be kept within acceptable limits.

10.4.5.6 During drilling and grouting operations fluid pressures in the drilled hole are to be within the limits set by hydraulic fracturing of the soil and by the stability of the hole itself.

10.4.6 Filling of voids

10.4.6.1 For general requirements regarding material for filling of voids see 9.6.6.

10.4.6.2 The filling is to be done with stresses well within the limits set by considerations of structural and foundation integrity. The system used is to be able both to transport sufficient filling material to the desired location and to remove trapped water from such locations.

10.5 Construction offshore

10.5.1 General

10.5.1.1 Subsection 10.5 covers requirements concerning the operations connected with completion of the platform structure after it is fixed to the sea bed.

10.5.2 Installation of structural parts

10.5.2.1 Prior to all mounting operations, such as installation of deck sections, module support structures, modules, packages etc., geometrical tolerances on structural parts to be connected are to be established.

10.5.2.2 All placements of structural parts are to be followed by a verification that the actual support and fixation conditions are in accordance with designer's specifications.

10.5.3 Lifting

10.5.3.1 It is to be documented that structures to be lifted have structural strength adequate for the operation. Special attention is to be paid to dynamic loads.

10.5.3.2 For all lifting operations, the structural strength and general suitability of the equipment are to be considered. Such equipment may be;

- cranes
- crane barges
- mooring system of barges
- slings and shackles
- spreader frames

10.5.3.3 For lifting lugs/padeyes primary structural steel is normally to be used.

10.5.3.4 Stabbing guides installed to ensure smooth placing of lifted items are to have adequate strength to withstand the impact loads likely to occur during the lifting operation. The guides are to be constructed such that the primary structure suffers no damage if the imposed loads should exceed those assumed.

10.5.4 Special operations

10.5.4.1 Special operations include activities required to install special items on platform structures, such as conductors, scour protection, foundation drains, performance instrumentation, risers etc.

10.5.4.2 Special operations are to be considered in each case with respect to their influence on the integrity of the structure itself and its foundation.

9090

SECTION 11

MAINTENANCE OF CERTIFICATE OF APPROVAL

11.1 General

11.1.1 The Certificate of Approval will be maintained in the operating phase provided the requirements of these Rules are satisfied.

11.1.2 The Certificate of Approval may be withdrawn or amended if major changes occur in the operating conditions or in the condition of the structure. See 2.2.2.

11.1.3 The maintenance of the Certificate of Approval requires that the structure is subjected to periodical surveys, that it is operated in accordance with the Operations Manuals approved by DnV, and that the Owner expediently notifies DnV of conditions, events or planned actions that may make it necessary to perform a special survey. See 11.3.

11.1.4 It is assumed that the Owner will carry out running inspection as required to maintain the structure in a safe condition.

11.1.5 The Owner is to maintain files of the running inspection and the remedial measures taken and make these files available to DnV upon request.

11.1.6 Monitoring of environmental data and of the performance of the structure and its foundation may be required. Plans for instrumentation, data acquisition and reporting are to be submitted to DnV for information in such cases.

11.2 Periodical surveys

11.2.1 General requirements

11.2.1.1 The Owner is to submit to DnV for information sufficient drawings, schematics and supplementary notes to fully present and describe the structures that are included in the certificate. The schematics are to identify the structural elements and components that are included in the periodical surveys.

11.2.1.2 The Owner is to submit to DnV for approval a general, long term programme for the periodical surveys of the structure. Normally, the first long term survey programme should appear in connection with commissioning of the structure. The programme should describe the general arrangements the Owner intends to make and specify basic principles such as

- inspection frequency
- element selection procedure
- inspection methods

11.2.1.3 In due time ahead of each periodical survey, the Owner is to submit to DnV for approval a detailed description of the survey. The description shall define the structural elements to be included in the survey and give details on cleaning and other preparations, and on any non-destructive testing to be carried out.

11.2.1.4 The Owner is to notify DnV in advance when periodical surveys will be carried out and make all necessary arrangements for a DnV Surveyor to be present during the survey.

11.2.1.5 The methods, procedures and testing equipment used for inspection are subject to acceptance, and the work is to be carried out to the satisfaction of a DnV Surveyor.

11.2.2 Extent of periodical surveys

11.2.2.1 In principle the periodical survey is to comprise inspection of selected elements of the structures, e.g. selected joints, zones, members and components. The element selection should be on a rotational basis except for elements that are monitored regularly for trend analysis or other reasons.

11.2.2.2 The extent of each periodical survey is to be based on accumulated evidence regarding the condition of the structure and its foundation as obtained by earlier surveys, monitoring systems or other relevant means. Operating conditions and the functions of the structure are to be taken into account.

11.2.2.3 Normally each survey is to include:

- (a) General visual inspection of selected parts of the structure to determine the general condition of the structure and to locate areas that should be subjected to close inspection and testing.
- (b) Close visual inspection and non-destructive testing of selected local areas of the structure to detect possible material deterioration or incipient cracking.
- (c) Visual inspection and testing as needed to check the condition and function of corrosion protection systems.
- (d) Inspection as needed to check the condition of the foundation and of scour protection systems where installed.
- (e) Inspection as needed to determine the amount of marine growth on the structure and the presence of debris in contact with the structure.

11.2.2.4 In conjunction with surveys, cleaning of structures to be inspected is to be carried out as needed.

11.2.3 Frequency of periodical surveys

11.2.3.1 The long term survey programme (see 11.2.1.2) is to be scheduled so that the whole structure is covered in a period of 5 years, i.e., before renewal of the Certificate of Approval. See 2.2.1.3.

11.2.3.2 The frequency of each periodical survey is to be evaluated in each case taking into account type and condition of structure, its foundations and degree of exposure to potential damage or deterioration.

11.2.3.3 The frequency of all periodical surveys of structures below water and in the splash zone is to be evaluated in the light of the survey methods applied and the certainty attached to each survey.

11.3 Special surveys

11.3.1 General

In the event of accident, discovery of damages or deterioration, modifications or any other noted or possible change in the condition or operation of the structure that may affect its short term safety, a special survey may be required.

11.3.2 Owner's obligation

It is the obligation of the Owner to notify DnV of any events as mentioned in 11.3.1 that may require a special survey.

11.3.3 Execution

Special surveys are normally to be carried by or in the presence of a DnV Surveyor. The DnV's Surveyor is to be provided with the facilities needed for first hand evaluation of the conditions necessitating the survey.

11.3.4 Extent and methods

The extent of the survey and the methods, procedures and equipment etc. to be used are to be specified by the Owner and submitted to DnV for acceptance prior to execution.

11.4 Repairs

11.4.1 Repairs or rework of structural parts that are the subject of certification are to be approved and surveyed by DnV.

11.4.2 The Owner is to notify DnV in advance of any such action and to submit the necessary plans and specifications for approval. The exact documentation that is to be submitted for approval or information purposes is to be decided in each particular case.

11.5 Conversion

11.5.1 If changes are planned in the function of the structure so that assumptions and criteria used in the design and construction may be violated, the Owner is to notify DnV.

11.5.2 Such conversions will normally be subject to approval in accordance with the Rules for new constructions.

9090

APPENDIX C

Alaska Oil and Gas Association
Industry Research Projects, March 1980

ALASKA FRONTIER OCS AREAS

INDUSTRY RESEARCH PROJECTS

LEASE-SALE PLANNING AND RESEARCH COMMITTEE

ALASKA OIL AND GAS ASSOCIATION

March 17, 1980

INDEX

<u>PROJECT</u>	<u>TITLE</u>
Project #1	Bristol Bay Environmental Report
Project #2	Sea Ice Investigation, Beaufort Sea
Project #3	Chukchi Sea - Arctic Coast Environmental and Ecological Data
Project #4	Chukchi Sea Environmental Study
Project #5	Beaufort Sea Environmental Study
Project #6	Beaufort Sea Reconnaissance
Project #7	Beaufort Sea Ice Scouring
Project #8	North and South Bering Sea Environmental Study
Project #9	Western Alaska (Onshore) Environmental Study
Project #10	Arctic Marine Terminal Facilities, Chukchi Sea
Project #11	Offshore Oil Terminal Structure Facilities in the Chukchi Sea
Project #12	Sea Ice Activity and Pressure Ridge Growth in the Beaufort Sea
Project #13	Beaufort Sea Environmental Study
Project #14	Study of Behavior of Oil Spills in the Arctic
Project #15	Manhattan Voyage Study
Project #16	Arctic Tanker Design Study
Project #17	Over Flights: Nome to Resolute
Project #18	Offshore Pipelaying on the Alaskan North Slope - Feasibility Study
Project #19	Characteristics and Distribution of Nearshore Permafrost, Beaufort Sea
Project #20	Sea Ice Dynamics and Properties, Beaufort Sea
Project #21	Arctic Oil Biodegradation
Project #22	Investigation of Ice Forces on Cylinder and Conical Offshore Structures
Project #23	Artificial Ice Island Feasibility Study

<u>PROJECT</u>	<u>TITLE</u>
Project #24	Analysis of Arctic Ocean Under Ice Profiles, Beaufort Sea
Project #25	Bering and Chukchi Seas - Feasibility Study of Production Operations and Marine Crude Transportation During Ice Covered Periods
Project #26	Beaufort Sea Ice Statistics from Satellite (ERTS-1 data)
Project #27	Ice Movement Study for Winter, 1975-1976 Beaufort Sea
Project #28	Aerial Reconnaissance 1974-75 - Prudhoe Bay - Harrison, Point Lay and Kotzebue Sound and Ice Movement - Prudhoe Bay - Harrison Bay
Project #29	Bering/Chukchi Seas Sea Ice Statistics from Satellite Data
Project #30	Unmanned Subsea Work Vehicle Study
Project #31	Crushing Pressure of Ice
Project #32	Triaxial Ice Measurements (Fresh Water Ice)
Project #33	Arctic Ice Islands
Project #34	Feasibility of Constructing Artificial Gravel Islands, Beaufort Sea
Project #35	Summer Sea Ice Conditions, North Alaskan Coast
Project #36	Artificial Ice Island, Beaufort Sea
Project #37	St. George Basin Sea Ice Statistics from Satellite
Project #38	Saline Ice Triaxial Tests
Project #39	Beaufort Sea Ice Movement Study 1976-77
Project #40	Developing Ice Ridging Statistics in the Bering and Chukchi Seas from Submarine Under-Ice Profile Data
Project #41	Oil Spill Response in the Nearshore Beaufort Sea
Project #42	Beaufort Sea Ice Movement Study, 1977-78
Project #43	Aerial Mapping of 1978 Sea Ice in Norton Sound and Northern Bering Sea
Project #44	Beaufort Sea Wind, Wave, Currents
Project #45	Arctic Mobile Drilling Structure
Project #46	Study of Methods and Costs of Offshore Pipeline Installation and Trenching in the Beaufort Sea

150

<u>PROJECT</u>	<u>TITLE</u>
Project #47	Yukon Delta Rubble Pile Investigation 1978
Project #48	Beaufort Sea Floor Geophysical Study
Project #49	Ice Island Experiment
Project #50	Offshore Alaska Seismic Exposure Study (OASES)
Project #51	Aerial Mapping of 1979 Sea Ice in the Norton Sound and Northern Bering Sea
Project #52	Beaufort Sea Ice Movement Study 1978-79
Project #53	Beaufort Sea Ice Movement Studies 3-Year Summary and Analysis
Project #54	Norton Sound and Northern Bering Sea Rubble Pile Investigation 1978-79
Project #55	Beaufort Sea First-Year Ice Survey
Project #56	Bering Sea Phase I Oceanographic Study
Project #57	Reindeer Island Ice Island & Bridge Studies
Project #58	Arctic Skimmer Final Design Project
Project #59	Arctic Dispersant Study
Project #60	Air Cushion Platform Capabilities for Oilspill Cleanup in the Alaskan Beaufort Sea
Project #61	Conical Structure Test Program
Project #62	Under-Ice Rig Noise-Measurement Program
Project #63	Beaufort Wind, Wave, Current Hindcast
Project #64	Bering Sea Aerial Photography Data - 1977
Project #65	Beaufort Sea Drilling Effluent Disposal Study
Project #66	GOAOC PROJECT--Yakutat Wave Data
Project #67	GOAOC PROJECT--Group Oceanographic Survey - Gulf of Alaska
Project #68	GOAOC PROJECT--Weather Forecast Trial
Project #69	GOAOC PROJECT--1973 Soil Boring Program
Project #70	GOAOC PROJECT--Dynamic Soil Analysis
Project #71	GOAOC PROJECT--ARCO Cost Well
Project #72	GOAOC PROJECT--Lab Dynamic Soil Analysis

<u>PROJECT</u>	<u>TITLE</u>
Project #73	GOAOC PROJECT--Oil-Spill Trajectory (Two Reports)
Project #74	GOAOC PROJECT--Socio-Economic Impact of Drilling and Production
Project #75	GOAOC PROJECT--Sea and Subsea Floor Properties
Project #76	GOAOC PROJECT--Seismic Risk Analysis for the Gulf of Alaska
Project #77	GOAOC PROJECT--Superstructure Icing
Project #78	GOAOC PROJECT--1974 Ocean Current Measurement Program
Project #79	GOAOC PROJECT--Gulf of Alaska Hindcast Evaluation (WHEP)
Project #80	GOAOC PROJECT--Earthquake Soil Response Analysis
Project #81	GOAOC PROJECT--Gulf of Alaska Meteorological and Oceanographic Forecasting Program (MOFP)
Project #82	GOAOC PROJECT--Gulf of Alaska Wave and Wind Measurement Program (GAWWMP)
Project #83	GOAOC PROJECT--Seismic Risk Analysis for the Gulf of Alaska
Project #84	GOAOC PROJECT--Gulf of Alaska Wave Hindcasting Pilot Study (GAPS)
Project #85	ASOC PROJECT--Bering Sea - St. George Basin/Western Bristol Bay Wave and Wind Measurement Program (BOMP)
Project #86	ASOC PROJECT--Bering Sea Oceanographic Measurement Program 1977-1978 (extension of 1976-1977 BOMP)
Project #87	Yakutat Wave Data
Project #88	Kodiak COST Well
Project #89	Kodiak COST Well Geotechnical Study
Project #90	St. George Basin COST Well
Project #91	Marathon Satellite Current Study
Project #92	Kodiak Shelf Geotechnical Study
Project #93	Gulf of Alaska Ground Response Analysis - Phase I

<u>PROJECT</u>	<u>TITLE</u>
Project #94	1979 Beaufort Break-up
Project #95	1974-1975 Beaufort Aerial Reconnaissance Study
Project #96	Model Tests and Analysis of Multiyear Pressure Ridges Failing Against a 45° Cone
Project #97	Sonar Ice Mapping System (SIMS) - The Development and the 1977-1978 Measurement Program
Project #98	Feasibility Study of an Air Cushion Drilling System for Shallow Water Areas of the North Slope of Alaska
Project #99	Yukon Delta Tide Gauge Program - 1979
Project #100	Beaufort Sea Floor Geotechnical
Project #101	Norton Phase I Geotechnical
Project #102	Beaufort Sea Freeze-up Movement Study - 1979
Project #103	OSI Stress Sensor Study
Project #104	OSI Beaufort Oceanographic Study
Project #105	Seismicity of Offshore Alaska Regions (SOAR) Program
Project #106	Arctic Cone Test Structure - Phase I
Project #107	Large Scale In-Situ Ice Strength Measurement
Project #108	1979-80 Beaufort Sea Ice Movement Study
Project #109	Level Ice and Pressure Ridge Characteristics During USCGC Polar Star Deployment in Bering and Chukchi Seas
Project #110	Bering Sea Ice Aerial Mapping - 1980
Project #111	Aerial Mapping of Sea Ice in the Chukchi Seas, 1980
Project #112	Bering Sea Ice Features

Project Number	Project	Cost to Next Participant
1.	Bristol Bay Environmental Report	\$ 24,000
2.	Sea Ice Investigation, Beaufort Sea	18,536
3.	Chukchi Sea Environmental and Ecological Data	17,280
4.	Chukchi Sea Environmental Study	1,000
5.	Beaufort Sea-Arctic Coast Oceanographic and Climatologic Data Analysis	7,500
6.	Beaufort Sea Reconnaissance	22,115
7.	Beaufort Sea Ice Scouring	15,681
8.	North and South Bering Sea Environmental Study	2,000
9.	Western Alaska (Onshore) - Environmental Study	1,000
10.	Arctic Marine Terminal Facilities, Chukchi Sea	317,896
11.	Offshore Oil Terminal Structure Facilities in the Chukchi Sea	7,300
12.	Sea Ice Activity and Pressure Ridge Growth in the Beaufort Sea	82,550
13.	Beaufort Sea Environmental Study	16,333
14.	Study of Behavior of Oil Spills in the Arctic	--
15.	Manhattan Voyage Study	2,000,000

Amoco	ARCO	Sohio BP	Chevron	Cities Service	Conoco	Exxon	Getty	Gulf	Marathon	Mobil	Phillips	Placid	Shell	Sun	Texaco	Union	Hamilton Bros.	Others
x	x		x	x	x	x			x				x	x				1
x	x	x	x	x	x	x	x	x		x	x		x	x	x	x	x	1
x	x		x	x	x	x			x		x				x			1
			x							x								
x		x	x			x				x	x		x		x	x		1
x		x	x			x							x			x	x	2
x	x	x	x			x		x		x			x	x				
				x						x								
										x								
x	x					x												
								x										
x	x					x												

Project Number	Project	Cost to Next Participant	2
16.	Arctic Tanker Design Study	403,745	x x x
17.	Overflights: Nome to Resolute	40,718	x x x
18.	Offshore Pipelaying on the Alaskan North Slope - Feasibility Study	9,667	x x x x x x x x
19.	Characteristics and Distribution of Nearshore Permafrost, Beaufort Sea	--	ALL
20.	Sea Ice Dynamics and Properties, Beaufort Sea	--	ALL
21.	Arctic Oil Biodegradation	--	ALL
22.	Investigation of Ice Forces on Cylinder and Conical Offshore Structures	10,000	x x x x x x x
23.	Artificial Ice Island Feasibility Study	10,200	x x x x x x x x
24.	Analysis of Arctic Ocean Under-Ice Profiles	12,125	x x x x x x x
25.	Bering and Chukchi Seas--Feasibility Study of Production Operations and Marine Crude Transportation During Ice-Covered Periods	8,700	x x x x x x x x x x x x
26.	Beaufort Sea Ice Statistics from Satellite (ERTS-1 Data)	23,100	x x x x x x
27.	Ice Movement Study for Winter, 1975-1976, Beaufort Sea	84,365	x x x x x x x x
28.	Aerial Reconnaissance - Prudhoe Bay - Harrison, Point Lay and Kotzebue Sound and Ice Movement - Prudhoe Bay - Harrison Bay	20,000	x x x x x x x

Project Number	Project	Cost to Next Participant
29.	Bering/Chukchi Sea Ice Statistics from Satellite Data	23,550
30.	Unmanned Subsea Work Vehicle Study	7,675
31.	Crushing Pressure of Ice	10,000
32.	Triaxial Ice Measurements	10,000
33.	Arctic Ice Islands	10,000
34.	Feasibility Study for Construction of Artificial Gravel Islands, Beaufort Sea	8,223
35.	Summer Sea Ice Conditions, North Alaskan Coast	5,000
36.	Artificial Ice Islands, Harrison Bay, Beaufort Sea	20,000
37.	St. George Basin Sea Ice Statistics From Satellite	5,125
38.	Saline Ice Triaxial Tests	33,500
39.	Beaufort Sea Ice Movement Study 1976-1977	92,402
40.	Developing Ice Ridging Statistics in the Bering and Chukchi Seas from Submarine Under-Ice Profile Data	9,540
41.	Oil Spill Response in the Nearshore Beaufort Sea	3,636
42.	Beaufort Sea Ice Movement Study, 1977-1978	90,166

Project Number	Project:	Cost to Next Participant
43.	Aerial Mapping of 1978 Sea Ice in Norton Sound and Northern Bering Sea	22,237
44.	Beaufort Sea Wind, Wave, Current Program	53,600
45.	Arctic Mobile Drilling Structure	60,000
46.	Study of Methods and Costs of Offshore Pipeline Installation and Trenching in the Beaufort Sea, Alaska	16,335
47.	Yukon Delta Rubble Pile Investigation 1978	8,567
48.	Interpretation of Existing Geological, Geophysical and Engineering Data, 1971-1977, for the Beaufort Sea, Alaska	25,957
49.	Ice Island Experiment	320,000
50.	Offshore Alaska Seismic Exposure Study (OASES)	none
51.	Aerial Mapping of 1979 Sea Ice in the Norton Sound and Northern Bering Sea	25,643
52.	Beaufort Sea Ice Movement Study, 1978-1979	46,775
53.	Beaufort Sea Ice Movement Studies (BSIMS) Three-Year Summary and Analysis	33,805
54.	Norton Sound and Northern Bering Sea Rubble Pile Investigation, 1978-1979	33,762

[illegible]

Others	
Hamilton Bros.	
Union	
Texaco	
Sun	
Shell	x
Placid	
Phillips	
Mobil	x
Marathon	
Gulf	
Getty	
Exxon	x
Conoco	
Cities Service	
Chevron	x
Sohio RP	
ARCO	x
Ampco	

Others
Hamilton Bros.
Union
Texaco
Sun
Shell
Placid
Phillips
Mobil
Marathon
Gulf
Getty
Exxon
Conoco
Cities Service
Chevron
Sohio BP
ARCO
Amoco

Project Number	Project	Cost to Next Participant
95.	1974-1975 Beaufort Aerial Reconnaissance Study	
96.	Model Tests and Analysis of Multiyear Pressure Ridges Failing Against a 45° Cone	30,000
97.	Sonar Ice Mapping System (SIMS) - The Development and the 1977-1978 Measurement Program	30,100
98.	Feasibility Study of an Air Cushion Drilling System for Shallow Water Areas of the North Slope of Alaska	
99.	Yukon Delta Tide Gauge Program 1979	19,000
100.	Beaufort Sea Geotechnical	
101.	Norton Phase I Geotechnical	
102.	Beaufort Sea Freeze-up Movement Study - 1979	37,500
103.	OSI Stress Sensor Study	
104.	OSI Beaufort Oceanographic Study	
105.	Seismicity of Offshore Alaska Regions (SOAR) Program	50,000
106.	Arctic Cone Test Structure - Phase I	36,600

x									
			x						
				x					
x			x						
				x					
x	x		x			x	x		
x	x	x		x			x	x	x

Others
Hamilton Bros.
Union
Texaco
Sun
Shell
Placid
Phillips
Mobil
Marathon
Gulf
Getty
Exxon
Conoco
Cities Service
Chevron
Sohio BP
ARCO
Amoco

Project Number	Project	Cost to Next Participant
107.	Large Scale In-situ Ice Strength Measurement	
108.	1979-80 Beaufort Sea Ice Movement Study	70,000
109.	Level Ice and Pressure Ridge Characteristics During USCGC Polar Star Deployment in Bering and Chukchi Seas	21,875
110.	Bering Sea Ice Aerial Mapping - 1980	59,115
111.	Aerial Mapping of Sea Ice in the Chukchi Sea, 1980	
112.	Bering Sea Ice Features	

x	x		x	x	x	x	x	x
x	x		x			x		x
	x		x	x		x		x
						x		

PROJECT #1

TITLE: Bristol Bay Environmental Report

PURPOSE & METHOD: To establish an environmental background for considering operational problems which might be anticipated in Bristol Bay, a search of the literature was conducted, which included existing weather records; ship observations and other pertinent reports. Collected data was interpreted and compiled into three volumes of reports. Weather data was input into a hindcast model, so that wind, wave, current and sea level data can be estimated for Bristol Bay areas. Data from 35 extreme storms was included.

CONTRACTOR: Ocean Science & Engineering, Inc.
45 Del Ray Avenue
Washington, D. C. 20014

OPERATOR: None - All participants executed agreement with OSE, Inc.

REPORT: Bristol Bay Environmental Report - three volumes.

COST: \$144,000--cost to next participant \$24,000.

PARTICIPANTS: Sun, Shell, Mobil, Exxon, CONOCO, Cities Service, Chevron, ARCO, Amoco and 1 other.

FINAL REPORT: December, 1970

CONFIDENTIALITY:

PROJECT #2

TITLE: Sea Ice Investigation, Beaufort Sea

PURPOSE & METHOD: Near-shore fast ice characteristics were studied. The primary objective was to determine type and magnitude of ice movement, and character of ice and bottom sediments where measurements were made.

Surveyed lines were established perpendicular to the coast, and some distance onto the ice. These lines were re-surveyed at intervals, and the survey data compared. Ice cores were taken and bottom sediments sampled at several points on the survey lines.

Polexi established several lines during the winter of 1969-1970, and incorporated data from a survey by Standard of California done in the 1968-1969 winter, and a similar survey done by Mobil in the 1969-1970 winter.

CONTRACTOR: Polexi (AINA) - Arctic Institute of North America
1619 New Hampshire Avenue, N.W.
Washington, D. C. 20009

OPERATOR: None - All participants executed agreement with Polexi.

REPORT: Offshore Ice Investigation - Polexi.

COST: \$198,000--cost to next participant \$18,536.

PARTICIPANTS: Hamilton Brothers, Union, Texaco, Sun, Shell, Phillips, Mobil, Gulf, Exxon, CONOCO, Cities Service, Chevron, ARCO, Amoco and 1 other.

FINAL REPORT: December, 1970

CONFIDENTIALITY: March 16, 1980

PROJECT #3

TITLE: Chukchi Sea - Arctic Coast Environmental and Ecological Data Analysis

PURPOSE & METHOD: To provide a comprehensive data base for planning offshore exploration and development operations in the Chukchi Sea and adjacent coastal areas. Oceanographic and land based data in the form of magnetic tapes, punch cards, computer print-outs, open-file research reports, card indices, raw data plot sheets, etc., were obtained from numerous U.S. government agencies, universities, and private research centers. These data were analyzed in order to provide answers to specific offshore questions raised by operational problems associated with the following interrelated environmental and ecological elements:

Sea Waves	Tides
Sea Ice	Ocean Currents
Precipitation	Earthquake Activity
Air and Sea Temperatures	Tidal Waves (tsunami)
Humidity and Pressure	Permafrost
Wind Velocity and Direction	Wildlife
Visibility, Ceiling, Clouds, Storms	Aircraft Flight Operations
Sea-Water Physical Properties	Logistics
Sea-Bottom Sediments	Radio Communications
Bathymetry	U.S.S.R. Political Implications
	Dew Line Information

CONTRACTOR: Continental Shelf Data Systems (CSDS)
Division of Amuedo and Ivey
155 South Madison, Suite 230
Denver, Colorado 80209

OPERATOR: None - All participants required to execute a purchase agreement with CSDS for the use of these data.

REPORT: The final report is in three volumes, containing 775 pages of text, diagrams, tables, charts and maps assimilating information on the above categories. Includes 12 bathymetric contour maps at the scale of 1"=16,000'.

COST: \$8,120 text in two volumes (775 pages)
\$3,400 12 bathymetric maps

PARTICIPANTS: Sun, Phillips, Marathon, Exxon, CONOCO, Cities Service, Chevron, ARCO, Amoco and 1 other.

FINAL REPORT: 1971

PROJECT #3 CONTINUED

CONFIDENTIALITY:

Each company that purchases these reports and/or bathymetric maps is required to execute a purchase agreement containing the following statement:

"The data obtained from this Study shall be kept and remain confidential by the Purchaser and shall not be disclosed or transferred to any party not a party to this Agreement; however, the data may be utilized by a purchasing company's affiliates, wholly owned subsidiaries, contractors and consultants, such as for the purpose of ship building, platform or pipeline construction, weather or oceanographic studies, and exploration planning."

PROJECT #4

TITLE: Chukchi Sea Environmental Study

PURPOSE & METHOD: The report is a compilation and interpretation of historical geographic and environmental data for the Chukchi Sea area.

CONTRACTOR: Ocean Science and Engineering, Inc.

OPERATOR: Contracted by Mobil Oil Corporation
P. O. Box 5444, Terminal Annex
Denver, Colorado 80217

REPORT: Chukchi Sea Environmental Report

COST: \$3,000 - cost to next participant \$1,000.

PARTICIPANTS: Mobil and Chevron

FINAL REPORT: June, 1970

CONFIDENTIALITY: Unanimous consent of participants

PROJECT #5

TITLE: Beaufort Sea-Arctic Coast Oceanographic and Climatologic Data Analysis

PURPOSE & METHOD: To provide a comprehensive data base for planning offshore exploration and development operations in the Beaufort Sea and adjacent coastal areas. Oceanographic and land based data in the form of magnetic tapes, punch cards, computer print outs, open-file research reports, card indices, raw data plot sheets, etc., were obtained from numerous U.S. government agencies, universities, and private research centers. These data were analyzed in order to provide answers to specific offshore questions raised by operational problems associated with the following interrelated environmental and ecological elements:

Sea Waves	Surface Winds
Ocean Surface Currents	Precipitation
Sea Ice	Visibility
Sea Temperatures	Air Temperature
Bathymetry	Communication Interference
Tides	Aircraft Flight Operations
Storm Conditions	Permafrost

CONTRACTOR: Continental Shelf Data Systems (CSDS)
Division of Amuedo and Ivey
155 South Madison, Suite 230
Denver, Colorado 80209

OPERATOR: None - All participants required to execute a purchase agreement with CSDS for the use of these data.

REPORT: The final copyrighted report contains 140 pages (14"x 20") of text, diagrams, tables, charts and maps assimilating information on the above categories. Includes 12 bathymetric contour maps at the scale of 1"=16,000'.

COST: \$4,100 - text, one volume
\$3,400 - 12 bathymetric maps

PARTICIPANTS: Union, Texaco, Shell, Phillips, Mobil, Exxon, Chevron, Sohio-BP, Amoco and 1 other.

FINAL REPORT: 1969

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PROJECT #6

TITLE: Beaufort Sea Reconnaissance

PURPOSE & METHOD: To determine the distribution and characteristics of soils, sediments and ice and sub-ice oceanographic conditions, Point Storkersen to Milne Point, North Slope, Alaska.

Nineteen soil borings were drilled, by a "Becker" type drill, to depths of 10.5 - 125 feet. The samples were taken from various different surface environments. Field temperature readings were taken and samples were lab-tested for cohesion, expansion, consolidation, shear strength, density, moisture content, angle of repose, etc. Detailed lithologic descriptions of each boring were also done. Scuba dives through the ice at five different locations were made. The divers collected data on ice thickness, character, and sub-ice oceanographic bottom conditions and characteristics such as water currents, visibility, plant and animal life, etc. These studies provide basic data pertinent to the planning and designing of drilling and production facilities.

CONTRACTOR: Marine Advisors Inc.

OPERATOR: Hamilton Brothers Oil Company
1800 Broadway
Denver, Colorado 80202

REPORTS: Reconnaissance Studies of Soils, Sediments and Ice, Point Storkersen to Milne Point, Alaska.

COST: \$241,000--cost to next participant \$22,115.

PARTICIPANTS: Hamilton Brothers; Union, Shell, Exxon, Chevron, Sohio-BP, Amoco and 2 others.

FINAL REPORT: August, 1970

CONFIDENTIALITY: April 12, 1981

PROJECT #7

TITLE: Beaufort Sea Ice Scouring

PURPOSE & METHOD: The Beaufort Sea bottom was observed by Side-Scan Sonar, Sub-bottom Profiler, and Precision Fathometer to determine the extent and character of scour trenches caused by the movement of large ice features. Observations were made during two summer cruises with the Coast Guard, in the offshore area between Harrison Bay and the Canning River Delta. The first year's survey was conducted in water depths ranging from 50' to 250', and the second year from 50' to shore.

CONTRACTOR: General Dynamics
Electric Boat Division
Eastern Point Road
Groton, Conn. 06340
Attn: Manager, Industrial Safety

OPERATOR: None - All participants executed agreement with General Dynamics.

REPORT: Ice Scouring on the Alaskan Continental Shelf.
Volumes I and II.

COST: \$115,000--cost to next participant \$15,681.

PARTICIPANTS: Sun, Shell, Mobil, Gulf, Exxon, Chevron, Sohio-BP, ARCO and Amoco.

FINAL REPORTS: Volume I--November, 1971
Volume II--November, 1972

CONFIDENTIALITY:

PROJECT #8

TITLE: North and South Bering Sea Environmental Study.

PURPOSE & METHOD: The report is a compilation and interpretation of historical geographic and environmental data from the Bering Sea.

CONTRACTOR: Ocean Science and Engineering, Inc.

OPERATOR: Contracted by Mobil Oil Corporation
P. O. Box 5444, Terminal Annex
Denver, Colorado 80217

REPORT: North and South Bering Sea Environmental Study.

COST: \$6,000--cost to next participant \$2,000.

PARTICIPANTS: Marathon and Cities Service.

FINAL REPORT: October, 1970

CONFIDENTIALITY: Unanimous consent of participants

PROJECT #9

TITLE: Western Alaska (Onshore)

PURPOSE & METHOD: The report is a compilation and interpretation of historical geographic and environmental data for Western Alaska.

CONTRACTOR: Ocean Science and Engineering, Inc.

OPERATOR: Contracted by Mobil Oil Corporation
P. O. Box 5444, Terminal Annex
Denver, Colorado 80217

REPORT: Western Alaska Environmental Report.

COST: \$3,000--cost to next participant \$1,000.

PARTICIPANTS: Mobil

FINAL REPORT: July, 1971

CONFIDENTIALITY: Consent of operator

PROJECT #10

TITLE: Arctic Marine Terminal Facilities, Chukchi Sea

PURPOSE & METHOD: To determine the feasibility of constructing and operating a marine terminal in the arctic. Terminal and component concepts were screened to determine general technical feasibility taking into consideration known environmental and operating requirements, and a reasonable scheme of terminal development was selected for detailed study and cost analysis.

A scheme was selected that is suitable for staged construction to allow minimum commitment of money until construction experience is gained and behavior of the components in place can be observed. Several possible locations for the terminal are indicated and assumptions have been made with the help of knowledgeable personnel to estimate such parameters as soil conditions, sea ice forces, ship maneuverability in ice, etc.

CONTRACTOR: Van Houten Associates, Inc.

OPERATOR: Esso Research and Engineering Company
Contact: Manager, Marine Department
Exxon Company, U.S.A.
P. O. Box 2180
Houston, Texas 77001

REPORT: Arctic Marine Terminal Facilities - Engineering Study

COST: \$1,271,586---cost to next participant \$317,896.

PARTICIPANTS: Exxon, Sohio-BP and ARCO.

FINAL REPORT: November, 1969

CONFIDENTIALITY: Expired

PROJECT #11

TITLE: Offshore Oil Terminal Structure Facilities in the Chukchi Sea.

PURPOSE & METHOD: To design an offshore terminal in the Arctic Ocean for use of tankers but excluding the study of how tankers can get to the area. Included is a study of various designs that take advantage of or protect from particular environmental conditions. This involves a study of subsurface soil conditions, meteorology, oceanology, and ice conditions in the area of interest. Operational criteria and port designs are set forth. Desirable research and field tests are recommended and construction considerations are outlined. Also, a glossary of arctic terms is included.

CONTRACTOR: Frederic R. Harris, Inc.

OPERATOR: Humble Oil & Refining Company (Now Exxon Company, U.S.A.)
Contact: Manager, Marine Department
Exxon Company, U.S.A.
P. O. Box 2180
Houston, Texas 77001

REPORT: Offshore Oil Terminal Structure Facilities in the Chukchi Sea - Feasibility Study

COST: \$29,197--cost to next participant \$7,300.

PARTICIPANTS: Exxon, Sohio-BP and ARCO.

FINAL REPORT: December, 1968

CONFIDENTIALITY: Expired

PROJECT #12

TITLE: Sea Ice Activity and Pressure Ridge Growth
in the Beaufort Sea

PURPOSE & METHOD: To study the mutual effects of sea ice - ice
island interaction two grounded ice islands
(Unak 1 and Unak 2) were surcharged with frozen
sea water during the winter of 1968-69 to offset
the anticipated ablation during the summer
period. Pressure ridge formation and ice move-
ment around the ice islands were observed and
photographed during the next several months.

CONTRACTOR: Institute of Arctic Environmental Engineering,
University of Alaska

OPERATOR: Humble Oil and Refining Company (Now Exxon
Company, U.S.A.)
Contact: Manager, Marine Department
Exxon Company, U.S.A.
P. O. Box 2180
Houston, Texas 77001

REPORT: AMTF - 70-10001

COST: \$330,219--cost to next participant \$82,550.

PARTICIPANTS: Exxon, Sohio-BP and ARCO.

FINAL REPORT: November, 1969

CONFIDENTIALITY: Expired

PROJECT #13

TITLE: Beaufort Sea Environmental Study

PURPOSE & METHOD: This is a very general study for the region between Bering Straits and Victoria Island and reports on ice coverage, ice reporting and forecasting, transportation, tides and currents, bathymetry and meteorology. Similar studies for Svlabard, Norway, Greenland, Labrador, Hudson Bay, Canadian Arctic Islands, and Southern Alaska.

CONTRACTOR: Marex Ltd, Cowes, United Kingdom
Marine Exploration Ltd.
Marex H. O.
High Street
Cowes, Ilse of White
England

OPERATOR: Compagnie Francaise de Petrole.

REPORT: Beaufort Sea Environmental Study. One of a set of eight regional studies.

COST: \$49,000--cost to next participant \$16,333.

PARTICIPANTS: Sohio-BP

FINAL REPORT:

CONFIDENTIALITY:

PROJECT #14

TITLE: Study of Behavior of Oil Spills in the Arctic

PURPOSE & METHOD: To study effects of oil spills in the arctic, a series of small controlled oil spill tests were conducted during the summer of 1970. These tests were designed to obtain information on the behavior of spilled crude oil, its resistance to cleanup, and the effectiveness of various methods to recover the oil. Tests were made on water between ice floes, under the ice, and on the ice surface.

CONTRACTOR: U. S. Coast Guard

OPERATOR: U. S. Coast Guard
Contact: Manager, Marine Department
Exxon Company, U.S.A.
P. O. Box 2180
Houston, Texas 77001

REPORT: USCG Report 714108/A/001, 002 "A Study of the Behavior of Oil Spills in the Arctic"

COST: \$15,000

PARTICIPANTS: Exxon

FINAL REPORT: February, 1971

CONFIDENTIALITY: Expired

PROJECT #15

TITLE: Manhattan Voyage Study

PURPOSE & METHOD: To determine the feasibility of shipping oil by tanker through the Northwest Passage and to obtain ice breaking criteria for future tanker design, two trips were made by a converted tanker to arctic waters. In the summer of 1969, the SS Manhattan with an icebreaker bow and strengthened hull completed a round trip through the Northwest Passage and tested ice-breaking capabilities in Viscount Melville Sound. In the second voyage, the ship tested icebreaking capabilities in the Baffin Bay in the spring of 1970. The data obtained have been analyzed by various numerical methods and compared with model data.

CONTRACTOR: Several contractors.

OPERATOR: Humber Oil & Refining Company (now Exxon Company, U.S.A.)
Contact: Manager, Marine Department
Exxon Company, U.S.A.
P. O. Box 2180
Houston, Texas 77001

REPORT: Arctec, Inc., No. 00170, Vol. 1 and 2 plus Appendices A-A5, B-K. Humble Oil & Refining Company (Now Exxon Company, U.S.A.) "Manhattan Spring 1970 Arctic Test Voyage"

COST: \$40,000,000+ ---cost to next participant \$2,000,000.

PARTICIPANTS: Exxon, Sohio-BP and ARCO.

FINAL REPORT: December, 1970

CONFIDENTIALITY: Expired

PROJECT #16

TITLE: Arctic Tanker Design Study

PURPOSE & METHOD: To design an icebreaker tanker for operation in arctic waters. Operational and scientific data acquired during the 1969 and 1970 test voyages on the Manhattan and ice model test results have been utilized to make a preliminary design of a future arctic tanker. These studies have resulted in establishing the characteristics of a workable and feasible first generation ship design. Further optimization can be expected in the future after additional model tests have been carried out and after actual experience is gained with operating tankers in the arctic.

CONTRACTOR: Newport News Ship Building Company

OPERATOR: Humble Oil & Refining Company (now Exxon Company, U.S.A.)
Contact: Manager, Marine Department
Exxon Company, U.S.A.
P. O. Box 2180
Houston, Texas 77001

REPORT: Arctic Tanker Design Study

COST: \$1,614,977--cost to next participant \$403,745.

PARTICIPANTS: Exxon, Sohio-BP and ARCO.

FINAL REPORT: August, 1970

CONFIDENTIALITY: Expired

PROJECT #17

TITLE: Overflights: Nome to Resolute

PURPOSE & METHOD: To observe and document ice conditions over the Northwest Passage as a pre-requisite to traverses such as that by the Icebreaker Tanker, SS Manhattan. Using SLAR (side-looking airborne radar), overflights obtained raw photographic data. These data have been analyzed by the Raytheon Company and Philco-Ford Corporation to obtain a summary of ice conditions.

CONTRACTOR: The Raytheon Company and Philco-Ford Corporation

OPERATOR: Humble Oil & Refining Company (now Exxon Company, U.S.A.)
Contact: Manager, Marine Department
Exxon Company, U.S.A.
P. O. Box 2180
Houston, Texas 77001

REPORT: "Analysis of SLAR Imagery of Sea and Fast Ice Areas" FR-4290-53, Raytheon Company. "SLAR Imagery Reports" Humble Purchase Order DC111414, Philco-Ford Corporation.

COST: \$162,872--cost to next participant \$40,718.

PARTICIPANTS: Exxon, Sohio-BP and ARCO.

FINAL REPORT: 1969

CONFIDENTIALITY: Expired

PROJECT #18

TITLE: Offshore Pipelaying on the Alaskan North Slope - Feasibility Study

PURPOSE & METHOD: The technical and economic feasibility of off-shore pipelaying methods for the Alaskan North Slope will be explored. The geographical area under study will lie between the Canning and Colville Rivers from the shoreline out to the 100-foot water depth contour. Both conventional and unconventional pipelaying techniques will be examined. The conventional techniques include lay-barge, reel-barge and pull methods while unconventional techniques for near shore application include tunneling, suspension bridges and pipelaying on gravel berms built above the water line. Pipelaying from the ice surface will also be examined. The research will be of a preliminary nature to select promising methods for more detailed study. No environmental field data will be collected during the program; existing data will be used.

CONTRACTOR: Shell Development Company, Pipeline Research and Development Laboratory
P. O. Box 35335
Houston, Texas 77035

OPERATOR: Shell Development Company

REPORT: "A Feasibility Study of Offshore Pipelaying in the Southern Beaufort Sea":

Volume 1 - Summary Report by S. K. Bhatia and T. Enger, Shell Development Co., Technical Progress Report 9(a) -73

Volume 2 - Appendices to Summary Report, Shell Development Co., Technical Progress Report 9(b) -73

Volume 3 - Ice Coverage Study, Shell Development Co., Technical Progress Report 9(c) -73

Volume 4 - Soils and Trenching, Shell Development Co., Technical Progress Report 9(d) -73

COST: \$60,000--cost to next participant \$9,667.

PARTICIPANTS: Shell, Mobil, Gulf, Exxon, Chevron, Sohio-BP, ARCO and Amoco.

FINAL REPORT: June, 1973

CONFIDENTIALITY: June, 1983

PROJECT #19

TITLE: Characteristics and Distribution of Nearshore
Permafrost, Beaufort Sea

PURPOSE & METHOD: To define the characteristics and distribution
of nearshore permafrost by drilling and sampling
core holes near Barrow, Alaska. Cores will be
taken and logged, bore hole temperature measured.
Drilling will be attempted on a line from shore,
across lagoons, on barrier islands, and seaward
of the islands.

CONTRACTOR: University of Alaska, Geophysical Institute
Arctic Coastal Engineering Program
Fairbanks, Alaska 99701

OPERATOR: None - Project funded by the Office of Naval
Research with a contribution from the AOGA
membership.

REPORT: Completed 1975

COST: \$30,000 (\$5,000 from AOGA) - 1973
\$62,004 (\$19,000 from AOGA) - 1974

PARTICIPANTS: All AOGA members.

FINAL REPORT:

CONFIDENTIALITY: The report is public information.

PROJECT #20

TITLE: Sea Ice Dynamics and Properties, Beaufort Sea

PURPOSE & METHOD: To gain a better understanding of the dynamic processes and stress levels which nearshore sea ice undergoes in generating its characteristic features. The ice will be observed on the Chukchi Sea shore near Barrow for a period commencing sometime in March, 1973 to near break-up. Observations will be made with radar equipment and the resulting imagery recorded on film using a time-lapse technique. Simultaneous measurements will be made of internal ice stress using several arrays of stress transducers imbedded in two dimensional patterns in the land-fast sea ice.

CONTRACTOR: University of Alaska, Geophysical Institute
Arctic Coastal Engineering Program
Fairbanks, Alaska 99701

OPERATOR: None - Project funding mainly by Sea Grant with contribution from the AOGA membership.

REPORT: Completed 1975

COST: \$65,000 (\$13,600 from AOGA) - 1973
\$1,291,146 (\$13,000 from AOGA) - 1974

PARTICIPANTS: All AOGA members.

FINAL REPORT:

CONFIDENTIALITY: The report is public information.

PROJECT #21

TITLE: Arctic Oil Biodegradation

PURPOSE & METHOD: To determine the oil biodegradation potential in the Arctic Ocean waters, studies of the biodegradation rates and temperature coefficients of the metabolic processes were undertaken.

CONTRACTOR: University of Alaska, Institute of Marine Science
Fairbanks, Alaska 99701

OPERATOR: None - Project funded principally by the U.S. Coast Guard with a small contribution from the AOGA membership.

REPORT: Interim report included in University of Alaska (Institute of Marine Science) No. R 72-3
"Baseline Data Study of the Alaskan Arctic Aquatic Environment" will be complete in summer of 1973.

COST: \$130,000 (\$4,500 from AOGA)

PARTICIPANTS: All AOGA members.

FINAL REPORT:

CONFIDENTIALITY: The report is public information.

PROJECT #22

TITLE: Investigation of Ice Forces on Cylinder and Conical Offshore Structures

PURPOSE & METHOD: Purpose is to investigate forces that a uniform sheet of ice can exert on cylindrical and conical shaped structures. The work was carried out with small scale models of cones, cylinders and ice, in a test cold room at Chevron Oil Field Research Company laboratory in La Habra, Calif. Results yield important data as to the magnitudes of force for the condition of the ice initially adhering to the cone, and for the condition when ice is prevented from adhering to the cone.

CONTRACTOR: None

OPERATOR: All work performed by Chevron Oil Field Research Company
P. O. Box 446
La Habra, California

REPORTS: An Experimental Investigation of Ice Forces on Cylindrical Structures

An Experimental Investigation of Ice Forces on Cone-Shaped Structures

COST: \$10,000 per participant (irrespective of number of participants).

PARTICIPANTS: Sun, Shell, Phillips, Exxon, Chevron and Amoco.

FINAL REPORTS: September, 1973

CONFIDENTIALITY: January 1, 1980

PROJECT #23

TITLE: Artificial Ice Island Feasibility Study

PURPOSE & METHOD: To study the physical processes applicable to artificial ice island construction in the near-slope area of the Beaufort Sea, and to assess the value of such a structure in terms of its utility, and for forces that may act upon it. If a construction process is found to be feasible, and a potential structure utilizable, the study will undertake to optimize the construction process, specify techniques and equipment, and outline a testing program which would verify the design parameters for construction.

CONTRACTOR: Dames & Moore, Anchorage, Alaska.

OPERATOR: Mobil Oil Corporation
P. O. Box 5444, Terminal Annex
Denver, Colorado 80217

REPORT: Feasibility Study, Construction of Artificial Ice Island in the Beaufort Sea.

COST: \$68,000--cost to next participant \$10,200.

PARTICIPANTS: Sun, Shell, Mobil, Gulf, Exxon, Chevron, Sohio-BP, ARCO and Amoco.

FINAL REPORT: November, 1975

CONFIDENTIALITY: Unanimous consent of participants.

PROJECT #24

TITLE: Analysis of Arctic Ocean Under-Ice Profiles

PURPOSE & METHOD: Under-ice profile data recorded by "upward looking" sonar on the U.S. Navy's nuclear submarines SARGO and SEADRAGON during summer and winter 1960 cruises under the polar ice pack of the Beaufort Sea were analyzed to evaluate the ice parameters. Included statistical analysis of sea ice depth, linear frequency of under-ice pressure ridges, (Keels), frequency of occurrence of keels of different depths, percentage of ice at each depth, and shape and volume of under-ice masses. These under-ice profile data were recorded in strip chart form and are being digitized for computer analysis. Although thousands of miles of profile data exist, the present study concerns the analysis of two 50-mile segments of winter ice intersection at a right angle near 72°N, 150°W, and one 50-mile segment of summer ice near 74°N, 162°W. Results from this study show this unique source of data will be valuable for developing ice design criteria for arctic offshore structures.

CONTRACTOR: LeSchack Associates, Ltd.
1111 University Boulevard West, Suite 116
Silver Spring, Maryland 20902

REPORT: Analysis of Arctic Ocean Under-Ice Profiles

COST: \$48,500. Cost to next participant \$12,125.

PARTICIPANTS: Sun, Shell, Phillips, Exxon, Chevron and Amoco.

FINAL REPORT: July, 1975

CONFIDENTIALITY: Unanimous consent of all participants

PROJECT #25

TITLE: Bering and Chukchi Seas--Feasibility Study of Production Operations and Marine Crude Transportation During Ice-Covered Periods

PURPOSE & METHOD: All available sea ice data will be collected to evaluate the feasibility of conducting production operations and supporting marine crude tanker transportation in the winter ice-covered Bering and Chukchi Seas. The study area is bounded by the Alaska coast in the east, Aleution Islands on the south, the U.S.A. - U.S.S.R. boundary on the west and 72° latitude on the north (just north of Pt. Barrow).

These seas present winter ice conditions for which little is known on how best to conduct production and marine tankering operations on a year-round basis. Data is needed to develop drilling and operating costs, and to compare relative advantages of tanker, pipeline, or combination pipeline/tanker transportation schemes.

The study will collect all available and pertinent sea ice data including information from satellite imagery, provide insight into operating problems, estimate crude tankering costs, and evaluate alternative tankering and/or ice breaking schemes. Task 1 to develop a technical and management plan was completed prior to offering the study for joint participation.

CONTRACTOR: Arctec, Incorporated
9104 Red Branch Road
Columbia, Maryland 21045

OPERATOR: Standard Oil Company of California
c/o Chevron Oil Field Research Company
Box 446, La Habra, California 90631
Attention: Mr. Larry D. Brooks

REPORT: Feasibility Study of Bering/Chukchi Seas Production and Marine Transportation System

COST: \$70,000--cost to next participant 150% of prorata cost at time of late joining.

PARTICIPANTS: Union, Sun, Shell, Phillips, Mobil, Marathon, Gulf, Getty, Chevron, ARCO, Amoco and 1 other.

FINAL REPORT: November, 1975

CONFIDENTIALITY: November 1, 1980

PROJECT #26

TITLE: Beaufort Sea Ice Statistics from Satellite
(ERTS-1 Data)

PURPOSE & METHOD: To derive statistics of sea ice distributions in the Beaufort Sea using imagery from ERTS-1 (Earth Resources Technology Satellite). Statistics to be derived will include: the location of the edge of the pack ice; the frequency of the currents of pack ice invasion along the coast; the size distribution of ice flows in relation to the edge of pack ice; ice movement; the extent and dates of break-up of shore fast ice. Also, studies will be conducted using imagery and digitized data to verify further techniques to identify ice types developed in earlier studies.

CONTRACTOR: Environmental Research & Technology, Inc.
696 Virginia Road
Concord, Massachusetts 01742

OPERATOR: None

REPORT: Beaufort Sea Ice Statistics from ERTS-1 Data

COST: \$77,000--cost to next participant \$23,100.

PARTICIPANTS: Shell, Gulf, Exxon and Sohio-BP.

FINAL REPORT: July, 1976

CONFIDENTIALITY: July, 1981

PROJECT #27

TITLE: Ice Movement Study for Winter, 1975-1976,
Beaufort Sea, Alaska

PURPOSE & METHOD: To measure the rate and extent of ice movement at select locations in the shore fast area between Cape Halkett and Tigvariak Island.

A mechanical reel system was used to measure movement data which was recorded on magnetic tape at the sites and also telemetered to a base station located in the Prudhoe Bay area. In addition to movement data, temperature, wind, tide, current and ice strain were collected and recorded.

CONTRACTOR: Oceanographic Services, Inc.

OPERATOR: Amoco Production Company
Security Life Bldg.
Denver, Colorado 80202

REPORT: Beaufort Sea Ice Movement Study, 1975-1976

COST: \$457,777--cost to next participant \$84,365

PARTICIPANTS: Shell, Mobil, Gulf, Exxon, Chevron, Sohio-BP, ARCO and Amoco.

FINAL REPORT: September, 1976

CONFIDENTIALITY: June 1, 1981

PROJECT #28

TITLE: Aerial Reconnaissance - Prudhoe Bay -
Harrison, Point Lay and Kotzebue Sound
and Ice Movement - Prudhoe Bay - Harrison Bay

PURPOSE & METHOD: Aerial reconnaissance was flown at Harrison
Bay - Prudhoe Bay, Point Lay, and Kotzebue
Sound during the winter 1974-75 in November,
March and June. A total of 54 separate flight
lines were photographed over the ice to docu-
ment ice features and to detect changes in
features over the winter.

Ice movement measurements in the shore fast
areas of Prudhoe Bay - Harrison Bay were made
at three locations. The stations were located
southeast of Thetis Island, northeast of Stump
Island and west of Reindeer Island. Movements
were computed by calculating the change of
location of stations set up on the ice with
respect to land. The stations were located
with laser surveying devices in November,
March and May.

OPERATOR: Amoco Production Company
Security Life Bldg.
Denver, Colorado 80202

REPORTS: Ice Conditions in the Prudhoe Bay - Harrison
Bay, Point Lay and Kotzebue Sound Areas,
Winter 1974-75

Landfast Ice Movement in the Prudhoe Bay -
Harrison Bay Area, Winter 1974-75

COST: \$20,000 per participant

PARTICIPANTS: Shell, Exxon, Chevron, Sohio-DP, ARCO and Amoco.

FINAL REPORTS: December, 1975

CONFIDENTIALITY: January 1, 1981

PROJECT #29

TITLE: Bering/Chukchi Sea Ice Statistics from Satellite Data

PURPOSE & METHOD: Examine sea ice conditions in the entire Bering/Chukchi Seas using Landsat and meteorological satellite data available to date. Particular emphasis will be placed on basins where lease sales are scheduled (St. George, Bristol, Norton and Hope Basins) plus other interest areas such as the Bering Straight and possible locations of terminals. Statistics to be derived include: the seasonal progressive edges of the ice and its consistency by years; floe-size distribution; characteristics and behavior of shore-fast ice; ice movement patterns and rates; the extend and dates of break-up of shore-fast ice.

CONTRACTOR: Environmental Research & Technology, Inc.
696 Virginia Road
Concord, Massachusetts 01742

OPERATOR: None

REPORT: Further Studies of Sea-Ice Conditions in the Bering/Chukchi Seas Using Satellite Data

COST: \$78,500--cost to next participant \$23,550.

PARTICIPANTS: Mobil, Gulf, Exxon and Sohio-BP.

FINAL REPORT: Project initiated February 15, 1977.
Project complete March, 1979.

CONFIDENTIALITY: March 1, 1984

PROJECT #30

TITLE: Unmanned Subsea Work Vehicle Study

PURPOSE & METHOD: To evaluate the application of the U.S. Navy unmanned subsea technology to exploration and production tasks. The Navy CURV (Controlled Underwater Recovery Vehicle) technology is assessed against necessary offshore subsea operations.

The study includes an evaluation of under-ice application.

CONTRACTOR: Proto-Power Management Corporation
Mystic, Connecticut

OPERATOR: Amoco Production Company
Research Department
Tulsa, Oklahoma

REPORT: Cable Controlled Underwater Recovery Vehicle--
Technology Transfer Program. Two volumes.

COST: \$53,600--cost to next participant \$7,675.
Only penalty is inability to have been present at sea trials.

PARTICIPANTS: Shell, Phillips, Amoco and 3 others.

FINAL REPORT: December, 1975

CONFIDENTIALITY: December, 1978

PROJECT #31

TITLE: Crushing Pressure of Ice

PURPOSE & METHOD: To provide an up-to-date assessment of what is known and unknown about the failure of the ice sheets crushing against cylindrical structures.

Several theoretical analyses and previous experimental measurements of the forces resulting from ice crushing against cylindrical structures are described in this report. Included are new, unpublished theoretical results based on elastic-plastic limit analyses and finite element calculations, as well as an interpretation of ice force measurements that removes some of the ambiguity associated with existing experimental observations.

Ice properties are reviewed and new measurements of ice strength under triaxial loading conditions are presented. The use of an anisotropic, pressure-sensitive failure criterion is suggested to describe ice strength in further theoretical analyses of crushing failure of ice.

CONTRACTOR: None

OPERATOR: Exxon Production Research Company

REPORT: Crushing Pressure of Ice

COST: \$10,000

PARTICIPANTS: Shell, Gulf, Exxon and Amoco.

FINAL REPORT: December, 1975

CONFIDENTIALITY: December 31, 1979

PROJECT #32

TITLE: Triaxial Ice Measurements

PURPOSE & METHOD: To determine the strength of freshwater ice under triaxial stress states.

A series of 163 laboratory tests were conducted on columnar grained ice with horizontal c-axis. The test program consisted of 99 triaxial compression tests, 49 uniaxial compression tests, and 15 uniaxial tension tests. Confining pressure was varied in the range of 0-400 psi to determine the pressure dependence of ice strength. The anisotropy of ice strength was characterized by testing samples with the axial load applied at three angles (0°, 45°, 90°) with respect to the crystal growth direction. Variations in ice temperature and strain rates were also included in this test program.

CONTRACTOR: Arctec Canada, Ltd.

OPERATOR: Exxon Production Research Company

REPORT: Triaxial Ice Measurements

COST: \$10,000

PARTICIPANTS: Shell, Exxon and Chevron.

FINAL REPORT: June, 1975

CONFIDENTIALITY: December 31, 1979

PROJECT #33

TITLE: Arctic Ice Islands

PURPOSE & METHOD: To develop a model to estimate the risk of collisions between ice islands and selected offshore sites in the coastal waters of the Beaufort Sea.

A Monte Carlo model was developed to carry out the objectives of this project. The model assumes that ice islands enter the Beaufort Sea across a line extending from the approximate center of the Pacific gyral to the northwest corner of Banks Island. The model allows the islands to move in the gyral under the influence of currents and either ground and breakup along the coast, continue in the gyral, or exit into the Amundsen Gulf or the Eurasian sector of the Arctic Ocean. Input data for the Monte Carlo model were obtained from information gained by reviewing the literature. The source, number, drift paths, and the possibilities of ice island grounding and breaking up were reviewed.

The report covering this project describes the Monte Carlo model, evaluates its realism and develops ice island encounter probabilities at ten sites in the southern Beaufort Sea. Appendices contain the historical, physical and statistical information obtained from the literature review.

CONTRACTOR: None

OPERATOR: Exxon Production Company

REPORT: Arctic Ice Islands

COST: \$10,000

PARTICIPANTS: Shell, Exxon and Amoco.

FINAL REPORT: December, 1975

CONFIDENTIALITY: December 31, 1979

PROJECT #34

TITLE: Feasibility Study for Construction of
Artificial Gravel Islands, Beaufort Sea,
Alaska

PURPOSE & METHOD: To develop reliable information and data regarding
equipment requirements, U.S. equipment availability
and procurement, island construction and equipment
transportation costs, equipment scheduling,
requirements for materials and recommendations
for their exploration, and gravel island design
requirements for the construction of both
temporary and permanent gravel islands.

CONTRACTOR: Hydronamic B. V., Slidrecht, Holland

OPERATOR: Amoco Production Company
Security Life Building
Denver, Colorado 80202

REPORT: The Building of Artificial Islands in the
Offshore Area Between Flaxman Island and
Cape Halkett

COST: \$76,750--cost to next participant, 150% of prorata
cost at time of late joining.

PARTICIPANTS: Hamilton Brothers, Shell, Mobil, Marathon,
Gulf, Getty, Exxon, Chevron, Sohio-BP, ARCO,
Amoco and 2 others.

FINAL REPORT: March, 1976

CONFIDENTIALITY: June 1, 1981

PROJECT #35

TITLE: Summer Sea Ice Conditions, North Alaskan Coast

PURPOSE & METHOD: To document and perform preliminary statistical analyses of the historical data on summer ice conditions off the north Alaska coast. These types of analyses will be required to assess the feasibility and cost of operating at different locations in the study area during various times of the summer season. Historical data were obtained for 1953 through 1975 from ice observer flight logs, ship reports, satellite imagery and U.S. and Canadian annual summary reports.

CONTRACTOR: Sea Ice Consultants

OPERATOR: Amoco Production Company (Research Department)
P. O. Box 591
Tulsa, Oklahoma 74102

REPORTS: All reports entitled:

Sea Ice Conditions Along the North Coast of Alaska - Cape Halkett to Camden Bay - June through October, 1953 through 1975

Volume I - Report, Plots and Tabulations
Volume II - Tabulations and Worksheets
Volume III - Ice Charts, 1953-64
Volume IV - Ice Charts, 1965-75
Supplemental report prepared by Amoco

COST: \$5,000 (independent of number of participants).

PARTICIPANTS: Shell, Gulf, Exxon, ARCO, Amoco and Sohio-BP.

FINAL REPORT: December, 1976

CONFIDENTIALITY: January 1, 1982

PROJECT #36

TITLE: Artificial Ice Islands, Harrison Bay,
Beaufort Sea

PURPOSE & METHOD: To build an ice island capable of being used
as a drilling platform for oil exploration in
shallow arctic offshore situations. The ice
island had to be acceptable to all federal and
state agencies for permitting purposes.

The location of the ice island is in Harrison
Bay on the North Plains of Alaska at the mouth
of the Colville River. Once the natural ice
had frozen thick enough to support activity,
water was pumped from beneath the ice to on
top of the ice in thin layers and allowed to
freeze. This was continued until an ice block
was formed that reached from the surface of the
water to the bottom of the bay.

A comprehensive report containing formation
and data about the island has been prepared.
Ice strength, salinity, weather, ice movements,
point load tests, temperature profiles, radiant
energy evaluation are included in the reports.
A section on cold room study which covers
freezing rates and strength of ice with respect
to temperature and salinity is also included.

Operating information is provided as to the
type of equipment and technique of physically
building the ice island.

CONTRACTOR: Dames & Moore

OPERATOR: Union Oil Company of California

REPORTS: Arctic Ice Island Study, Harrison Bay, Alaska
by Frederick C. Duthweiler, 1975

Grounded Ice Islands Field & Laboratory Research
Interim Report by F. C. Duthweiler & M. E. Utt

Grounded Ice Islands Field & Laboratory Research
Final Report by F. C. Duthweiler & M. E. Utt

COST: \$20,000

PARTICIPANTS: Union, Shell, Mobil, Gulf, Exxon, Amoco and 1 other.

FINAL REPORTS: November, 1976

CONFIDENTIALITY: December 31, 1980

PROJECT #37

TITLE: St. George Basin Sea Ice Statistics From Satellite

PURPOSE & METHOD: Define ice conditions in the St. George basin area relative to floating drilling vessel, bottom founded structures and ocean shipping. Landsat satellite imagery will be used to define seasonal ice edge location, types of ice present, percent of ice cover, floe size and extent of shore fast ice.

CONTRACTOR: Escatech, Long Beach, California

OPERATOR: Marathon

REPORT: Bering Sea (St. George) Ice Statistics From Satellite

COST: \$41,000--cost to next participant \$5,125.

PARTICIPANTS: Union, Texaco, Sun, Marathon, Gulf, Getty, Exxon, CONOCO, Cities Service, Amoco and 2 others.

FINAL REPORT: Estimated July, 1977

CONFIDENTIALITY: Unanimous consent of participants.

PROJECT #38

TITLE: Saline Ice Triaxial Tests

PURPOSE & METHOD: To determine the strength of laboratory grown saline ice under triaxial stress states.

A series of 153 uniaxial tests will be conducted on laboratory grown, columnar-grained saline ice with horizontal c-axis. The ice salinity will be 3 / and 6 / . Confining pressure will vary in the range of 0-400 psi to determine the dependence of strength on hydrostatic stress. The anisotropy of ice strength will be characterized by testing samples with the axial load applied at three angles (0, 45, 90) with respect to the crystal growth direction. Variations in ice temperature and strain rate will also be included in the program. The estimated time required for the program is 12 months.

CONTRACTOR: Arctec Canada, Ltd.

OPERATOR: None

REPORT: Triaxial Compressive Tests on Lab Grown Saline Ice

COST: \$134,000--cost to next participant \$33,500.

PARTICIPANTS: Shell, Gulf, Exxon, Chevron and Amoco.

FINAL REPORT: November, 1977

CONFIDENTIALITY: December 31, 1982

PROJECT #39

TITLE: Beaufort Sea Ice Movement Study 1976-77

PURPOSE & METHOD: To measure the rate and extent of ice movement at select locations in the shore fast area between Cape Halkett and Brownlow Point.

This study is a continuation of the 1975-76 study (AOGA Project #27) and is also expanded to cover additional area from Tigvariak Island to Brownlow Point.

A mechanical reel system was used to measure movement data which was recorded on magnetic tape at sites and also telemetered to a base station located in the Prudhoe Bay area. In addition to movement data, temperature, wind, tide, current and ice strain have been collected and recorded.

An aerial photography program was included as a part of the 1976-77 survey to obtain statistical information on ice conditions in the nearshore area. This program included 16 flight lines at 3,000 feet altitude, extending offshore for 20 miles, and one flight line flown at 6,000 feet altitude, extending offshore for 60 miles. These flight lines, obtained both in March and June, 1977, were spaced intermittently along the coast over the ice movement study area. Also obtained during the June, 1977 flight program were 52 high level (12000' alt.) flight lines, 30 miles offshore from the coastline. This high level program provides complete coverage of the entire ice movement study area to aid in mapping trends of ice features found on the low level flights.

CONTRACTOR: Oceanographic Services, Inc.

OPERATOR: None--coordinated by Amoco Production Company.

REPORT: Beaufort Sea, Ice Movement Study, 1976-77
(two volumes)

COST: \$530,114--cost to next participant \$92,402.
Participation in AOGA Project #27 not prerequisite to this study.

PARTICIPANTS: Shell, Mobil, Gulf, Exxon, Chevron, Sohio-BP, ARCO and Amoco.

FINAL REPORT: June, 1978

CONFIDENTIALITY: June 1, 1982

PROJECT #40

TITLE: Developing Ice Ridging Statistics in the Bering and Chukchi Seas From Submarine Under-Ice Profile Data

PURPOSE & METHOD: Under ice profile data recorded by "upward looking" sonar on the U.S. Navy's nuclear submarines Sargo and Seadragon on 17, one hundred foot stip-charts covering approximately 1,800 miles of cruise track between 60°N and 72°N during 1960-62 in the Bering and Chukchi Seas are analyzed for ice morphology parameters. Data analysis is for 2-4 mile segments and summarized in 50 mile intervals and includes statistics of sea ice depth occurrence at deeper than 6, 15, 30 and 45 feet, linear occurrence, frequency at each depth, percent of profile below each depth, frequency of ice mass below 10 feet and other. Statistics are particularly directed at providing useful data for design and use of offshore drilling vessels, offshore structures and transportation systems.

CONTRACTOR: LeSchack Associates, Ltd.
1111 University Boulevard West, Suite 116
Silver Spring, Maryland 20902

OPERATOR: None

REPORT: Developing Ice Ridging Statistics in the Bering and Chukchi Seas from Submarine Under-Ice Profile Data

COST: \$31,800--cost to next participant \$9,540.

PARTICIPANTS: Shell, Mobil, Marathon, Exxon and Amoco.

FINAL REPORT: March, 1977

CONFIDENTIALITY: Unlimited

PROJECT #41

TITLE: Oil Spill Response in the Nearshore Beaufort Sea

PURPOSE & METHOD: To identify the currently available techniques and equipment that may be suitable for use in the nearshore Beaufort Sea, along with environmental conditions under which they could be applied; to identify those operating conditions in the nearshore Beaufort Sea under which currently available techniques and equipment are judged to be inadequate; and to identify the research objectives which must be satisfied in order to obtain the desired level of capability in oil spill response. To develop an engineering research development program directed toward meeting these objectives.

CONTRACTOR: Arctec, Inc.
Columbia, Maryland

OPERATORS: ARCO, Exxon Shell

REPORT: "Oil Spill Response in the Nearshore Beaufort Sea"

COST: \$40,000--cost to next participant \$3,636.

PARTICIPANTS: Shell, Phillips, Mobil, Gulf, Getty, Exxon, Cities Service, Chevron, Sohio-BP, ARCO and Amoco.

FINAL REPORT: August, 1978

CONFIDENTIALITY: May 1, 1982

PROJECT #42

TITLE: Beaufort Sea Ice Movement Study, 1977-78

PURPOSE & METHOD: To measure the magnitude and rate of ice movement at twelve locations in the landfast ice between Cape Halkett and Flaxman Island off the Alaskan North Coast. The measurement program is scheduled from November through May. An OSI wire/reel ice movement system will be used to measure the ice motions and data will be telemetered to Deadhorse.

To obtain stereo aerial photography of the sea ice in the study area and perform analyses on the geometry and distribution of large ice features and surface roughness.

This study is cimilar in scope to AOGA Project #39.

CONTRACTOR: Oceanographic Services, Inc.

OPERATOR: None

REPORT: Beaufort Sea Ice Movement Study, 1977-78

COST: \$510,000--cost to next participant is estimated at \$90,166.

PARTICIPANTS: Shell, Mobil, Gulf, Getty, Exxon, Chevron, ARCO and Amoco.

FINAL REPORT: January, 1979

CONFIDENTIALITY: June 1, 1983

PROJECT #43

TITLE: Aerial Mapping of 1978 Sea Ice in Norton Sound and Northern Bering Sea

PURPOSE & METHOD: The project consists of flying approximately 1200 miles of stereo photography over Norton Sound and the Northern Bering Sea at a negative sale of 1 inch = 1000 feet. Resultant photos will be spliced into continuous strips corresponding to individual flight line segments. Some 15 sections of these strips, each about 10 miles long, will be selected and analyzed to determine percentage of ice by type, frequency of ridging and rafting, and height and width of other surface features. Additional, less detailed, study will be conducted on all photos. To supplement the high resolution photographic data, applicable government satellite and other remote sensing data will be obtained, where possible. Ice charts and a narrative of the entire 1977-78 ice season in the Bering Sea will be included.

CONTRACTOR: Oceanographic Services, Inc. (OSI)
Santa Barbara, California

OPERATOR: None

REPORT: Aerial Mapping of 1978 Sea Ice in Norton Sound and Northern Bering Sea

COST: \$110,135. Cost to next participant \$12,237 + \$10,000 late participation fee = \$22,237.

PARTICIPANTS: Amoco, ARCO, Sohio-BP, Chevron, Exxon, Gulf, Mobil and Shell

FINAL REPORT: December 1, 1978

CONFIDENTIALITY: November 1, 1983

PROJECT #44

TITLE: Beaufort Sea Meteorological and Oceanographic Measurement Program (BEAUMOP)

PURPOSE & METHOD: To gather oceanographic and meteorological data for the Alaskan Beaufort Sea. The objectives of this program are to measure winds, waves, currents, tides, storm surge, and barometric pressure at selected sites within the Prudhoe Bay offshore region. Measurement sites have been selected to complement data being collected by the University of Alaska and to provide a spatial description of the oceanographic conditions. It is intended to utilize the data for calibration in the development of a hindcast model of the region.

CONTRACTOR: Oceanographic Services, Inc. (OSI)
Santa Barbara, California

OPERATOR: Gulf Research and Development Company
P. O. Box 36506
Houston, Texas 77036

REPORT: Beaufort Sea Meteorological and Oceanographic Measurement Program (BEAUMOP), Summer 1978

COST: \$285,875. Cost to next participant \$53,600.

PARTICIPANTS: ARCO, Sohio-BP, Exxon, Getty, Gulf, Marathon, Mobil and Shell.

FINAL REPORT: February, 1979

CONFIDENTIALITY: Earliest of one year after the Beaufort Sea nearshore lease sale or five years after program termination.

PROJECT #45

TITLE: Arctic Mobile Drilling Structure

PURPOSE & METHOD: To develop a conically shaped, mobile exploratory drilling system preliminary design suitable for the Beaufort Sea environment.

This project consists of the results of a Preliminary Design Study and supporting studies for a gravity foundation steel-hulled cone drilling system. Major systems are defined and cost and weight estimates are given.

Supporting studies include predicted ice forces, foundation capacity predictions, hull heat transfer analyses, and preliminary predictions of wave forces and floating dynamic properties of the system. Results of preliminary studies that investigate various alternate structural systems are also included.

CONTRACTOR: The Offshore Company
Chevron Oil Field Research
P.M.B. Systems Engineering
Spencer Engineering Associates

OPERATOR: Standard Oil Company of California

REPORTS: Arctic Mobile Drilling Structure: Preliminary Design Study (two volumes) and six other reports.

COST: \$50,000 fixed fee to original 6 licensees. License fee now \$60,000.

PARTICIPANTS: Amoco, ARCO, Chevron, Exxon and Shell.

FINAL REPORT: April, 1978

CONFIDENTIALITY: Seven years from effective date of license.

PROJECT #46

TITLE: Study of Methods and Costs of Offshore Pipeline Installation and Trenching in the Beaufort Sea, Alaska

PURPOSE & METHOD: To study methods and costs for installation and trenching of submarine pipelines for the Alaskan Beaufort Sea. The study includes consideration of laying, protection/trenching, connection, and repair problems. It is limited primarily to methods and equipment currently available.

Typical values and ranges are defined for environmental parameters. The study determines the general feasibility, capabilities and limitations of various installation and burial techniques as a function of the environmental parameters. Equipment requirements are defined. Available methods for pipeline connection and tie-in are reviewed for their technical economical applicability in the Arctic. The study also assesses methods of pipeline repair for their applicability and time required to make repairs.

Two pipeline installation scenarios are evaluated in detail. Sufficient details of unit costs, equipment, and time requirements are provided to facilities preparation of cost estimates for other cases.

CONTRACTOR: R. J. Brown and Associates of America, Inc.

OPERATOR: Shell Oil Company

REPORT: Study of Methods and Costs of Offshore Pipeline Installation, Trenching, Connection and Repair, Beaufort Sea, Alaska

COST: \$125,650. Cost to next participant--\$16,335.

PARTICIPANTS: ARCO, Sohio-BP, Chevron, Exxon, Getty, Marathon, Mobil, Phillips and Shell.

FINAL REPORT: October, 1978

CONFIDENTIALITY: To the earliest of one year following the Federal/State Beaufort Sea lease sale or five years after termination of the study.

PROJECT #47

TITLE: Yukon Delta Rubble Pile Investigation 1978

PURPOSE & METHOD: To measure the submerged profile and local bathymetry around ice rubble piles found in the Yukon River Delta area of Alaska. Ice samples were also taken of the rubble piles for the determination of salinity and particulate material characteristics. The submerged profiles were measured using sonar techniques.

CONTRACTOR: Oceanographic Services, Inc.
P. O. Box 6783
Santa Barbara, California

OPERATOR: None

REPORT: Yukon Delta Rubble Pile Analysis of 1978

COST: \$24,960. Cost to next participant \$8,567. Participation in AOGA Project #43 is prerequisite for this study.

PARTICIPANTS: ARCO, Sohio-BP, Chevron, Exxon, Mobil and Shell

FINAL REPORT: February, 1979

CONFIDENTIALITY: November 1, 1983

PROJECT #48

TITLE: Interpretation of Existing Geological, Geophysical and Engineering Data, 1971-1977, for the Beaufort Sea, Alaska

PURPOSE & METHOD: To identify and interpret geophysical and physical data collected by the USGS and CRREL.

Corehold, seismic, vibracore and dive site data will be investigated by provided information on recent sediments, ice gouging and permafrost. The investigation will cover the 1979 lease sale area and immediate adjacent area. The report will concern itself with two different subjects, the geological aspects and the engineering aspects of the sea bottom.

CONTRACTOR: Harding-Lawson Associates

OPERATOR: None

REPORT: Interpretation of Geophysical, Geological and Engineering Data, 1971-1977, for the Beaufort Sea, Alaska

COST: \$119,800. Cost to next participant \$25,957.

PARTICIPANTS: ARCO, Chevron, Exxon, Getty and Mobil

FINAL REPORT: April 1, 1979

CONFIDENTIALITY: In effect until one year after the Beaufort Sea Lease Sale or five years after termination of this study, whichever is later.

PROJECT #49

TITLE: Ice Island Experiment

PURPOSE & METHOD: To extend the state of the art regarding the construction of ice islands and their use as temporary drilling platforms in shallow arctic waters.

A 1200-foot diameter ice island is being constructed six miles north of the Prudhoe Bay East Dock at a water depth of ten feet. Construction is planned throughout the winter to achieve a completed island freeboard of 20 feet.

Various techniques to accelerate ice growth will be evaluated in this program. The island will be monitored continuously, from its commencement through fall freeze-up following completion, to observe its resistance to lateral ice forces and its rate of deterioration during the summer open-water season.

OPERATOR: Exxon Company, U.S.A.

COST: \$2,400,000. Cost to next participant: 30% of cumulative cost to date plus 20% of remaining project cost.

PARTICIPANTS: Sohio-BP, Exxon, Mobil and Phillips

FINAL REPORT:

CONFIDENTIALITY: Continues for two years after Beaufort Sea lease sale or until January 1, 1985, whichever is earlier.

PROJECT #50

TITLE: Offshore Alaska Seismic Exposure Study (OASES)

PURPOSE & METHOD: To assess the seismic exposure as precisely as possible in terms of probability of exceedence in nine OCS areas around Alaska. OASES is a statement of the state-of-the-art of seismic exposure methodology and is based entirely on nonproprietary data. The results are presented as contour maps of various ground motion parameters for several return periods. The results are compared with the 1978 API RP2A earthquake provisions.

CONTRACTOR: Woodward-Clyde Consultants
San Francisco, California

OPERATOR: For the Alaska Subarctic Offshore Committee (ASOC)
Exxon Company, U.S.A.

REPORT: Offshore Alaska Seismic Exposure Study Volumes I through V, plus an Executive Summary.

COST: \$380,715.

PARTICIPANTS: Members of ASOC.

FINAL REPORT: March, 1978

CONFIDENTIALITY: Report released without confidentiality provisions.
Copies have been distributed to the attached list.

Addressee list for OASES report

Mr. Klaus H. Jacob, Lamont-Doherty, Geological Observatory, Palisades, NY
Dr. K. Stokoe, III, University of Texas, Austin, TX
Dr. Gary Latham, University of Texas, Marine Science, 700 Strand, Galveston, TX
Mr. Gerald B. Shearer, USGS, Box 259, Anchorage, AK
Professor Paul Jennings, California Institute of Technology, Pasadena, CA
Dr. Nathan Newark, University of Illinois, Urbana, IL
Dr. M. D. Trifunac, University of Southern California, Los Angeles, CA
Dr. Rudolph Englemann, Director, OCSEAP, NOAA, EPL, Boulder, CO
Dr. Ted Algermissen, USGS, Denver, CO
Dr. R. A. Page, USGS, Menlo Park, CA
Professor H. Shan, Earthquake Engineering Inst., Stanford University, Stanford, CA
Dr. H. B. Seed, University of California, Berkeley, CA
Dr. Allin Cornell, Massachusetts Institute of Technology, Cambridge, MA
Professor Paul H. Wirshing, University of Arizona, Tucson, AZ
Professor Fred Moses, Case Western Reserve University, Cleveland, OH
Professor James T. P. Yao, Purdue University, W. Lafayette, Indiana
Dr. Carl Kisslinger, University of Colorado, Boulder, CO
Mr. Robert L. Wesson, USGS-National Center, Reston, VA
Dr. B. Mohraz, Southern Methodist University, Dallas, TX
Dr. C. Martin Duke, University of California, Los Angeles, CA
Professor A. S. Veletsos, Rice University, Houston, TX
Dr. Juan Roederer, Institute of Geophysics, University of Alaska, Fairbanks, AK
Dr. John Blume, URS/J. A. Blume & Associates, San Francisco, CA

PROJECT #51

TITLE: Aerial Mapping of 1979 Sea Ice in the Norton Sound and Northern Bering Sea

PURPOSE & METHOD: To obtain and analyze 1500 miles of stereo aerial photography of sea ice in Norton Sound and the Northern Bering Sea. Visual analyses will be performed at ten-mile intervals to determine the amount of open water, floe size, ridge heights, ridging frequency, and preferred orientations. Analyses also include digitizing, profiling, and computing ridge statistics on 118 selected ten-mile segments. Special ice features such as rubble piles, floebergs, etc., will also be documented.

To evaluate NASA's side looking airborne radar (SLAR) imagery and scanning multiband microwave radiometer (SMMR) data as tools to remotely gather sea ice data. The NASA imagery will be obtained through the NASA/AOGA Bering Sea Co-operative Experiment. The sea ice aerial photography obtained by OSI during the NASA overflights will be used as "ground truth" data in this investigation.

CONTRACTOR: Oceanographic Services, Inc.

OPERATOR: None

REPORT: Aerial Mapping of Sea Ice in the Bering Sea, 1979. A report will also be prepared for NASA evaluating the SLAR and SMMR data as part of the NASA/AOGA Bering Sea Co-operative Experiment.

COST: Total estimated cost of \$140,790. Cost to next participant is estimated at \$25,643.

PARTICIPANTS: Amoco, ARCO, Sohio-BP, Chevron, Exxon, Gulf, Mobil and Shell.

FINAL REPORT: March 1, 1980

CONFIDENTIALITY: November 1, 1984

PROJECT #52

TITLE: Beaufort Sea Ice Movement Study, 1978-79

PURPOSE & METHOD: To measure the magnitude and rate of ice movement at three locations in the land-fast ice in the vicinity of Reindeer and Narwhal Islands off the Alaskan North Coast. The measurement program is scheduled for November through May. An OSI wire/reel ice movement system will be used to measure the ice motions and data will be telemetered to Deadhorse.

This study is similar to the ice movement portion of AOCA PROJECT #42, but of reduced scope.

CONTRACTOR: Oceanographic Services, Inc.

OPERATOR: None

REPORT: Beaufort Sea Ice Movement Study, 1978-79

COST: Total estimated cost of \$133,876. Cost to next participant is estimated at \$46,775.

PARTICIPANTS: ARCO, Sohio-BP, Chevron, and Exxon.

FINAL REPORT: February, 1980.

CONFIDENTIALITY: October 1, 1984

PROJECT #53

TITLE: Beaufort Sea Ice Movement Studies (BSIMS)
Three-Year Summary and Analysis

PURPOSE & METHOD: To reanalyze and summarize three winters (1975-76, 1976-77, and 1977-78) of ice movement and ice conditions data obtained by OSI and Amoco off the Alaskan North Coast. The results are to be presented in a form which can be directly used in planning offshore Arctic operations. Tasks to be performed include preparation of: net hourly ice movement tables, detailed plots of ice movement during extreme events, and statistics on extreme ice features and sea ice surface roughness. An attempt will also be made to understand the cause of selected major ice movement events.

CONTRACTOR: Oceanographic Services, Inc.

OPERATOR: None

REPORT: BSIMS Three-Year Summary and Analysis

COST: Total estimated cost of \$150,442. Cost to next participant is estimated at \$33,805. In addition, AOGA projects 27, 39 and 42 are prerequisites.

PARTICIPANTS: Amoco, ARCO, Chevron, Exxon, Gulf, Mobil and Shell

FINAL REPORT: February, 1980.

CONFIDENTIALITY: October 1, 1984

PROJECT #54

TITLE: Norton Sound and Northern Bering Sea Rubble Pile Investigation, 1978-79

PURPOSE & METHOD: To investigate the origin, movement, physical characteristics and overall distribution of large pieces of consolidated ice rubble found in Norton Sound and the Northern Bering Sea.

Large ice rubble piles were previously observed as a part of Norton Sound aerial photographic programs conducted by OSI during the 1976-1977 and 1977-1978.

The program will begin with reconnaissance flights in the Norton Sound area to monitor the appearance of the rubble piles. Once they appear, the following programs will be initiated: precision aerial photography; field measurements; the deployment of satellite positioning buoys to determine movement; and reconnaissance flights to monitor the rubble piles during ice breakup.

CONTRACTOR: Oceanographic Services, Inc.

OPERATOR: None

REPORT: Northern Bering Sea Rubble Pile Investigation, 1978-79

COST: \$166,339. Cost to next participant \$33,762.

PARTICIPANTS: Amoco, ARCO, Exxon, Gulf, Mobil and Shell

FINAL REPORT: March, 1980.

CONFIDENTIALITY: October 1, 1984

PROJECT #55

TITLE: Beaufort Sea First-Year Ice Features Survey

PURPOSE & METHOD: To investigate first-year pressure ridges and rubble piles in the Alaskan Beaufort Sea. The objectives of this program are: to provide extreme first-year ridge and rubble pile populations that can be correlated to give frequency of ridge-structure interaction; to establish statistical ridge and rubble pile geometries for pile-up and loading design criteria; and to determine internal ridge characteristics. The program will include both an on-the-ice field survey and aerial photography. The results of this study should aid in assessing the threat of first-year ice features to offshore structures and installations.

CONTRACTOR & OPERATOR: Gulf Research and Development Company
P. O. Box 36506
Houston, Texas 77036

REPORT: Volume I--Field Investigations
Volume II--Aerial Photography
Volume III--Digitized Profile
Volume IV--Flightline Mosaics

COST: \$163,000. Cost to next participant \$30,562

PARTICIPANTS: ARCO, Chevron, CONOCO, Exxon, Gulf, Mobil, Phillips and Shell

FINAL REPORT: January, 1980

CONFIDENTIALITY: Earliest of one year after the Beaufort Sea nearshore lease sale or five years after program termination.

PROJECT #56

TITLE: Bering Sea Phase I Oceanographic Study

PURPOSE & METHOD: This project has two principal objectives. The first objective is to provide preliminary estimates of extreme oceanographic conditions in the following basins: Bristol Bay, St. George, Navarin, St. Lawrence, and Norton Sound. The second objective is to assess the scope of a subsequent Phase II Oceanographic Study, including definition of the types and locations of wind and wave data needed for model calibration and definition of the wave generation and dissipation mechanisms that must be included in the model.

The project will involve computer modeling of severe historical storms. Deep water wave hindcasts will be made for the 20 worst historical storms using the calibrated ODGP spectral wave model and accounting for ice cover. Shallow water wave transformations will be studied using both two-dimensional shoaling and refraction models and one-dimensional models that allow both wave generation and dissipation in shallow water. Storm surges in Norton Sound will be calculated for several storms. Finally, statistical extrapolation procedures will be used to predict return periods for rare, extreme wave conditions.

CONTRACTORS: Oceanweather, Inc.
Ocean Research & Engineering

OPERATOR: None

REPORT:

COST: \$203,500. Cost to next participant \$23,600.

PARTICIPANTS: ARCO, Sohio-BP, Chevron, Cities Service, Exxon, Gulf, Mobil and Shell

FINAL REPORT: May, 1980.

CONFIDENTIALITY: February 1, 1984

PROJECT #57

TITLE: Reindeer Island Ice Island & Ice Bridge Studies

PURPOSE & METHOD: The report will describe the design, construction and maintenance of the 8-mile ice road and ice bridge constructed during the winter of 1978-1979 to Reindeer Island. The report includes a critical review of the construction and maintenance equipment used on the project including detailed cost data and a discussion of potential problem areas. The study program also included physical measurements of ice properties in the area and the results of a dynamic stress and strain measurement program conducted as part of the project.

CONTRACTOR: FENCO Consultants Inc.
805 - 8th Avenue, S. W.
Calgary, Alberta, Canada T2P 1H7

OPERATOR: Sohio Petroleum Company

REPORT: Reindeer Island Ice Road & Ice Bridge Studies 1978-79.

COST: \$4,430,000. Cost to next participant:

PARTICIPANTS: 18 members of RIST well 1978-79

FINAL REPORT: September 1, 1979

CONFIDENTIALITY:

PROJECT #58

TITLE: Arctic Skimmer Final Design Project

PURPOSE & METHOD: To complete final construction drawings for a Centrifugal Systems, Inc. (CSI) arctic catamaran skimmer.

This vessel would be able to safely recover spilled oil in wave heights up to three feet with some ice cover. The design is not an icebreaking hull, but rather ice strengthened to resist impact of ice chunks during cleanup.

The design is for a maximum draft of four feet; on board separation and storage facilities for 70-100 barrels of oil and provides for offloading the recovered oil rapidly to temporary storage. Vessel length is 48 feet.

CONTRACTOR: Centrifugal Systems, Inc.
Houston, Texas

OPERATOR: Sohio Petroleum Company

REPORT: CSI ARCAT 2-29 Arctic Oil Skimmer Final Design Project

COST: \$68,000.

PARTICIPANTS: 14

FINAL REPORT: April, 1980

CONFIDENTIALITY: Until construction or release by AOGA.

PROJECT #59

TITLE: Arctic Dispersant Study

PURPOSE & METHOD: To screen a group of oil dispersants to determine their suitability in arctic marine conditions. Thirty-two commercial dispersants were tested using the Mobil Oil Static Oil Dispersion test, a method which determines the quantity of oil which can be dispersed in seawater using a specified amount of chemical. The rate of separation of the oil/water dispersion was also measured. The results of this study should aid in preparing for arctic leasing and exploration activities. This investigation does not address toxicity or required dosage rates. These topics are addressed in proposed future studies by LPRC.

CONTRACTOR & OPERATOR: ARCO Oil and Gas Company
Box 360
Anchorage, Alaska 99510

REPORT: Arctic Dispersant Project - Task I

COST: \$20,000. No late participants

PARTICIPANTS: Amoco, ARCO, Chevron, Citgo, Getty, Gulf, Marathon, Mobil, Phillips, Shell, Sohio, Union, Champlin, Exxon.

FINAL REPORT: May, 1979

CONFIDENTIALITY: Report will be held confidential until such time as the data are published. ARCO retains the right to publish the data from this study one year after the Joint Federal-State Beaufort Sea Lease Sale.

PROJECT #60

TITLE: Review Air Cushion Platform Capabilities for Oilspill Cleanup in the Alaskan Beaufort Sea.

PURPOSE & METHOD: To review the capabilities of air cushion platforms which might be considered for use offshore.

The review will include a discussion of the service for which platform was designed, its equipment and operational requirements, its capital and operating costs, operational experience, reliability and availability.

The capability for use in oil spill tasks will be a prime consideration with all aspects of response and practicality considered and reviewed.

CONTRACTOR: D. F. Dickens
Yellowknife, Y.T., Canada

OPERATOR: Shell Development Company

REPORT: Review of state-of-the-art air cushion vehicle capabilities in support of oilspill cleanup operations in the nearshore Alaskan Beaufort Sea.

COST: \$31,729. Cost to next participant \$ 3,430.

PARTICIPANTS: 13

FINAL REPORT: March, 1980.

CONFIDENTIALITY: February 15, 1984

PROJECT #61

TITLE: Conical Structure Test Program

PURPOSE & METHOD: To investigate the interaction of a shallow-angle conical structure with ice sheets containing ridges and with large unconsolidated and partially consolidated ice rubble. A total of eight ridges, eight unconsolidated rubble fields, and five partially consolidated rubble fields were tested. The conical structure was a 30° cone with a water-line diameter of 12 feet.

Several previous test programs have investigated the interaction of ice with 45° cones. Based on an assessment of the size of multi-year ridges which may be encountered in the Arctic and on an estimate of the maximum force which might be exerted by such features, it seems likely that conical shapes less than 45° may be needed to limit design horizontal forces. Therefore, the structure was designed to investigate ice interaction with a cone having an angle of 30° to the horizontal. The interaction of conical structures with ice rubble fields also needed to be studied and results were obtained for various combinations of rubble field parameters.

The program was intended to provide a data base which could be used to verify computational methods for predicting ice forces. The model structure does not necessarily represent an optimal or feasible structure. The modeled ice conditions do not necessarily represent design conditions.

CONTRACTOR: Esso Resources Canada Limited

OPERATOR: Exxon Production Research Company

REPORT: Conical Structure Test Program, Winter 1978-1979

COST: About \$400,000 with six participants. Cost to next participant is \$95,000. Funds contributed by participants in excess of program costs will be distributed equally to participants.

PARTICIPANTS: Chevron, Dome, Exxon, Gulf, Shell and Sohio

FINAL REPORT: Spring, 1980.

CONFIDENTIALITY: February 1, 1984

PROJECT #62

TITLE: Under-Ice Rig Noise Measurement Program

PURPOSE & METHOD: To measure drilling rig-produced noise and its propagation under floating ice in the Prudhoe Bay area.

Existing literature contains no direct measurements or sufficient data to accurately predict the acoustic environmental impact of arctic offshore drilling operations.

Acoustic pressure measurements were taken in the water through holes drilled in the ice with very sensitive hydrophones obtained from the Navy. The measurement locations were made at known distances from the Reindeer Island COST well and from the SOHIO-BP-Alaska well on Niakuk 3. These field measurements were then analyzed to determine background and rig-produced noise levels as well as attenuation rates of the rig-produced noises.

CONTRACTOR: Bolt, Beranek and Newman Inc.

OPERATOR: Exxon

REPORT: Measurement of underwater acoustic noise in Prudhoe Bay, Alaska. BBN technical memo No. 513.

COST: About \$50,000. Cost to next participant \$4,000.

PARTICIPANTS: Amoco, ARCO, Sohio-BP, Chevron, Cities, Exxon, Getty, Gulf, Marathon, Mobil, Phillips, Shell and Union

FINAL REPORT: May, 1979

CONFIDENTIALITY: Unlimited

PROJECT #63

TITLE: Beaufort Sea Extreme and Normal Oceanographic Conditions Study

PURPOSE & METHOD: To develop preliminary estimates of storm-generated wave, current and surge conditions in the Beaufort Sea during the relatively ice-free or open water season of July to October.

Historical meteorological data are analyzed to determine the characteristics of severe storms. Historical ice cover data are used to determine available fetch. Storm windfields are developed for 12 storms. Waves are hindcast with a directional wave spectra model based on the JONSWAP parametric wave model. Currents and storm surges are hindcast with a proprietary model developed by Shell Development Company. Standard extreme value statistical analysis are used to estimate as a function of annual exceedance probability winds, waves, currents and surges.

The study also addresses normal summer oceanographic conditions and extreme wind speeds during the winter.

CONTRACTOR: Oceanweather, Inc. and Sea Ice Consultants, Inc.

OPERATOR: Shell Development Company

REPORTS:

1. Hindcast Study of Windfields and Wave Spectra for Severe Storms in the Beaufort Sea--Oceanweather, Inc.
2. Beaufort Sea Storm Wind and Wave Study--Shell Dev. Co.
3. Beaufort Sea Storm Surge and Current Study--Shell Dev.
4. Beaufort Sea Normal Meteorological and Oceanographic Conditions--Shell Dev. Co.

COST: \$20,000 per participant.

PARTICIPANTS: Shell, Mobil

FINAL REPORT: April 1979

CONFIDENTIALITY: April 1989

PROJECT #64

TITLE: Bering Sea Aerial Photography Data - 1977

PURPOSE & METHOD: To acquire high resolution aerial photography of Norton Sound and Bering Sea ice, and to analyze the photography to determine the size, shape, elevation, frequency, and distribution of ice features.

Over 1800 statute miles of Norton Sound, Bering Sea and Bristol Bay ice conditions were photographed in stereo in April, 1977. Photos from selected lines were visually analyzed to determine percent ice coverage, ice types, floe sizes, types of ice features and roughness. Selected stereo models were analyzed, digitized and the vertical digital profiles prepared for statistical analysis. Descriptive narratives, vertical profiles, special features profiles and statistical tables for 24 selected areas, each about 10 miles long, were prepared.

The 1977 Bering Sea aerial photography program resulted in an extensive collection of photogrammetric quality ice photographs and corresponding ice surface elevation profiles. The work provides an insight as to the nature, variability, and roughness of sea ice in Norton Sound and the Bering Sea.

CONTRACTOR: Oceanographic Services, Inc.

OPERATOR: Exxon Production Research Company

REPORTS: Bering Sea Aerial Photography Final Report; Bering Sea Aerial Photography Summary Report; digitized profile plots, blue line air photo mosaics.

COST: \$15,000 + \$1,000 (approximately) reproduction costs per report.

PARTICIPANTS: Amoco, ARCO, Chevron, Exxon, Gulf and Mobil

FINAL REPORT: January, 1978

CONFIDENTIALITY: Five years from date of agreement

PROJECT #65

TITLE: Beaufort Sea Drilling Effluent Disposal Study

PURPOSE & METHOD: The objective is to assess impacts of over-ice and under-ice drilling effluent disposal techniques upon the benthic and epibenthic communities and demersal fish that may or may not be tied to the benthic invertebrates as a food source.

The methods and procedures by which the objectives are to be accomplished are as follows:

- 1) Discharge up to 100 barrels of drilling effluent by gravity feed from disposal tank trucks through holes in the sea ice at selected locations;
- 2) Release drilling effluents as a liquid or solid onto surface of sea ice;
- 3) Simulated above ice disposal: drilling effluent would be deposited onto the sea floor through a grid of holes in the ice;
- 4) Static bioassay tests would be conducted upon active drilling mud and cuttings obtained directly from a wellsite;
- 5) Mathematical modeling will be used to establish a method of predicting the dispersion and mixing of both above ice and below ice discharge of drilling mud and cuttings.

CONTRACTOR: Northern Technical Services
900 W. Fifth Avenue, Suite 240
Anchorage, Alaska 99501

OPERATOR: Sohio Petroleum Company

REPORT: Beaufort Sea Drilling Effluent Disposal Study

COST: \$731,000.

PARTICIPANTS: Amerada Hess, Amoco, ARCO, Chevron, Cities, CONOCO, Exxon, Getty, Gulf, Idemitsu, Marathon, Mobil, Phillips, Shell, Tenneco, Texas Eastern, Union and Sohio.

FINAL REPORT: Estimated November, 1979

CONFIDENTIALITY: None

PROJECT #66

TITLE: Yakutat Wave Data

PURPOSE & METHOD: This is a report of additional wave data obtained after completion of the Group Oceanographic Survey in the Gulf of Alaska.

CONTRACTOR: Intersea Research, Inc.

OPERATOR: Marine Advisor, Inc.

REPORT: Volume 7 - Recorded Data

COST: \$22,984. Cost to next participant \$

PARTICIPANTS: 20—Amoco,

FINAL REPORT: October 1970

CONFIDENTIALITY:

PROJECT #67

TITLE: Group Oceanographic Survey - Gulf of Alaska

PURPOSE & METHOD: The purpose of this program was to obtain oceanographical and climitalogical historical data and then hindcast winds and waves based on a few in-ocean measurement sensors taking ocean temperature, currents, wave heights, and periods. The report in eight volumes provides oceanographic, climitalogic and environmental data for the coastal and continental shelf area, 850 miles long. Extreme wave heights for a hundredth year recurring storm are estimated to exceed 100 feet based on a hindcast of 30 storms. In-ocean measurements were obtained for one year at Yakutat and were used to calibrate the hindcasting of normal and operational waves. The measuring station was located in 60 feet of water which is too shallow for extreme storm to reach and no compensation was achieved for wave heights of 20 feet or more. The hindcast of five representative years has served as valuable data in analysing exploratory drilling vessel motion and hence drilling time for location in the study area.

CONTRACTOR: Marine Advisers, Inc. (Bendix)

OPERATOR: Chevron-U.S.A. Inc.

REPORT: Gulf of Alaska Group Oceanographic Survey Phase I Area (10 vols. & supplement) September, 1970

COST: \$1,400,000. Cost to next participant \$

PARTICIPANTS: 19--Amoco,

FINAL REPORT: September, 1970

CONFIDENTIALITY:

PROJECT #68

TITLE: Weather Forecast Trial

PURPOSE & METHOD: The purpose was to determine the feasibility of wind and wave forecasting in the Gulf of Alaska during the winter months and to compile measured wave data during this most severe season. The data from the waverider buoy was transmitted to the weather office at Yakutat airport. Data was transmitted with regular forecasts to the Santa Barbara office by teletype. Forecasts were made based on these data and compared to real events in the forecast period. The report presents data obtained including forecasting experience and accuracy.

CONTRACTOR: Oceanographic Services, Inc. (OSI)

OPERATOR: Exxon

REPORT: Wave and Weather Forecast Study, Gulf of Alaska, July, 1972

COST: \$38,000. \$4,825 fixed cost per participant.

PARTICIPANTS: Amoco

FINAL REPORT: 1972

CONFIDENTIALITY:

PROJECT #69

TITLE: 1973 Soil Boring Program

PURPOSE & METHOD: The purpose of this study was to obtain information on the engineering properties of the subsea-floor soil to aid feasibility and cost studies for future development in the area Icy Bay to Kayak Island. The study presents data on nine surface drop cores taken at three locations and a soil boring with 225.5 feet of penetration.

CONTRACTOR: Exploration Services Company, Inc.

OPERATOR:

REPORT: Gulf of Alaska Soil Boring Project, 1973 (4 Vols.)

COST: \$359,000. Cost to next participant \$

PARTICIPANTS: 9--Amoco,

FINAL REPORT: 1973

CONFIDENTIALITY:

PROJECT #70

TITLE: Ground Response Study

PURPOSE & METHOD: The purpose is to conduct a dynamic soil analysis for the determination of ground response to seismic events. Using the soil samples obtained during the 1973 soil boring program in the Icy Bay area, the following was performed: prepared a summary sheet for the original eight cases studied including accelerogram and spectral values, expanded the original report to discuss selection of seismic design parameters, and evaluated potential for the development of cumulative strains in the soil profile during seismic events. Earthquake forces of 0.15, 0.33, and 0.50g were investigated.

CONTRACTOR: Shell Development Company

OPERATOR: Shell Development Company

REPORT: Ground Response Study

COST: \$35,000. Cost to next participant \$5,200

PARTICIPANTS: Amoco, ARCO, Marathon, Mobil, Phillips, Shell, Sun, Socal, USGS

FINAL REPORT: Spring, 1975

CONFIDENTIALITY: January 12, 1981

PROJECT #71

TITLE: ARCO COST Well

PURPOSE & METHOD: The objective was to drill a stratigraphic test well to 16,000 feet at a non-productive location. Drilling ceased on October 10, 1975 at 5,000 feet when the rig had to move off due to weather. All data still remains confidential.

CONTRACTOR: Global Conception, Drilling Vessel

OPERATOR: ARCO

REPORT: Gulf of Alaska COST Well

COST: \$11,930,000. No late participants

PARTICIPANTS: Al-Aquitaine, Amerada Hess, American Petrofina, Amoco, ARCO, BP, Cities, CONOCO, Diamond Shamrock, Exxon, Getty, Gulf, Marathon, Mobil, Pennzoil, Phillips, Placid, Shell, Skelly, SOCAL, Sun, Superior, Tenneco, Texaco, Texas Eastern, Union.

FINAL REPORT: Well completed October 9, 1975.

CONFIDENTIALITY: Expired.

PROJECT #72

TITLE: Lab Dynamic Soil Analysis

PURPOSE & METHOD: The purpose was to take laboratory measurements of the soil samples from GOA covering large strains rates under cyclic loading.

CONTRACTOR: BB&N

OPERATOR:

REPORT: "Report on Test Program on Soil Samples Obtained from borings in Gulf of Alaska", November, 1975.

COST: \$25,000

PARTICIPANTS: 5—Amoco,

FINAL REPORT: 1975

CONFIDENTIALITY:

PROJECT #73

TITLE: Oil-Spill Trajectory (Two Reports)

PURPOSE & METHOD: The purpose was to determine the fate of oil from a Gulf of Alaska spill using existing data. The direction of a spill movement was assessed by seasons. Also the probable time the spill would arrive at the beach was determined as well as the probability of what beach segments the spill would arrive at.

CONTRACTOR: IRC and Chevron

OPERATOR:

REPORT: Dr. Clayton McAuliffe, Chevron, gave his report to the August 1975, Gulf of Alaska Sale Hearing.

IRC's "Numerical Simulation of Oil-Spill Trajectories in the Northern Gulf of Alaska", September, 1975.

COST: \$5,000

PARTICIPANT: Chevron

FINAL REPORT: 1975

CONFIDENTIALITY:

PROJECT #74

TITLE: Socio-Economic Impact of Drilling and Production

PURPOSE & METHOD: The purpose was to determine the social and economic impact of offshore drilling and production in the state of Alaska with special emphasis on the coastal area of Northeast Gulf of Alaska. The study concentrated on the labor requirements and market, effects of activities on government supplied facilities (schools, sewers, etc.) and the impact on the state of Alaska population.

CONTRACTOR: Mathematical Sciences Northwest, Inc.

OPERATOR: GOA Operators Committee

REPORT: "An Economic and Social Impact Study of Oil Related Activities, Gulf of Alaska", May 5, 1975.

COST: \$80,000

PARTICIPANTS: GOAOC membership.

FINAL REPORT: 1975

CONFIDENTIALITY:

PROJECT #75

TITLE: Sea and Subsea Floor Properties

PURPOSE & METHOD: The purpose of this study was to determine sea floor and subsea floor properties through acoustical profiling and soil samples. Approximately 3,000 miles of multiscanner acoustic profiles were taken from Yakutat to Kayak Island to Middleton Island. Approximately 60 massive piston samples were taken to define subsea floor composition and verify the acoustic data. Geotechnical sample analysis was performed on board ship and in the laboratory. The final report includes a description of the surveys taken, data reduction and analysis, and a description of all cores taken.

CONTRACTOR: BB&N

OPERATOR:

REPORT: Geotechnical Core Hole Program (with Associated Hazard maps) Gulf of Alaska, August, 1975

COST: \$60,000 per participant.

PARTICIPANTS: Amoco,

FINAL REPORT: 1975

CONFIDENTIALITY:

PROJECT #76

TITLE: Seismic Risk Analysis for the Gulf of Alaska

PURPOSE & METHOD: The purpose of the program was to evaluate earthquake records for seismic activity in the area and apply simple probabilistic theory to determine the seismic risk in the Eastern Gulf of Alaska.

CONTRACTOR: John Wiggins Company

OPERATOR:

REPORT: "Seismic Risk Analysis for the Gulf of Alaska", September, 1975.

COST: \$20,000

PARTICIPANTS: GOAOC membership.

FINAL REPORT: September, 1975

CONFIDENTIALITY:

PROJECT #77

TITLE: Superstructure Icing

PURPOSE & METHOD: This study is a literature search on the incidence of superstructure icing in the Gulf of Alaska area. It looks at the causes and seriousness of superstructure icing, i.e., icing from salt spray and fog on boats, choppers and drilling vessels.

CONTRACTOR: CRREL

OPERATOR: Marathon

REPORT: Ice Accumulation on Fixed and Floating Ocean Structures

COST:

PARTICIPANTS:

FINAL REPORT: September, 1975

CONFIDENTIALITY:

PROJECT #78

TITLE: 1974 Ocean Current Measurement Program

PURPOSE & METHOD: The purpose of the study is to determine current speed and direction at 10 locations in the Gulf of Alaska from Yakutat to Kayak Island and Kayak Island to Middleton. Buoys with three current meters (on bottom, mid-depth, and near-surface) were installed at the chosen locations for 30 days. Temperature and salinity measurements were made at the time the buoys were installed. Routine weather observations including anemometer readings on the vessel were taken at six hour intervals. Five thousand drift cards and 500 drift bottles were released throughout the vessels track. All data obtained was accumulated and statistically analyzed by computer to document and predict current conditions in this area. Seven locations were actually occupied. Program data was supplemented with two or three NOAA locations, November 1974-March 1975.

CONTRACTOR: BB&N

OPERATOR:

REPORT: A Data Collection, Analysis, and Simulation Program to Investigate Ocean Currents, North East Gulf of Alaska (2 Vols.) Sept. 1975

COST: \$20,000 per participant.

PARTICIPANTS: Amoco,

FINAL REPORT: September, 1975

CONFIDENTIALITY:

PROJECT #79

TITLE: Gulf of Alaska Hindcast Evaluation (WHEP)

PURPOSE & METHOD: The purpose of the program was to evaluate the Lockheed model's ability to predict wave forces by comparing predicted values to those measured in GAWWMP. The use of this data permitted comparison of wave heights and some comparison of spectral data.

CONTRACTOR: Intersea Research Corporation

OPERATOR: Marathon

REPORT: "Gulf of Alaska Hindcast Evaluation, First Report - September-November 1974 Data", May, 1975.

"Second Report - December 1974-February 1975 Data", August, 1975.

"Final Report - March 1975-May 1975 and Tri-Quarterly Data Summary", March, 1976.

COST: \$69,000

PARTICIPANTS. 13--Amoco,

FINAL REPORT: 1975-1976

CONFIDENTIALITY:

PROJECT #80

TITLE: Earthquake Soil Response Analysis

PURPOSE & METHOD: The purpose of this study was for Shell to interact with Woodward-Clyde to develop and verify a non-linear soil reaction computer program under cyclic loading and to then use the program in conjunction with the data collected from Shell's dynamic soil analysis program. This new program gives soil reaction which although much smaller than those obtained in the first dynamic soil analysis program are considered much more realistic.

CONTRACTOR: Woodward-Clyde

OPERATOR: Shell Oil Company

REPORT: Earthquake Soil Response Analysis

COST: \$70,000. Cost to next participant \$10,200.

PARTICIPANTS: Amoco, ARCO, Marathon, Mobil, Phillips, Shell, Socal, USGS

FINAL REPORT: April, 1976

CONFIDENTIALITY: January 12, 1981

PROJECT #81

TITLE: Gulf of Alaska Meteorological and Oceanographic
Forecasting Program (MOFP)

PURPOSE & METHOD: The objective was to build a weather prediction
computer model and practice forecasting to
insure its capability and accuracy at predicting
weather for operating in the Gulf of Alaska
area. This was done by modifying an existing
weather prediction model to fit the Gulf of Alaska.
Accuracy checks were run against measured wind
and waves from GAWWMP.

CONTRACTOR: Ocean Routes, Inc.

OPERATOR: Marathon Oil Company

REPORT:

COST: \$416,000

PARTICIPANTS: 8

FINAL REPORT: July, 1976

CONFIDENTIALITY:

245
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PROJECT #82

TITLE: Gulf of Alaska Wave and Wind Measurement Program (GAWWMP)

PURPOSE & METHOD: The program employs deployment of 15 wave rider buoys in clusters of three each at five locations. The stations are close enough to provide geographically continuous data around the Gulf of Alaska (Yakutat to Chirikof). Weather stations will be placed in exposed shore locations near the wave measurement stations to develop meteorological data for correlation to the wave data for forecasting.

CONTRACTOR: Marathon

OPERATOR: Intersea Research Corporation

REPORT: Gulf of Alaska Wave and Wind Measurement Program, Sept. 1974 - May, 1976 (13 Vols.)

COST: \$1.3 million.

PARTICIPANTS: 13—Amoco,

FINAL REPORT: July, 1976

CONFIDENTIALITY:

PROJECT #83

TITLE: Seismic Risk Analysis for the Gulf of Alaska

PURPOSE & METHOD: The purpose of this program was to define the effect of various earthquake intensities on platforms up to an 8.6 richter scale earthquake. Various earthquake (acceleration level and duration) were applied to a platform design through computer programs. The degree of damage and/or failure was rated. The objective was to establish adequate platform design criteria for given levels of earthquakes which may be expected in the various Alaskan areas.

CONTRACTOR: Shell

OPERATOR: Shell

REPORT: Seismic Risk Analysis for the Gulf of Alaska

COST: \$36,000.

PARTICIPANTS: GOAOC Membership

FINAL REPORT: September, 1975

CONFIDENTIALITY:

PROJECT #84

TITLE: Gulf of Alaska Wave Hindcasting Pilot Study (GAPS)

PURPOSE & METHOD: The objective is to develop and calibrate a hindcast model for hindcasting historical storms in the Gulf of Alaska. Initially, the model will be calibrated against three storms measured in the GAWWMP program. Final calibration will be against four more GAWWMP storms and a 1955 storm considered one of the more severe will be hindcasted.

Phase 2 of this program to perform hindcast using the calibrated model is not recommended due to the declining interest in the Gulf of Alaska.

CONTRACTOR: Ocean Weather, Inc. (Vince Cardone)

OPERATOR: Shell Development Company

REPORT: Gulf of Alaska Hindcasting Pilot Study - Phase I (GAPS)

COST: \$197,500. Cost to next participant

PARTICIPANTS: ARCO, Chevron, Exxon, Mobil, Shell

FINAL REPORT:

CONFIDENTIALITY: April, 1984

PROJECT #85

TITLE: Bering Sea - St. George Basin/Western Bristol Bay Wave and Wind Measurement Program (BOMP)

PURPOSE & METHOD: The purpose of this study is to measure winds and waves and build a hindcast model to predict operating and design criteria for the area. Two groups of three wave rider buoys were deployed between Unimak and the Privilof Islands to measure waves and current. Winds were measured on St. Paul and St. George Islands. Using these data a hindcast model was developed.

CONTRACTOR: Interseas Research Croperation

OPERATOR: Marathon Oil

REPORT: "Bering Sea Oceanographic Measurement Program 1976 - 1977", four volumes.

COST: \$534,000--cost to next participant \$89,000.

PARTICIPANTS: 8

FINAL REPORT: February, 1978

CONFIDENTIALITY: February, 1983

PROJECT #86

TITLE: Bering Sea Oceanographic Measurement Program 1977 - 1978 (extension of 1976 - 1977 BOMP)

PURPOSE & METHOD: The purpose was again to measure winds and waves and build a hindcast model to predict operating and design criteria for the area. Two groups of three wave rider buoys were deployed between Unimak and the Privilof Islands to measure waves and currents through December, 1978. Winds were measured at St. Paul and St. George Islands.

A program extension of approximately \$20,000 was approved on 1/15/79 to do a two-year summary of the BOMP data.

CONTRACTOR: Interseas Research Corporation

OPERATOR: Marathon Oil Company

REPORT: "Bering Sea Oceanographic Measurement Program 1977-78", volumes 5 through 8.

The two-year summary will be volume 9.

COST: \$304,000 plus a two-year summary at \$20,000-- cost to next participant \$60,000.

PARTICIPANTS: 7

FINAL REPORT: Volumes 5 through 8, January, 1979.

Volume 9, April, 1979

CONFIDENTIALITY: April, 1984

PROJECT #87

TITLE: Yakutat Wave Data

OPERATOR: Exxon

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PROJECT #88

TITLE:

Kodiak Cost Well

PROJECT #89

TITLE: Kodiak Cost Well Geotechnical Study

OPERATOR: Sun

253

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PROJECT #90

TITLE: St. George Basin COST Well

PURPOSE & METHOD: The objective was to drill a stratigraphic test well to approximately 15,000 feet at a non-productive location. Drilling operations ceased on October 1, 1976 and the rig moved to the Gulf of Alaska.

CONTRACTOR: Ocean Ranger, Drilling Vessel

OPERATOR: ARCO

REPORT: None

COST: \$14,300,000. No late participants.

PARTICIPANTS: ARCO, Amoco, Sun, SOCAL, Getty, Gulf Energy Minerals, Exxon, Shell, BP, Texaco, Phillips, Cities Service, CONOCO, Amerada Hess, Tenneco, Skelly, Pennzoil, Union, Marathon, Mobil.

FINAL REPORT: Well Completed 10/1/76

CONFIDENTIALITY: Under the St. George Basin COST Well contract, all material is confidential until after an OCS Sale occurs in the St. George Basin area.

PROJECT #91

TITLE:

Marathon Satellite Current Study

255

PROJECT #92

TITLE: Kodiak Shelf Geotechnical Study

PURPOSE & METHOD: To provide a broad overview of the geotechnical conditions on the Kodiak Shelf as pertinent to offshore platform siting and costs.

The study interprets geology of near-surface sediments as a guide to their engineering characteristics. It also maps geological hazards using publicly available information and data from a 1975 Shallow Seismic Program conducted by BBN.

CONTRACTOR: Woodward-Clyde Consultants

OPERATOR: Shell Oil Company

REPORT: A Broad Overview of Geotechnical Conditions, Proposed OCS Sale No. 46, Kodiak Shelf, Alaska

COST AND PARTICIPATION: This report is offered for sale at a cost of \$20,000 per company.

PARTICIPANTS: Shell

COMPLETION DATE: November 1976

FINAL REPORT: December 1976

CONFIDENTIALITY: December 31, 1981

PROJECT #93

TITLE: Gulf of Alaska Ground Response Analysis - Phase I

PURPOSE & METHOD: To assess potential effects of dynamic loadings on structures due to earthquakes.

The study uses soil profile data from a soil boring taken in the 1973 ESCI Soil Boring Program. Three dynamic soil models and three bedrock accelograms are selected. Soil response analyses are conducted for seven combinations of accelograms and soil stiffnesses. Cumulative cyclic strains are computed and soil modulus deterioration due to remolding is evaluated.

CONTRACTOR: Woodward-Clyde Consultants

OPERATOR: Shell Oil Company

REPORT: Ground Response Studies Boring No. 2 Site - Gulf of Alaska, Volume I and II.

COST: \$26,500. Cost to next participant--\$4,969.

PARTICIPANTS: Amoco, ARCO, Chevron, Gulf, Marathon, Mobil, Phillips, Shell, Sun, USGS.

COMPLETION DATE: March 1975.

FINAL REPORT December 1974 and March 1975

CONFIDENTIALITY: December 31, 1979.

PROJECT #94

TITLE: 1979 Break-up
CONTRACTOR: Oceanographic Services Inc.
PARTICIPANTS: 6--Amoco,

PROJECT #95

TITLE: 1974-1975 Aerial Reconnaissance Study
CONTRACTOR: Oceanographic Services, Inc.
PARTICIPANTS: 5--Amoco,

PROJECT #96

TITLE: Model Tests and Analysis of Multiyear Pressure Ridges Failing Against a 45° Cone

PURPOSE & METHOD: To measure the forces on a 45° cone generated by model multiyear pressure ridges and to determine the mode of ridge failure, the effect of ridge size, length and the ice sheet thickness and to develop a mathematical model to predict ridge loads on cones.

Model tests of multiyear pressure ridges moving against a 45° conical structure were performed in ARCTEC's model ice test basin in Montreal, Canada. A total of 50 ridges were tested with the ridge axis being either parallel, perpendicular, or 45° to the direction of motion. Horizontal and vertical ridge forces on the cone were recorded. The mechanical properties of the ridge and those of the surrounding ice sheet were also measured.

A nonlinear mathematical model was developed to predict multiyear ridge forces on cones. This model assumes the ice to be elastic/perfectly plastic and uses the upper bound technique of plastic limit analysis. The required material properties were the flexural strengths of the ridge and the ice sheet, and the coefficient of friction between the model ice and the cone surface.

CONTRACTOR: ARCTEC Canada Limited (model tests)

OPERATOR: Exxon Production Research Company

REPORTS:

- A. Modelling the Interaction Between Pressure Ridges and Conical Structures (Assessment of the Effects of Ridge Length, Ice Cover Depth and Angle of Encounter), Arctec Canada Report No. 193-C, by Edwards, N.Y. and Abdelnour, R., February 15, 1977.
- B. A 16-mm movie film lasting approximately 100 minutes and illustrating model testing conducted for EPR in Montreal, Canada during September and October 1976 from which data for the above report was generated.
- C. Analysis of Model Tests of Pressure Ridges Failing Against Conical Structures, EPRCo report by Wang, Y.S.

COST: \$30,000 for each participant.

PARTICIPANTS: Exxon

FINAL REPORT: November, 1979

CONFIDENTIALITY: June 1, 1983

PROJECT #97

TITLE: Sonar Ice Mapping System (SIMS) - The Development and the 1977-1978 Measurement Program

PURPOSE & METHOD: To develop a self-contained sonar ice-mapping system suitable for unattended subsea profiling of Bering Sea ice. The prototype system was developed, field tested, and subsequently deployed in Norton Sound from September 1977 to July 1978.

The SIMS development phase was started with the design and fabrication of three prototype units, making maximum use of proven subsystems. The profiling system consists of a 200 KHz inverted depth sounder interfaced to a digital recorder. Packaged in the same cylindrical housing are a 27 KHz acoustic release, a 10 KHz locating beacon and the necessary battery packs.

Three SIMS units were deployed in September 1977 approximately 11 miles southwest of Sledge Island, Norton Sound. The systems operated unattended until recovery in July, 1978. Data from the three units were processed to yield profiles of the underside of the ice. The profiles were analyzed to determine monthly frequency distributions of ice keel depths.

CONTRACTOR: Oceanographic Services, Inc.

OPERATOR: Exxon Production Research Co.

REPORT: A series of five progress and data reports and the data tapes.

COST: \$30,000 plus \$100 (approximately) reproduction costs per set of reports. (Total license fees in excess of \$120,000 will be divided equally among licensees).

PARTICIPANTS: Exxon

FINAL REPORT: Complete

CONFIDENTIALITY: June 1, 1984

PROJECT #98

TITLE: Feasibility Study of an Air Cushion Drilling System for Shallow Water Areas of the North Slope of Alaska

PURPOSE & METHOD: To evaluate the capability of heavy lift air cushion platform to support exploration drilling activities in shallow waters near Prudhoe Bay off Alaska's North Slope.

The study consists of three major elements which comprise the air cushion drilling system, the air cushion drilling platform (ACDP), the ice defense system, and the logic support system for year-round operation. The ACDP in its drilling mode can be either floating or on an intermediate structure. The ACDP is isolated from direct contact with the ice by an open water (moat). The ice defense system consists of components required to establish and maintain the ice free moat around the ACDP. The logic support system considers the various mix of conventional land vehicles, aircrafts, and air cushion transports required to maintain year-round operation.

Technical descriptions, including drawings of the air cushion drilling platforms, air cushion support platforms, and support systems are included. Operational descriptions of the capability of the ACDS to various drillings, movings, and contingency scenarios are presented. Cost estimates for several methods of operation are also included.

CONTRACTOR: Global Marine Developments, Inc.

OPERATOR: Exxon Production Research Company

REPORT: Feasibility Study - Air Cushion Drilling System for The Shallow Water Areas of the North Slope of Alaska (plus ancillary drawings)

COST: \$25,000.

PARTICIPANTS: ARCO, Exxon

FINAL REPORT: Completed

CONFIDENTIALITY: March 6, 1982

PROJECT #99

TITLE: Yukon Delta Tide Gauge Program 1979

PURPOSE & METHOD: To measure storm tide surges near rubble piles in the Norton Sound and Northern Bering Sea.

Two retrievable Aanderaa Model WRL-5 tide gauges were placed near instrumented rubble piles in the Norton Sound and Northern Bering Sea prior to the 1979 breakup.

CONTRACTOR: Oceanographic Services, Inc.

OPERATOR: None.

REPORT: Study in Progress

COST: \$60,674. Cost to next participant: \$19,000.

PARTICIPATION: Exxon

FINAL REPORT: Spring, 1980

CONFIDENTIALITY: One year after first lease sale in area or consent of n-1 participants.

PROJECT #102

TITLE: Beaufort Sea Freeze-Up Movement Study - 1979

PURPOSE & METHOD: To obtain ice movement data in the nearshore Beaufort Sea during the freeze-up period from October to December.

Data are collected using a marine radar tracking system on Narwhal Island. Twenty passive radar reflectors are deployed inside and outside of the barrier islands within six miles of the tracking station. Time laps photography records images of the radar screen. These data are supplemented by time-lapse cameras recording ice conditions near Narwhal and hand-held aerial photographs during system service trips. Data analysis includes overlaying successive radar images to obtain movement vectors and rates.

CONTRACTOR: Oceanographic Services, Inc.

OPERATOR: None

REPORT: Analysis of 1980 Beaufort Sea freeze-up movement data

COST: \$165,000. Cost to next participant--\$37,500.

PARTICIPANTS: ARCO, Exxon, Phillips, Shell, SOCAL

COMPLETION DATE: February 1980

FINAL REPORT: Draft due April 1, 1980

CONFIDENTIALITY: September 1, 1985.

PROJECT #105

TITLE: Seismicity of Offshore Alaska Regions (SOAR) Program

PURPOSE & METHOD: In March, 1978, Exxon Production Research Co. (ERPCo.) formally initiated an earthquake measurement research program, Seismicity of Offshore Alaska Regions (SOAR) with the University of Texas' Marine Science Institute (UT-MSI). The program is being conducted in two phases. The immediate objective of Phase I was to develop a strong motion, ocean bottom seismometer (SM-OBS) capable of accurately measuring intense ground shaking. The focus of the effort was to engineer a system so that the cost, size, and weight of individual instruments facilitate the deployment and recovery of large numbers of stations with modest offshore effort. The Phase II effort consists of maintaining eight of the strong motion instruments offshore Kodiak Island for approximately one year. The program offered provides detailed documentation of the development, testing, and analysis of the SM-OBS (Phase I) and documentation of a limited data gathering operation along with any data collected (Phase II).

Phase I included development and testing of the instrumentation and other associated hardware; construction of three instruments; and experimental and analytical work on the soil-instrument coupling. This phase culminated in a limited field test where three sensors were deployed off Kodiak Island and successfully recovered after one month on bottom. An overview of this work is documented in the 1979 OTC paper 3615, "Soil Coupling of a Strong Motion, Ocean Bottom Seismometer."

Phase II includes modification and construction of additional five SM-OBS's; development of a preload system to ensure the instruments are well seated on the bottom; and deployment and operation of eight sensors offshore Kodiak Island, Alaska for approximately one year (June 1979-June 1980). The offshore deployment and recovery is being conducted from NOAA vessels. In addition, Phase II includes an EPR/UT-MSI/University of Alaska Program in which three strong motion stations were installed on nearby land sites around Kodiak during the summer of 1979.

CONTRACTOR: Exxon Production Research Company
P. O. Box 2189
Houston, Texas 77001
Attention: Mr. J. A. Rickard

OPERATOR: None

REPORT: Phase I Report.
Phase II Report includes a special report describing the instrument preload system and copies of all uncorrected ground motion measurements made.

Continuation of Project #105.....

COST: \$50,000/Participant; Closing date without penalty is February 1, 1980.

FINAL REPORT: Fall 1980

CONFIDENTIALITY: As per Agreement between Exxon Production Research and participant. Proposed Agreement available upon request.

PROJECT #106

TITLE: Arctic Cone Test Structure - Phase I

PURPOSE & METHOD: To evaluate the feasibility of constructing and installing in the Arctic a conical test structure to measure ice forces.

The study examines test structures applicable to the 20 to 60 foot water depth range in the Beaufort and Chukchi Seas. Phase I includes site selection, preliminary structural design, ice and wave load calculations, preliminary design of instrumentation system, identification of potential construction sites, project timing, and estimated test program costs.

CONTRACTOR: Brian Watt Associates, Inc. and Evans-Hamilton, Inc.

OPERATOR: Shell Oil Company

REPORT: Report on feasibility, preliminary design and costs of an Arctic cone test structure and associated instrumentation system.

COST: \$213,000. Cost to next participant--\$36,600.

PARTICIPANTS: ARCO, Exxon, Mobil, Phillips, Shell, SOCAL, Sohio

COMPLETION DATE: March, 1980

FINAL REPORT: March, 1980

CONFIDENTIALITY: September 1, 1985.

PROJECT #108

TITLE: Beaufort Sea Ice Movement Study, 1979-80

PURPOSE & METHOD: To measure the rate and extent of ice movement at three locations of the Beaufort Sea barrier islands. The stations have been located in water depths less than 40 feet, a zone in which little data have been obtained previously. Station 1 is located 1.75 n. miles east of Cross Island. The water depth here is 30 feet. Station 2 is 2.75 n. miles west-northwest of the west end of Pole Island in 25 feet of water. The last station is 2 n. miles northwest of the west end of Narwhal Island in 25 feet of water.

Ice movement will be measured with a mechanical reel system. Data will be recorded on magnetic tape at the sites and also telemetered to a base station located in the Prudhoe Bay area. In addition to ice movement data, winds, temperature, and barometric pressure will be measured at selected stations.

CONTRACTOR: Oceanographic Services, Inc.

COST: Cost to next participant is \$70,000.

REPORT:

PARTICIPANTS:

COMPLETION DATE:

CONFIDENTIALITY:

BACKGROUND: Similar ice movement programs have been conducted during the previous four winters (AOGA projects 27, 39, 42 and 52). These programs gathered significant information concerning the magnitude and rate of ice movements along with prevailing environmental conditions.

Participation in previous programs is not a prerequisite for joining the 1979-80 program. Those desiring to receive copies of the previous data may do so by entering into the appropriate contract with Amoco Production Company or Oceanographic Services, Inc.

PROJECT #109

TITLE: Level Ice and Pressure Ridge Characteristics During USCGC Polar Star Deployment in Bering and Chukchi Seas.

PURPOSE & METHOD: To determine ridging geometries prevalent in the Bering and Chukchi Seas using the icebreaker POLAR STAR as a logistics base. In addition to ridging geometries, ice ridge forces on the vessel will be measured along with an investigation of internal ridge characteristics. Level ice thicknesses and core samples will also be collected. The results of this study should provide information pertinent to marine transportation, ice forces on floating structures, and statistics on ice ridging intensity and underwater geometry.

CONTRACTOR: ARCTEC, Incorporated
9104 Red Branch Road
Columbia, Maryland 21045

OPERATOR: None.

REPORT: Study in progress.

COST: \$140,000. Cost to next participant \$21,875.

PARTICIPANTS: Amoco, ARCO, Chevron, Exxon, Getty, Gulf, Mobil, Phillips, Shell.

CONFIDENTIALITY: Indefinite.

PROJECT #110

TITLE: Aerial Mapping of Sea Ice in the Bering Sea (AMSIBS) 1980

PURPOSE & METHOD: To obtain and analyze 1800 miles of stereo aerial photography of sea ice in the Norton Sound and Bering Sea. Six hundred miles of photography will be gathered in mid-January, late February and early April. Flight line photos will be reviewed and selected intervals visually analyzed to determine average floe size, percent open water, significant ridge height, ridging frequency and the preferred orientation of leads and ridges. Ice maps will be prepared by an experienced ice observer from his observations during the flights. As part of this program, Bering Sea ice conditions during the entire 1979-80 ice season will be documented and analyzed. These data will be extracted from satellite imagery.

This project is a continuation of previous studies including Project #64 (1977), #43 (1978) and #51 (1979). Joinder of these studies is not a prerequisite to participation in #110.

CONTRACTOR: Oceanographic Services, Inc.

OPERATOR: None

COST: Total estimated cost of \$195,579. Cost to next participant is estimated at \$59,115.

PARTICIPANTS: Amoco, ARCO, Exxon, Phillips and Shell

FINAL REPORT: Estimated 12/20/80

CONFIDENTIALITY: January 1, 1986

PROJECT #111

TITLE: Aerial Mapping of Sea Ice in the Chukchi Sea, 1980.

PURPOSE & METHOD: To analyze 2400 miles of stereo aerial photography of sea ice in the Chukchi Sea obtained during two overflights. To fly a reconnaissance flight in January 1980 to obtain general ice conditions in the same area. Visual analyses will be performed at 10 mile intervals to determine the amount of open water, floe size, ridge heights, and ridging frequency on a subset of the data. Further analyses, including digitizing, profiling and computation of statistics will be performed on a smaller subset.

CONTRACTOR: Oceanographic Services, Inc.

OPERATOR: None.

REPORT: A report will be issued December 1980.

COST: \$195,579

PARTICIPANTS: ARCO Oil & Gas Company, Exxon, U.S.A., Gulf, Mobil, Shell

FINAL REPORT: December 1980

CONFIDENTIALITY: January 1, 1986

ALASKA FRONTIER OCS AREAS
INDUSTRY RESEARCH PROJECTS

	<u>Description of Project</u>	<u>Operator</u>	<u>Number of Participants</u>	<u>Status</u>	<u>Cost (\$M)</u>
1.	Bristol Bay Environmental Study - Detailed historical study with wind and wave hindcast	None	10	Completed Dec. 1970	144
2.	Sea Ice Investigation - North Slope - Field measurement of fast ice movement and characteristics	None	16	Completed Dec. 1970	198
3.	Chukchi Sea - Arctic Coast Environmental and Ecological Data	None	10	Completed 1970-1971	115
4.	Chukchi Sea Environmental Study - Review and compilation of historical data	Mobil	2	Completed June 1970	3
5.	Beaufort Sea Environmental Study - Review and compilation of historical data and make new bathymetric maps	None	10	Completed 1969	113
6.	Beaufort Sea - Reconnaissance studies of soils, sediments and ice	Hamilton	9	Completed Aug. 1970	241
7.	Beaufort Sea - Ice Scouring on the Arctic Sea floor (Alaska) - 2 seasons	None	9	Completed Nov. 1972	115
8.	North & South Bering Sea Environmental Study - Review and compilation of historical data	Mobil	2	Completed Oct. 1970	6
9.	Western Alaska (Onshore) Environmental Study - Review and compilation of historical data	Mobil	2	Completed July 1971	3

<u>Description of Project</u>	<u>Operator</u>	<u>Number of Participants</u>	<u>Status</u>	<u>Cost (\$M)</u>
10. Arctic Marine Terminal Facilities, Chukchi Sea - Engineering Study	Exxon Research & Engr. Co.	3	Completed Nov. 1969	1,272
11. Offshore Oil Terminal Structure Facilities in the Chukchi Sea - Design Feasibility Study	Exxon	3	Completed Dec. 1968	29
12. Sea Ice Activity and Pressure Ridge Growth - Vicinity of the surcharged grounded ice islands Unak 1 and Unak 2, Beaufort Sea	Exxon	3	Completed Nov. 1969	330
13. Beaufort Sea Environmental Study	CFP	2	Completed	49
14. Study of Behavior of Oil Spills in the Arctic	Exxon	1	Completed Feb. 1971	15
15. Manhattan Voyage Study	Exxon	3	Completed Dec. 1970	40,000
16. Arctic Tanker Design Study	Exxon	3	Completed Aug. 1970	1,615
17. Overflights: Nome to Resolute	Exxon	3	Completed 1969	163
18. Offshore Pipelaying on the Alaskan North Slope - Feasibility Study	Shell	8	Completed June 1973	60
19. Characteristics and Distribution of Near Shore Permafrost, Beaufort Sea	Sea Grant U of A	General Membership	Completed 1975	30 (1st yr.)
20. Sea Ice Dynamics Study, Beaufort Sea	Sea Grant U of A	General Membership	Completed 1975	65 (1st yr.)
21. Arctic Oil Biodegradation	Sea Grant U of A	General Membership	Completed 1975	30 (1st yr.)

	<u>Description of Project</u>	<u>Operator</u>	<u>Number of Participants</u>	<u>Status</u>	<u>Cost (\$M)</u>
22.	Investigation of Ice Forces on Cylindrical and Conical Offshore Structures	Chevron	6	Completed Sept. 1973	10*
23.	Artificial Ice Island Feasibility Study, Beaufort Sea	Mobil	9	Completed Nov. 1975	68
24.	Analysis of Arctic Ocean Under-Ice Profiles Analysis of U.S. Navy Submarine Sonar Data Under Polar Ice Pack	None	6	Completed July 1975	48.5
25.	Bering & Chukchi Seas -- Feasibility Study of Production Operations and Marine Crude Transportation During Ice-Covered Periods	Chevron Research	12	Completed Nov. 1975	70
26.	Beaufort Sea Ice Statistics from Satellite (ERTS-1 Data) - To Derive Statistics of Sea Ice Distributions in the Beaufort Sea Using Imagery from ERTS-1.	ERT	4	Completed July 1976	77
27.	Ice Movement Study for Winter, 1975- 1976, Beaufort Sea - Measure the Rate and Extent of Ice Movement at Select Locations	Amoco	8	Completed Sept. 1976	458
28.	Aerial Reconnaissance 1974-1975 - Prudhoe Bay - Harrison, Point Lay and Kotzebue Sound and Ice Movement - Prudhoe Bay - Harrison Bay	Amoco	5	Completed Dec. 1975	20*
29.	Bering/Chukchi Sea Ice Statistics from Satellite Data	ERT	4	Completed Mar. 1979	79

*Cost to next participant

275

<u>Description of Project</u>	<u>Operator</u>	<u>Number of Participants</u>	<u>Status</u>	<u>Cost (\$M)</u>
30. Unmanned Subsea Work Vehicle Study - To Evaluate the Application of U.S. Navy Unmanned Subsea Technology to Exploration and Production Tasks	Amoco	6	Completed Dec. 1975	54
31. Crushing Pressure of Ice - To Provide Up-to-date Assessment of What is Known and Unknown about Failure of the Ice Sheets Crushing Against Cylindrical Structures	Exxon	4	Completed Dec. 1975	10*
32. Triaxial Ice Measurements - To Determine the Strength of Freshwater Ice Under Triaxial Stress States	Exxon	3	Completed June 1975	10*
33. Arctic Ice Islands - To Develop a Model to Estimate the Risk of Collisions Between Ice Islands and Selected Offshore Sites in Coastal Waters of The Beaufort Sea	Exxon	3	Completed Dec. 1975	10*
34. Feasibility Study for Construction of Artificial Gravel Islands, Beaufort Sea	Amoco	13	Completed Mar. 1976	77
35. Summer Sea Ice Conditions, North Alaskan Coast - Cape Halkett to Camden Bay, June through October, 1953 through 1975	Amoco	5	Completed Dec. 1976	5*
36. Artificial Ice Islands, Beaufort Sea - To Build an Ice Island Capable of Being Used as a Drilling Platform for Oil Exploration in Shallow Arctic Offshore Situations	Union	7	Completed Nov. 1976	20*
37. St. George Basin Sea Ice Statistics from Satellite	Marathon	12	Completed Mar. 1977	41

*Cost to next participant

<u>Description of Project</u>	<u>Operator</u>	<u>Number of Participants</u>	<u>Status</u>	<u>Cost (\$M)</u>
38. Saline Ice Triaxial Tests - Determine the Strength of Laboratory Grown Saline Ice Under Triaxial Stress States	Exxon	5	Completed Nov. 1977	134
39. Beaufort Sea Ice Movement Study 1976-77	OSI	8	Completed June 1978	530
40. Developing Ridging Statistics in the Bering and Chukchi Seas From Submarine Under-Ice Profile Data	D&RT	5	Completed March 1977	32
41. Oil Spill Response in the Nearshore Beaufort Sea	ARCO, Exxon Shell	11	Completed Aug. 1978	40
42. Beaufort Sea Ice Movement Study 1977-1978	OSI	8	Completed Jan. 1979	510
43. Aerial Mapping of 1978 Sea Ice in Norton Sound and Northern Bering Sea	OSI	8	Completed Dec. 1978	110
44. Beaufort Sea Meteorological and Oceanographic Measurement Program (BEAUMOP)	Gulf R&D	8	Completed Feb. 1979	286
45. Arctic Mobile Drilling Structure	SOCAL	6	Completed June 1978	60*
46. Study of Methods and Costs of Offshore Pipeline Installation and Trenching in the Beaufort Sea	Shell	9	Completed Jan. 1979	126
47. Yukon Delta Rubble Pile Investigation 1978	OSI	6	Completed Feb. 1979	25
48. Beaufort Sea Floor Geophysical Study	Exxon	5	Completed Apr. 1979	120

*Cost to next participant

95

<u>Description of Project</u>	<u>Operator</u>	<u>Number of Participants</u>	<u>Status</u>	<u>Cost (\$M)</u>
49. Ice Island Experiment	Exxon	4	In Progress	2,400
50. Offshore Alaska Seismic Study (OASES)	Exxon	20 (ASOC)	Completed Mar. 1978	380
51. Aerial Mapping of 1979 Sea Ice in Norton Sound and Northern Bering Sea	OSI	8	Completed Mar. 1980	141
52. Beaufort Sea Ice Movement Study 1978-79	OSI	4	Completed Feb. 1980	134
53. Beaufort Sea Ice Movement Studies (BSIMS) 3-Year Summary and Analysis	OSI	7	Completed Feb. 1980	150
54. Norton Sound and Northern Bering Sea Rubble Pile Investigation 1978-79	OSI	6	Completed Mar. 1980	166
55. Beaufort Sea First-Year Ice Survey	Gulf R&D	8	Completed Jan. 1980	163
56. Bering Sea Phase I Oceanographic Study	Exxon	8	Completed May 1980	204
57. Reindeer Island Ice Island & Ice Bridge Studies	Sohio	18	In Progress	4,430
58. Arctic Skimmer Final Design	Sohio	14	Completed Apr. 1980	68
59. Arctic Dispersant Study	ARCO	14	Completed June 1979	20
60. Review Air Cushion Platform Capabilities for Oilspill Cleanup in Beaufort Sea	Shell	13	Completed Mar. 1980	32
61. Conical Structure Test Program	Exxon	6	Completed Spring, 1980	400

<u>Description of Project</u>	<u>Operator</u>	<u>Number of Participants</u>	<u>Status</u>	<u>Cost (\$M)</u>
62. Under-Ice Rig Noise Measurement Program	Exxon	13	Completed	50
63. Beaufort Sea Hindcast	Shell	2	Completed	20*
64. Bering Sea Aerial Photography Data - 1977	Exxon	6	Completed Jan. 1978	16*
65. Beaufort Sea Drilling Effluent Disposal Study	Shell	18	In Progress	731
66. GOAOC PROJECT--Yakutat Wave Data	Marine Advisor, Inc.	20	Completed Oct. 1970	23
67. GOAOC PROJECT--Group Oceanographic Survey - Gulf of Alaska	None	19	Completed Sept. 1970	1,400
68. GOAOC PROJECT--Weather Forecast Trial	Exxon		Completed 1972	38
69. GOAOC PROJECT--1973 Soil Boring Program	None	9	Completed 1973	359
70. GOAOC PROJECT--Ground Response Study	Shell	9	Completed Spring, 1975	35
71. GOAOC PROJECT--ARCO COST Well	ARCO	26	Completed Oct. 1975	11,930
72. GOAOC PROJECT--Lab Dynamic Soil Analysis	None	5	Completed Nov. 1975	25
73. GOAOC PROJECT--Oil-Spill Trajectory	None	1	Completed 1974	5
74. GOAOC PROJECT--Socio-Economic Impact of Drilling and Production	GOAOC	GOAOC Membership	Completed May, 1975	80

*Cost to next participant

279

	<u>Description of Project</u>	<u>Operator</u>	<u>Number of Participants</u>	<u>Status</u>	<u>Cost (\$M)</u>
75.	GOAOC PROJECT--Sea and Subsea Floor Properties			Completed 1975	60*
76.	GOAOC PROJECT--Seismic Risk Analysis for the Gulf of Alaska	None	GOAOC Membership	Completed Sept. 1975	20
77.	GOAOC PROJECT--Superstructure Icing	Marathon		Completed Sept. 1975	
78.	GOAOC PROJECT--1974 Ocean Current Measurement Program	None		Completed Sept. 1975	20*
79.	GOAOC PROJECT--Gulf of Alaska Hindcast Evaluation (WHEP)	Marathon	13	Completed 1975-1976	69
80.	GOAOC PROJECT--Earthquake Soil Response Analysis	Shell	8	Completed 1976	70
81.	GOAOC PROJECT--Gulf of Alaska Meteorological and Oceanographic Forecasting Program (MOFP)	Marathon	8	Completed July 1976	416
82.	GOAOC PROJECT--Gulf of Alaska Wave and Wind Measurement Program (GAWWMP)	Intersea Research	13	Completed July 1976	1,300
83.	GOAOC PROJECT--Seismic Risk Analysis for the Gulf of Alaska	Shell	GOAOC Membership	Completed Sept. 1975	36
84.	GOAOC PROJECT--Gulf of Alaska Wave Hindcasting Pilot Study (GAPS)	Shell	5	In Progress	197
85.	ASOC PROJECT--St. George Basin/Western Bristol Bay Wave and Wind Measurement Program (BOMP)	Marathon	8	Completed Feb. 1978	534
86.	ASOC PROJECT--Bering Sea Oceanographic Measurement Program 1977-1978	Marathon	7	Completed Apr. 1979	324

951
*Cost to next participant

<u>Description of Project</u>	<u>Operator</u>	<u>Number of Participants</u>	<u>Status</u>	<u>Cost (\$M)</u>
87. Yakutat Wave Data				
88. Kodiak COST Well				Est. 10,000
89. Kodiak COST Well Geotechnical Study				Est. 10,000
90. St. George Basin Cost Well	ARCO	20	Completed Oct. 1976	14,300
91. Marathon Satellite Current Study				
92. Kodiak Shelf Geotechnical Study	Shell	1	Completed Nov. 1976	20*
93. Gulf of Alaska Ground Response Analysis - Phase I	Shell	10	Completed March 1975	27
94. 1979 Beaufort Break-up		6	In Progress	
95. 1974-1975 Beaufort Aerial Reconnaissance Study		5	In Progress	15
96. Model Tests and Analysis of Multiyear Pressure Ridges Failing Against a 45° Cone	Exxon Prod. & Research	1	In Progress	30*
97. Sonar Ice Mapping System (SIMS) - The Development and the 1977-1978 Measurement Program	Exxon Prod. & Research	1	Completed	30*

*Cost to next participant

280
950

<u>Description of Projects</u>	<u>Operator</u>	<u>Number of Participants</u>	<u>Status</u>	<u>Cost (\$M)</u>
98. Feasibility Study of an Air Cushion Drilling System for Shallow Water Areas of the North Slope of Alaska	Exxon Prod. & Research	2	Completed	25
99. Yukon Delta Tide Gauge Program 1979	None	1	Completed Spring, 1980	61
100. Beaufort Sea Geotechnical			Completed	40
101. Norton Phase I Geotechnical			In Progress	195
102. Beaufort Sea Freeze-up Movement Study - 1979	None	5	In Progress	165
103. OSI Stress Sensor Study			Completed	30
104. OSI Beaufort Oceanographic Study			Completed	130
105. Seismicity of Offshore Alaska Regions (SOAR) Program	None		In Progress	800
106. Arctic Cone Test Structure - Phase I	Shell	7	In Progress	213
107. Large Scale In-situ Ice Strength Measurement			In Progress	1,330
108. 1979-80 Beaufort Sea Ice Movement Study			In Progress	70*
109. Level Ice and Pressure Ridge Characteristics During USCGC Polar Star Deployment in Bering and Chukchi Seas	None	9	In Progress	140

*Cost to next participant

<u>Description of Projects</u>	<u>Operator</u>	<u>Number of Participants</u>	<u>Status</u>	<u>Cost (\$M)</u>
110. Bering Sea Ice Aerial Mapping - 1980	none	5	In Progress	196
111. Aerial Mapping of Sea Ice in the Chukchi Seas, 1980		5	In Progress	196
112. Bering Sea Ice Features		5	In Progress	

112

4/2/80

APPENDIX D

Arctic Petroleum Operator's Association,
Industry Research Projects, January 1980

APOA BIBLIOGRAPHY

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TABLE OF CONTENTS

Introduction	i
A - Geography, Geomorphology, and Cartography	1
B - Geology, Mineralogy, Geochemistry, and Palaeontology	1
C - Soils and Permafrost	1
D - Oceanography	2
E - Meteorology and Climatology	5
F - Snow, Glaciology, and Hydrology	6
G - Ice (except Glacier Ice and Ground Ice)	6
H - Botany	16
I - Zoology	18
J - Ecology (includes Environmental Protection)	21
K - Medicine, Human Physiology, and Public Health	23
L - Communications and Transportation	24
Q - Petroleum, Natural Gas, and Pipelines	26
R - Government, Economic Conditions, and Social Conditions	38
S - Land Use, Land Management, and Regional Planning	38
T - Native Peoples (except Archaeology)	39
X - General	39
Y - Miscellaneous	40
Title Index	41
Author Index	50
Subject Index	57
Geographic Index	66
Operator Index	74

Introduction

The Arctic Petroleum Operator's Association (APOA) was formed in 1970 by a group of petroleum companies operating in the Canadian arctic. The purpose of the APOA is to promote joint research in the arctic, and to provide liaison between industry, government, and universities on arctic research related to petroleum development. Most APOA research has been directed towards obtaining engineering and environmental data, and towards adapting established operating techniques and equipment to meet the unique operating conditions of the arctic. In some cases the results of APOA research projects are released to the general public immediately, while in other cases the reports are released after a protected period of up to five years.

The purpose of the "APOA Bibliography" is to make other northern researchers more aware of the amount and type of research being conducted by the APOA, and to provide detailed author, subject and geographic access to this research. The bibliography contains all APOA-conducted or APOA-funded research reports in the ASTIS database as of January 9, 1980, a total of 218 documents. About 55% of these documents are from the "APOA Project Report" series which is available from the APOA on microfiche. Most of the remainder have been published by other agencies or in scientific journals. The bibliography includes only research sponsored by the APOA as a whole, and not the much larger amount of research done by individual member companies. All reports in this bibliography have been released to the public. The bibliography will be re-issued periodically as additional reports are released. About 75% of the documents in this bibliography have appeared previously in the "ASTIS Current Awareness Bulletin". The remainder were added to the ASTIS database specifically for the production of the "APOA Bibliography".

The Devon Island International Biological Programme Project, of which APOA was a major funder, produced approximately 90 journal articles, theses, and papers. Because of the large number of documents produced by this project it was decided to represent it in this bibliography by only the single book (J-29920) which summarized the results of the project. With this exception, and with the exception of one or two other reports which were not received in time for inclusion, the "APOA Bibliography" contains all the wholly or partially APOA-funded research reports of which ASTIS is aware. However, there may be some which have been missed, and it would be appreciated if the reader would draw any omissions or errors to our attention.

The first section of the "APOA Bibliography" gives the citation and abstract of each document, and is produced in exactly the same format as the "ASTIS Current Awareness Bulletin". Documents are grouped in broad subject categories, each of which is represented by a capital letter. Within each category documents are listed in ascending order by ASTIS document number. The usual ASTIS subject categories have been used, and

therefore, because of the subject matter of the bibliography, some categories have far more documents than others. Since documents which discuss the environmental impact of a specific industry are placed with that industry, section Q contains works on environmental impacts of the petroleum industry. Documents which apply to more than one broad subject category are listed in the most applicable category, and are cross-referenced in the "See Also" list which appears at the end of other pertinent categories. The second-last line of each citation gives the ASTIS broad subject and geographic categories to which the document has been assigned. The last line of each citation gives a location where the document may be obtained. All documents in this bibliography are available from the University of Calgary Library (CaACU) via Interlibrary Loan. Please give the title, author, and ASTIS document number when ordering. The code at the end of each abstract indicates whether the abstract was written by the author (Au), or by ASTIS staff (ASTIS).

The Title, Author, Subject, and Geographic Indexes refer back to the first section of the bibliography using a combination of the broad subject category and the ASTIS document number. A convenient listing of APOA project reports by project number begins on the first page of the Title Index. Missing project numbers either did not produce reports or the reports have not yet been released to the public. The Operator Index indicates which APOA projects were managed by a given company. Note that the numbers given in this index are project numbers, and that the Title Index must be used to find the reports produced by a given project.

A secondary purpose in producing the "APOA Bibliography" has been to demonstrate the capabilities of the ASTIS database for the production of specialized bibliographies. The results of any ASTIS online search can be used to automatically generate a fully indexed bibliography in camera-ready form. The cost of producing such a bibliography is, therefore, largely dependant on whether or not additional documents must be added to the database for its production. ASTIS invites inquiries about the production of additional specialized bibliographies.

A - GEOGRAPHY, GEOMORPHOLOGY, AND CARTOGRAPHY

A-25062

The coastal environment of southern Baffin Island and northern Labrador-Ungava / [by] B.G. Barry, R.G. Crane, J.W. Locke, W.W. Locke III, and G.H. Miller, Institute of Arctic and Alpine Research, University of Colorado.
[Calgary : Distributed by APOA, 1977.
4 microfiches : ill., maps, figures, tables ; 11x16cm.
(APOA project no. 138 : Environmental investigations and analysis in Davis Strait - second half 1977. Report, no. 1)
Final report to: Imperial Oil Ltd., Aquitaine Company of Canada Ltd., Canada Cities Service Ltd.
Appendices.
References.
A G08124
CaACU

... This report deals with the physical environment of coastal zones that could be affected by possible slicks originating in the Southern Davis Strait area The basic objective of the study was to provide reconnaissance maps of the coastal environment of southeastern Baffin Island, Ungava Bay and northern Labrador at a scale of 1:250,000 together with summary maps at 1:1,000,000. ... The morphology and sediment characteristics of the beach and the intertidal zone were the primary features to be mapped. This information and other limited data in the literature were then used to provide an evaluation of areas of sensitivity and an assessment of access from the sea to such areas. Since sea ice is present along the coast, or offshore, ... an analysis of its growth and decay was also undertaken. (Au)

A-30031

Coastal sedimentary processes and sediments, southern Beaufort Sea / C.P. Lewis and D.L. Forbes.
Victoria, B.C. : Beaufort Sea Project, Dept. of the Environment, 1975.
68p. : ill., maps, photos. ; 28cm.
(Technical report - Canada. Beaufort Sea Project, no. 24)
(APOA project no. 72 : Beaufort Sea Environmental Program. Report, no. 24)
Appendix: Physical aspects of the Beaufort Sea coast. Prepared testimony presented to the Mackenzie Valley Pipeline Inquiry, February 13, 1976.
Bibliography: p. 39-40.
A G0811
CaACU

This technical report is based primarily on fieldwork conducted during the summer of 1974 into the geometry, composition, origin and stability of coastal landforms bordering the Beaufort Sea from the Alaska-Yukon boundary east to the Mackenzie Delta. The 1974 study followed general reconnaissance investigations of the northwest coast of the Tuktoyaktuk Peninsula in 1973 and of the Yukon coast in 1972 As well, prepared testimony by the senior author, presented to the Mackenzie Valley Pipeline Inquiry on February 13, 1976, is included in this report as an appendix. The reader is referred to this appendix for a more general overview of physical aspects of the Beaufort Sea coast, discussion of the implications of offshore hydrocarbon resource development on the coastal zone, and for additional detailed information on the modern Mackenzie delta plain. (Au)

B - GEOLOGY, MINERALOGY, GEOCHEMISTRY, AND PALAEONTOLOGY

B-24546

Gravel inventory survey, Richards Island and adjacent areas / prepared by J.D. Mollard and Associates Limited.
[Calgary : Distributed by APOA, 1972].
3 microfiches : figures, maps, tables ; 11x16cm.
(APOA project no. 42 : Mackenzie Delta gravel inventory. Report)
B G08121
CaACU

The proposed study includes a review of all available pertinent geological reports and maps, including relevant GSC data to obtain: 1. Best estimates of probable quantities of materials in absence of field drilling and testing; 2. Appraisal of quality of materials from a commercial-use standpoint; 3. Discussion of problems of development along with alternate methods of development; 4. Location of places to field test and suggestions for procedures for field testing. (Au)

See Also : D-21253, G-25526

C - SOILS AND PERMAFROST

C-6408

The occurrence of permafrost and frozen sub-seabottom materials in the southern Beaufort Sea / [by] J.A.M. Hunter [et al].
Victoria, B.C. : Beaufort Sea Project, Dept. of the Environment, 1976.
iv, 174p. : maps, tables, graphs ; 28cm.
(Technical report - Canada. Beaufort Sea Project, no. 22)
(APOA project no. 72 : Beaufort Sea Environmental Program. Report, no. 22)
Bibliography: p. 81-88.
C G07
CaACU

Permafrost conditions exist beneath most of the Beaufort Sea shelf area. As a result of large changes in the surface thermal regime in the recent geological past, non-equilibrium conditions are probably found in most areas; hence permafrost is both aggrading and degrading. Permafrost is generally at much higher temperatures offshore than the equivalent permafrost conditions onshore and as a result is much more susceptible to thawing by a thermal disturbance. The occurrence of ice-rich sub-seabottom sediments over large areas of the shelf has been interpreted from seismic data. Such sediments are potentially susceptible to hazardous thermal degradation. Because of low sediment temperatures, natural gas in shallow sediments may be found in the form of clathrate hydrates, which may cause additional technical problems for exploratory drilling. ... (Au)

C-21261

Offshore permafrost, southern Beaufort Sea / [by] J. Ross Mackay.
[Calgary : Distributed by APOA, 1972].
1 microfiche : ill. ; 11x16cm.
(APOA project no. 4 : Geological analysis of ocean floor samples. Report, no. 2)
References.
C,D G07
CaACU

In the spring of 1970, permafrost was found in

drilling operations (Ocean Floor Sampling - Arctic Ocean of APOA) in the southern Beaufort Sea off the Yukon Coast and Mackenzie Delta-Tuktoyaktuk Peninsula area. Two quite small frozen samples from Bore Hole 7B (Sample 6) and Bore Hole 15A (Sample 7B) were given to the writer for study. In the summer of 1970, the Geological Survey of Canada, in its survey of the southern Beaufort Sea, cored into fresh water ice lenses about 20 miles north of Cape Bathurst. There is no doubt, therefore, that permafrost is present in the southern Beaufort Sea. Some tentative observations on offshore permafrost are given (Au)

C-30236

Changes to the active layer caused by surface disturbance / L.C. Bliss and R.W. Wein. (Proceedings - Seminar on the Permafrost Active Layer, Vancouver, 4-5 May, 1971 / Prepared by R.J.E. Brown. Ottawa : National Research Council. 1971. Technical memorandum - Canada. National Research Council. Associate Committee on Geotechnical Research, no. 103, p. 37-47) (APCA project no. 37 : Arctic environmental research, tundra and ecological studies on the Mackenzie Delta and Devon Island. Report) References. C, J G001 CaACU

... The objectives of this paper are to present information on natural and man-induced surface disturbances in the Arctic, their influence on depth of the active layer and associated subsidence, and the implications for re-establishment of the vegetation. (Au)

See Also : D-21245, H-30198, H-30341

D - OCEANOGRAPHY

D-4766

Open water surface currents in the southern Beaufort Sea / [by] M.R. MacNeill and J.F. Garrett. Victoria, B.C. : Beaufort Sea Project, Dept. of the Environment, 1975. ii, 113p. : ill., graphs, tables ; 28cm. (Technical report - Canada. Beaufort Sea Project, no. 17) (APOA project no. 72 : Beaufort Sea Environmental Program. Report, no. 17) References. D G07 CaACU

One of the investigations of the 1974-75 Beaufort Sea Project was an offshore, near-surface current study. A drifting surface drogus was developed that could be deployed and tracked using an aircraft, thus enabling examination of the surface currents over a large area of the Beaufort Sea. ... Tracking was carried out ... using the Twin Otter with the assistance of a Bell 206 Helicopter. The ice conditions in 1975 were entirely different from 1974 which no doubt had a significant effect on the surface currents and their response to weather systems. ... The 1975 data ... shows that the wind plays an important role in driving the currents, especially in the case of steady northwest winds and the aftermath of these winds; the other most important factor being the discharge from the Mackenzie River. Eddies of several different scale sizes and areas of divergence and convergence complicate the picture. In Mackenzie Bay, a persistent divergence is observed, and north of Richards Island a convergence is frequently observed. ... (Au)

D-15466

Sediment dispersal in the southern Beaufort Sea / [by] B.R. Pelletier. Victoria, B.C. : Beaufort Sea Project, 1975. 80p. : figures, tables ; 28cm. (Technical report - Canada. Beaufort Sea Project, no. 25a) (APOA project no. 72 : Beaufort Sea Environmental Program. Report, no. 25a) Appendices. References. D G07 CaACU

This is a study of sediment dispersal based on textural examination of the bottom sediments. It involves the nature, distribution and origin of these sediments as they occur on the sea bottom. ... (Au)

D-15474

Suspended matter in the southern Beaufort Sea / [by] Brian D. Bornhold. Victoria, B.C. : Beaufort Sea Project, 1975. [31]p. : ill., figures, tables ; 28cm. (Technical report - Canada. Beaufort Sea Project, no. 25b) (APOA project no. 72 : Beaufort Sea Environmental Program. Report, no. 25b) Appendix. References. D G07 CaACU

Concentrations of suspended matter measured in the southern Beaufort Sea in August and September, 1975 ranged from less than 0.1 mg/l to more than 17 mg/l. The highest concentrations were recorded at nearshore stations off Kugmallit Bay. Mid-water and near-bottom zones of turbid water are common, though their exact causes are not clear. ... The major components of the suspended matter include fine inorganic particles, organic aggregates of plankton and inorganic particles, and phytoplankton. ... (Au)

D-21245

1970 bottom sampling program - south coast of Beaufort Sea Mackenzie Bay to Liverpool Bay, Northwest Territories / Golder, Branner and Associates Ltd. [Calgary : Distributed by APOA, 1970]. 2 microfiches ; 11x16cm. (APOA project no. 3 : Ocean floor sampling Beaufort Sea 1970. Report, no. 1) At head of title: Report to Imperial Oil Limited. D, C G07 CaACU

... The purpose of the drilling and sampling program was to determine the nature and characteristics of the sea bottom sediments, and to assess their general suitability for support of offshore oil drilling platforms and construction of artificial islands. The description and classification of the sea bottom sediments encountered during the investigation program are presented, together with the results of field and laboratory testing. The sea bottom sediments west of Kugmallit Bay consist essentially of clay and silt. The bottom sediments located east of Kugmallit Bay consist essentially of fine to medium sand. Relic permafrost was encountered in some of the exploratory holes at depths ranging from 20 ft. to 70 ft. below the sea bed. The significance of the permafrost relative to the support of artificial islands and offshore drilling platforms is discussed. ... (Au)

D-21253

Geological sampling and analytical program - Beaufort Sea / compiled by M. M. Lerand. [Calgary : Distributed by APOA], 1971. 4 microfiches : ill. ; 11x16cm. (APOA project no. 4 : Geological analysis of ocean floor samples. Report, no. 1) Appendices. References. D,E G07 CaACU

The project consisted of studies of the palynology, micropaleontology, organic geochemistry, mineralogy and sedimentology of the sea bottom soil samples obtained at eleven locations in the Beaufort Sea during APOA Project 3. ... (Au)

D-24490

Wind, waves, weather and icebergs in Baffin Bay and Davis Strait, summer 1972 / Marine Environmental Services Limited. [Calgary : Distributed by APOA, 1972]. 1 microfiche : tables ; 11x16cm. (APOA project no. 35 : Environmental study of the Baffin Bay-Davis Strait region. Report, no. 1) Mostly tables. D,E G09 CaACU

Presents tabulated data on winds, waves, weather and icebergs collected by the vessel m/v Hans Egede during the 1972 seismic operations in the Baffin Bay and Davis Strait regions. (ASTIS)

D-24503

Environmental conditions in Baffin Bay and Davis Strait including presentation of data collected during summer 1972 / Marine Environmental Services Limited. [Calgary : Distributed by APOA, 1972]. 2 microfiches : tables ; 11x16cm. (APOA project no. 35 : Environmental study of the Baffin Bay-Davis Strait region. Report, no. 2) Appendices. References. D,E G09 CaACU

To present existing environmental data of the Canadian portion of the Baffin Bay - Davis Strait Region in a format suitable for use in planning exploration and development activities in this frontier region. All existing environmental data was studied by Marerx and summarized in usefull charts and diagrams. In addition, an observer was placed aboard a seismic vessel working in the area in the summer of 1972. This data added significantly to the limited amount of quantitative data available and forms an important part of the report. (Au)

D-25601

Normal and extreme winds and waves in the Canadian southern Beaufort Sea / Intersea Research Corporation. [Calgary : Distributed by APOA], 1974. 2 microfiches : figures, maps, tables ; 11x16cm. (APOA project no. 70 : Wind/wave hindcast, Canadian Beaufort Sea. Report) Prepared for Imperial Oil Company Ltd. References. D,E G07 CaACU

... This study describes the surface environmental events with substantial accuracy so that a high degree of confidence may be placed in the results. Specifically, the

consultant will (a) evaluate all available wind data associated with recorded wave data to correlate wind velocity, duration and fetch with wave height; (b) use the fetch and wind data to make a wave hindcast; (c) compare the hindcast results with the wave-rider data in order to select the best hindcast method; (d) make a search of past severe storm wind reports; (e) prepare a hindcast model for the locations of interest. (Au)

D-26514

Field report on the oceanographic cruises during April, July-August, October-November, 1976 / MacLaren Atlantic Limited. [Calgary : Distributed by APOA], 1977. 2 microfiches : figures, tables ; 11x16cm. (APOA project no. 135 : Biological studies in the vicinity of Hudson Strait, Davis Strait and Labrador Sea area - 1976. Report, no. 2) Prepared for Imperial Oil Limited. D,J G09 CaACU

... The primary purpose of these cruises was to obtain current meter data in the Flemish Pass and in the Davis Strait The second and third cruises were eventually expanded to include salinity-temperature readings, biological sampling and coring. The first cruise in April 1976 was for the sole purpose of deploying two current meter moorings in the Flemish Pass. ... The second cruise extended from July 12 to August 12, 1976, and was conducted on the Lady Johnson II. The primary purpose of this cruise was the retrieval of the current meters which were moored in April and the deployment of new moorings in the Flemish Pass and the Davis Strait. This cruise agenda was eventually extended to include salinity-temperature readings, biological sampling and coring The third cruise extended from September 29 to November 16, 1976, and again employed the Lady Johnson II as cruise ship. The primary purpose of this cruise was retrieval of the current meter moorings in the Flemish Pass and the Davis Strait. ... (Au)

D-26565

Report on sediment analysis of cores from Davis Strait and Flemish Pass / MacLaren Atlantic Limited. [Calgary : Distributed by APOA], 1976. 2 microfiches : graphs, tables ; 11x16cm. (APOA project no. 138 : Environmental investigations and analysis in Davis Strait - second half 1977. Report, no. 14) Prepared for Imperial Oil Limited. D G09 CaACU

MacLaren Atlantic Limited ... was instructed to obtain bottom sediment cores from the Flemish Pass and Davis Strait. ... Coring was attempted at six locations ... using an Alpine piston corer, Model 206, and an Alpine gravity corer. ... Analyses of the sediment subsampled ... was carried out by MacLaren Atlantic Limited to determine the soil type, Atterberg Limits (specifically liquid and plastic), natural moisture content, sediment particle size distribution, and organic content. The results of these analyses, along with photographs and sediment lithology, are presented in this report. (Au)

D-26581

Report on strength and deformation characteristics of sea-bed samples from Davis Strait / by R.M. Hardy and Associates Ltd. [Calgary : Distributed by APOA], 1978. 2 microfiches : figures, charts, tables ; 11x16cm. (APOA project no. 138 : Environmental investigations and analysis in Davis Strait -

second half 1977. Report, no. 16)
Prepared for Imperial Oil Limited.
Appendices.
D G09
CaACU

The geotechnical testing and analysis associated with the above project was divided into two phases. ... The second phase of the geotechnical aspects of this project is described in this report, and deals with the evaluation of the strength and deformation characteristics of the sea-bed materials in Davis Strait. During July-September, 1977, Imperial Oil Limited sampled sea-bottom sediments at 5 different locations Within each location, 3 different cores were obtained, designated 1, 2 and 3. Cores were obtained with a free-falling piston corer apparatus with a 1600 lb. core head, with a free fall of 12 feet. The samples were retained in two 20 foot sections of 2.5 inch liner. Sites 1, 3 and 5 are located within the Imperial Oil Limited lease area, this program is concerned with the testing and data analysis of soil samples from these 3 locations. (Au)

D-26590

Final report : 1977 ocean current study / Innovative Ventures Ltd.
[Calgary : Distributed by APOA, 1978].
1 microfiche : ill., maps, tables ; 11x16cm.
(APOA project no. 138 : Environmental investigations and analysis in Davis Strait - second half 1977. Report, no. 17)
Presented to Imperial Oil Ltd.
Appendices.
D G09
CaACU

... The following services were provided by I.V.L.: a) Design, construction and deployment of current meter arrays. b) Collection of salinity and temperature data (STD data) as a function of depth. c) On-board testing and release of satellite tracked drifting RAMS buoys. d) Responsibility for satellite navigation. e) Responsibility for meteorological observations. f) Assisting in the deployment of a meteorological buoy. g) Taking of current profiles. h) Recovery of current meter arrays. i) Calibration of current meters prior to deployment and after recovery. j) Processing of raw data recorded by current meters and the STD system preparatory to further data reduction and analysis. ...
(Au)

D-26603

Report on laboratory testing of sea-bed samples from Davis Strait / by R.M. Hardy and Associates Ltd.
[Calgary : Distributed by APOA], 1977.
1 microfiche : charts, map, table ; 11x16cm.
(APOA project no. 138 : Environmental investigations and analysis in Davis Strait - second half 1977. Report, no. 10)
Prepared for Imperial Oil Limited.
Appendices.
D G09
CaACU

The geotechnical testing and analysis associated with the above project was divided into two phases. The first phase is described in this report, and deals with the logging, sampling, classification and testing of samples from five locations in Davis Strait. During July-September, 1977, Imperial Oil Limited sampled sea-bottom sediments at 5 different locations Within each location, 3 different cores were obtained, designated 1, 2 and 3. Cores were obtained with a free-falling piston core apparatus with a 1600 lb. core head, with a free fall of 12 feet. The samples were retained in two 20 foot sections of 2.5

inch liner. ... (Au)

D-26620

Davis Strait surface drifter buoys program 1977 / by M. Metge.
[Calgary : Distributed by APOA], 1978.
2 microfiches : ill., figures, tables ; 11x16cm.
(APOA project no. 138 : Environmental investigations and analysis in Davis Strait - second half 1977. Report, no. 20)
Appendices.
References.
D G09
CaACU

1. Thirteen satellite tracked drogues, RAMS buoys were released in the northern Labrador Sea during 1977. All releases were successful. 2. The drift tracks obtained yielded a very detailed and accurate picture of the surface currents in the area, notably near Hudson Strait. They have been used to produce a surface current map for the area. 3. The drift tracks confirmed the current patterns obtained by current meters and geostrophic calculations.
(Au)

D-26638

Davis Strait wave climatic study using the 1970 through 1977 Meteorological and Oceanographic Centre synoptic significant wave charts : site number 1 - 63 deg. N 59 deg. W, Site number 2 - 60 deg. N 60 deg. W / W.N. McKay.
[Calgary : Distributed by APOA], 1978.
6 microfiches : charts, figures, tables ; 11x16cm.
(APOA project no. 138 : Environmental investigations and analysis in Davis Strait - second half 1977. Report, no. 21)
Appendices.
D G09
CaACU

The Meteorological and Oceanographic Centre Synoptic significant wave charts are the best means to date, of providing realistic wave climate information for these northern sites. The charts are the only source of continuous records for a sufficient length of time to provide an adequate sampling of the wave climate that has existed. The chart data has been shown to be realistic by making spot comparisons with Accelerometer Buoy wave data, and with the Sea Surface Marine Observation reports. Wave activity has been found to vary with the time of the year. Peak activity occurs during the months of November and December. It declines during the spring months to reach a minimum in July. It then increases again in the fall to reach peak activity again in November. The wave activity is such that a seven month season would result by using the interval April through October, rather than the six month season June through November. It would be desirable to avoid November if at all possible.
... (Au)

D-27553

Analysis of ocean currents, Davis Strait - 1977 / by Seaconsult Marine Research Ltd. Authored by T.R. Osborn, P.H. LeBlond, D.O. Hodgins.
[Calgary : Distributed by APOA], 1978.
15 microfiches : figures, maps, tables ; 11x16cm.
(APOA project no. 138 : Environmental investigations and analysis in Davis Strait - second half 1977. Report, no. 11, v.1-2)
Prepared for Imperial Oil Limited.
References.
D G09
CaACU

This report contains an analysis of oceanographic field data ... in the Northern

Labrador Sea and in the Davis and Hudson straits in 1977. Current data from the 1976 field program are also analyzed and discussed. These results are interpreted in the light of other oceanographic information available in the area. ... The main conclusions expressed ... concern: (1) the variability of oceanographic conditions in northern Davis Strait where the waters of the West Greenland Current are deflected westward to join the Baffin Current; (2) the structure of the mean flow and of its variations in western Davis Strait, and in particular, the influence exerted by Hudson Strait on the circulation near its mouth; (3) the circulation in Hudson Strait proper. Discussions include variability of the regional circulation over periods of weeks and longer, together with shorter-term tidal and high-frequency variability. (Au)

D-30007

Near bottom currents and offshore tides / W.S. Huggett, M.J. Woodward, F. Stephenson, P.V. Hermiston [and] A. Douglas.
Victoria, B.C. : Beaufort Sea Project, Dept. of the Environment, 1975.
38p. : ill., graphs, maps, tables ; 28cm.
(Technical report - Canada. Beaufort Sea Project, no. 16)
(APOA project no. 72 : Beaufort Sea Environmental Program. Report, no. 16)
D G37
CaACU

... Our specific objective was to gain some understanding of the bottom currents and offshore tides in the southern Beaufort Sea, their relationship to wind and ice conditions, and to measure storm surges along the coast in the Mackenzie River Delta area. ... (Au)

D-30015

The physical oceanography of the south-eastern Beaufort Sea / R.H. Merlivault and B.R. de Lange Eom.
Victoria, B.C. : Beaufort Sea Project, Dept. of the Environment, 1975.
viii, 97p. : ill., graphs, maps ; 28cm.
(Technical report - Canada. Beaufort Sea Project, no. 18)
(APOA project no. 72 : Beaufort Sea Environmental Program. Report, no. 18)
Bibliography: p.81-83.
D G37
CaACU

In the Beaufort Sea meteorological and ice conditions play a major role in the distribution of oceanographic properties. Field studies were conducted during the summer of 1974 ("worst ice conditions on record") as well as during the spring and summer of 1975 ("good ice conditions"). The discharge from the Mackenzie River dominates the surface waters of the southern Beaufort Sea, especially during bad ice years. The density distribution is salinity dominated throughout the system. The vertical profiles of salinity, temperature, turbidity and currents are described for summer and spring conditions. ... (Au)

D-30023

Storm surges / R.F. Henry.
Victoria, B.C. : Beaufort Sea Project, Dept. of the Environment, 1975.
41p. : ill., graphs, maps ; 28cm.
(Technical report - Canada. Beaufort Sea Project, no. 19)
(APOA project no. 72 : Beaufort Sea Environmental Program. Report, no. 19)
References.
D G37
CaACU

... This report describes a study, involving

numerical models, designed to permit prediction of surge levels between Herschel Island and Cape Bathurst and also to check if surge magnitudes at sites well off-shore are ever large enough to pose hazards to drilling operations. ... The accuracy of numerical storm surge models has to be verified by simulation of a number of actual surges. ... Two subsidiary topics discussed are 'negative surges', that is, temporary decreases in sea-level, which may hinder shipping, and winter surges, which though much less frequent than summer surges, should probably be considered during the design of near-shore structures, in view of their potential for causing ice damage. (Au)

See Also : C-21261, G-21237, G-26492, G-26727,
J-25240, J-25259, J-25267, J-26506, J-26522,
J-26530, X-30317

E - METEOROLOGY AND CLIMATOLOGY

E-11630

Real-time environmental prediction system / [by] J. Clodman and P.E. Muller.
Victoria, B.C. : Beaufort Sea Project, Dept. of the Environment, 1975.
ii, 138p. : maps, tables ; 28cm.
(Technical report - Canada. Beaufort Sea Project, no. 20)
(APOA project no. 72 : Beaufort Sea Environmental Program. Report, no. 20)
Appendices.
E G37
CaACU

Plans for offshore oil drilling in the Beaufort Sea must take into account such hostile environmental elements as ice, waves, storm surges, wind and weather. ... the intent of this study is to design a high-quality real-time environmental prediction system which can forecast ice movement, waves, storm surges, wind and weather and provide timely warnings of threats from these elements to the operations. ... (Au)

E-15458

A study of weather, waves and icing in the Beaufort Sea / [by] M.O. Berry, P.M. Dutchak, M.E. Lalonde, J.A.W. McCulloch and I. Savdie.
Victoria, B.C. : Beaufort Sea Project, 1975.
1v. (various pagings) : figures, maps, tables ; 28cm.
(Technical report - Canada. Beaufort Sea Project, no. 21)
(APOA project no. 72 : Beaufort Sea Environmental Program. Report, no. 21)
References.
E G37
CaACU

... Based on an analysis of data from three coastal locations, extreme wind values are presented for offshore areas. Values are given for various return periods and durations. The analysis suggests that the distribution of extreme winds is relatively uniform over southern and eastern portions of the area of interest. In the northwest, where the wind regime is virtually unknown, extreme values may differ from those presented. (Au)

E-26549

Environmental conditions off the east coast of Canada : Sites 3 (54 deg. N, 54 deg. W), 4 (49 deg. N, 48 deg. W) and 5 (47 deg. N, 47 deg. W) / by Maurice Danard, Atmospheric Dynamics Corporation.
[Calgary : Distributed by APOA], 1977.

97

3 microfiches : figures, maps, tables ;
11x16cm.

(APOA project no. 138 : Environmental investigations and analysis in Davis Strait - second half 1977. Report, no. 12, 12A)

Prepared for Imperial Oil Limited.

Partial contents: no. 12A Addendum:

Environmental conditions off the east coast of Canada : Godthaab, Greenland (64 deg. 10 sec. N, 51 deg. 45 sec. W).

E G09

CaACU

The climatology of environmental conditions affecting ship operations has been examined for the following three sites: (1) 3 (54.5 deg. N 54 deg. W), (2) (49 deg. N. 48 deg. W), (3) 5 (47 deg. N 47 deg. W), All available data between 1946 and 1976 were used. The following quantities were computed: 1. Percent frequency of winds from various directions and mean speed for each direction. 2. Percent frequency of wind speeds exceeding various values. 3. Extreme wind speeds for each month of each year in period of observation. 4. Extreme wind speeds for various return periods. 5. Percent frequency of simultaneous occurrence of high winds and air temperatures below -2 deg. C (the approximate freezing point of sea water). Such conditions are conducive to icing from sea spray. 6. Percent frequency of air temperatures below various values. 7. Percent frequency of sea temperatures below various values. 8. Percent frequency of visibilities below various values. 9. Percent frequency of sea-level pressures below various values. The most important of the above calculations are likely probabilities of wind speed exceedances (no. 2), icing (no. 5), and low visibilities (no. 8). ... In summary, in the summer months wind speeds generally decrease as one goes from north to south but fog becomes more prevalent. Icing from sea spray is a winter problem which, as expected, decreases from north to south. ... (Au)

See Also : D-24490, D-24503, D-25331, G-26557,
G-26727, H-30198, H-30341, Q-15547

F - SNOW, GLACIOLOGY, AND HYDROLOGY

F-6793

Mackenzie River input to the Beaufort Sea / [by] K.F. Davies.

Victoria, B.C. : Beaufort Sea Project, Dept. of the Environment, 1975.

ii, 72p. : ill., charts, tables, maps ; 28cm.

(Technical report - Canada. Beaufort Sea

Project, no. 15)

(APOA project no. 72 : Beaufort Sea

Environmental Program. Report, no. 15)

References.

F G08121

CaACU

This report contains a summary of the findings under the study, "Mackenzie River Input to the Beaufort Sea," one of a series of studies comprising the Beaufort Sea Project. Comprehensive descriptions of the gauging sites and methods used are included in the report. Distribution of flow in the main channels as a percentage of total flow has been determined on a month-by-month basis for the period July 1974 to June 1975. Suspended sediment transport, ice thickness, and water temperature in the Delta are also discussed and the results shown. (Au)

F-30295

[Proceedings] - Symposium on Applied Glaciology, Cambridge, 13-17 September 1976.

Cambridge : International Glaciological Society, 1977.

686p. : ill., graphs, photos., tables ; 25cm.

(Journal of glaciology, v. 19, no. 81, 1977)

Publication of this volume was assisted by the Arctic Petroleum Operators' Association. Abstracts in English, French and German.

References.

F,G G16

CaACU

... Invited papers ... were chosen to provide a review of the present state of the art in various branches of applied glaciology. ... Abstracts are also included for those contributed papers accepted for the meeting which, because of the absence of their authors, were not presented or discussed. An edited version of the discussions which took place is also included. ... The papers were presented at the Symposium in Sessions each of which was devoted to a main topic, ... thus snow engineering was the subject of Sessions A and F, ice engineering Sessions B and E, avalanches Sessions C and H. ... (Au)

G - ICE (except GLACIER ICE (use F) and GROUND ICE (use C))

G-3530

Sea ice topography in the Beaufort Sea and its effect on oil containment / by Peter Wadhams.

(ADJEX bulletin, no. 33, Sept. 1976, p. 1-52, ill., tables, charts)

(Technical report - Canada. Beaufort Sea Project, no. 36)

(APOA project no. 72 : Beaufort Sea

Environmental Program. Report, no. 36)

Originally appeared as Beaufort Sea Project

Technical Report No. 36, with the title "Sea

Ice Morphology in the Beaufort Sea."

Bibliography: p.49-52.

G G07

CaACU

The topography of the Beaufort Sea ice cover has been examined from airborne laser profiles obtained in September and October 1974 by the Atmospheric Environment Service, Environment Canada, and in April 1975 by the Canadian Maritime Command, Department of National Defence. Mean ridge heights and spacings were deduced for the elements of a grid covering much of the Beaufort Sea. ... On the basis of these and other studies of the Beaufort Sea Project, a discussion is given of the extent to which sea ice deformation features may govern the long-term spread of oil under ice. (Au)

G-11649

Movement and deformation of the landfast ice of the southern Beaufort Sea / [by] P.F. Cooper, Jr.

Victoria, B.C. : Beaufort Sea Project, Dept. of the Environment, 1975.

16p. : maps, tables ; 28cm.

(Technical report - Canada. Beaufort Sea Project, no. 37)

(APOA project no. 72 : Beaufort Sea

Environmental Program. Report, no. 37)

References.

G G07

CaACU

It is premature to assign definite mechanisms to explain the measured landfast ice movements Two points, however are clear: (1) Points on landfast ice around the mouth of Kugmallit Bay can move by distances of up to several tens of metres in the course of a winter. (2)

Smaller-scale measurements southeast of Herschel Island show deformations of the ice cover there of comparable magnitude (up to a few parts in 10,000), on scales of both 30 m and a few km. These indicate that whatever process is at work around Kugmallit Bay is of more general occurrence and that movement of the ice cover can be expected anywhere in the landfast ice between Herschel Island and Cape Bathurst. (Au)

G-15482
Ice climatology in the Beaufort Sea / [by] W.E. Markham.
Victoria, B.C. : Beaufort Sea Project, 1975.
87p. : ill., figures, tables ; 28cm.
(Technical report - Canada. Beaufort Sea Project, no. 26)
(APOA project no. 72 : Beaufort Sea Environmental Program. Report, no. 26)
References.
G G07
CaACU

This report consists of four separate studies concerned mainly with ice climatology in the southern Beaufort Sea. The first ... describes the variation of ice concentration with the time of year for six regions with different ice regimes. The second describes the motion of individual ice floes relative to the wind. The third describes a reasonably accurate method for predicting the gross features of the northward retreat of the polar pack ice in the Beaufort Sea and the fourth is an examination of the size of ice floes within various ice concentration ranges near the edge of the polar pack. (Au)

G-15539
Satellite observations of the Beaufort Sea ice cover / [by] J.R. Marko.
Victoria, B.C. : Beaufort Sea Project, 1975.
viii, 137p. : ill., figures, table ; 28cm.
(Technical report - Canada. Beaufort Sea Project, no. 34)
(APOA project no. 72 : Beaufort Sea Environmental Program. Report, no. 34)
References.
G G07
CaACU

Using the NOAA and ERTS series of satellites, observations of the Beaufort Sea and encompassing Canada Basin ice cover have been carried out for the March through October periods of the years 1973-5. The seasonal trends in motion and appearance over each of these years were detailed for the defined landfast-ice, transition and gyral pack zones. The positionings of the summer ice pack boundaries, the leads at the edge of the landfast-ice and other surface features were determined. ... (Au)

G-19283
The Beaufort Sea ice sampling project - 1970 / by K.R. Croasdale.
[Calgary : Distributed by APOA, 1970].
3 microfiches ; 11x16cm.
(APOA project no. 2 : Beaufort Sea - ice movement and current survey - 1970. Report, no. 1)
Appendices.
References.
G G08121
CaACU

Summary of Results - The ice at fifteen sites across the Mackenzie Delta area of the Beaufort Sea has been sampled during the period March 22 to April 19, 1970. Those properties affecting ice strength were sampled; in particular: thickness, snow cover, salinity, temperature, small scale strength and crystal structure. The

average of ice thickness measurements during the fourth week of March was 61 inches; the average snow cover about 4 inches. Ice salinities varied in the range 0 to 11.3 o/ooo (parts per thousand). Water salinities were in the range 0.2 to 28.5 o/ooo. The fresh water from the Mackenzie River has a considerable influence on salinity distributions. In most of Mackenzie Bay the ice can be considered fresh. Small scale strength values are typical for sea ice of low salinity and indicate a tensile strength of 100 psi at the most. The crystal structure examinations show typical columnar ice with a horizontal c-axis. (Au)

G-19291
The "Nutcracker" ice strength tests, 1969-70 / by K.R. Croasdale.
[Calgary : Distributed by APOA, 1970].
5 microfiches, ill. ; 11x16cm.
(APOA project no. 1 : Nutcracker ice strength tests, 1969-70. Report, no. 1)
Appendices.
References.
G G08121
CaACU

During field tests using the nutcracker ice testers we have measured ice crushing strengths in the range 600 to 900 psi. Approximate deflections at failure (peak stress) were in the range 0.6 to 2.3 inches. The tests were conducted in Tuktoyaktuk harbour where the ice was brackish with salinities up to about 3 grams/kg (i.e. parts per thousand). The results did not appear to be very sensitive to variations in loading rate in the range 200 to 1,500 psi/minute. Doubling the leg diameter did not significantly reduce the nominal ice failing stress. (Au)

G-19305
Ice and current measurements program, Beaufort Sea, Spring 1970 / submitted by Oceanographic Services, Inc.
[Calgary : Distributed by APOA, 1970].
1 microfiche ; 11x16cm.
(APOA project no. 2 : Beaufort Sea - ice movement and current survey - 1970. Report, no. 2)
Prepared for Imperial Oil Ltd.
G G07
CaACU

Under contract to Imperial Oil Limited (IOL), Oceanographic Services, Inc. (OSI) installed self-contained ocean current and ice movement sensors at several Beaufort Sea locations designated by IOL. These instruments recorded current velocity and ice movement data for approximately two months. Measurements of ice thickness and water depth were made at each location at times of installation and recovery of the instruments. The instruments were installed during the period February 23 to April 7, 1970, and recovered during the period April 30 to June 1, 1970. This report presents the data obtained during the survey and describes certain techniques used and problems encountered. (Au)

G-21237
Logistics operations : APOA Beaufort Sea projects 1970 / by J.G. Smith.
[Calgary : Distributed by APOA, 1970].
2 microfiches : ill. ; 11x16cm.
(APOA project no. 2 : Beaufort Sea - ice movement and current survey - 1970. Report, no. 3)
(APOA project no. 3 : Ocean floor sampling Beaufort Sea 1970. Report, no. 2)
Appendices.
G.D G07
CaACU

951

Imperial Oil Limited, operating on behalf of the Arctic Petroleum Operators Association (APOA), conducted a program in the Arctic in early 1970 to gather offshore environmental data. A sea-ice survey was undertaken to investigate movement of the ice, determine its composition and structure, and record ocean currents below it. An ocean-floor sampling study was conducted concurrently to determine the nature and characteristics of the sea-bottom sediments. The overall purpose of the program was to provide basic engineering design data for future offshore drilling and production operations. ... A helicopter-transportable seismic rig (HELI-DRILL) was contracted to drill and gather soil samples from the ocean-floor sediments. The ocean-floor sampling program was directed by a soil-mechanics consultant. Three helicopters were used to support the combined operations. Two small Bell 206 helicopters were used for surveying and sea-ice testing, while a larger Bell 205 helicopter was used to transport and supply the ocean-floor sampling group. ... (Au)

G-21296

The nutcracker ice strength tests, 1970-71 / by K.R. Croasdale.
[Calgary : Distributed by APOA, 1971].
3 microfiches : ill., figures ; 11x16cm.
(APOA project no. 9 : Nutcracker ice strength tests, 1970-71. Report)
Appendices.
References.
G G08121
CaACU

During the Arctic field tests ice strengths were measured in the range 595 to 1050 psi. These values confirm last years results. Taken in total the Arctic tests do indicate a size effect, however as only two sizes of pier were tested no working relationship can be derived. The modes of failure seemed more brittle than last year probably because the ice was even fresher; a typical salinity being about 0.1 gm/kg (parts per thousand). Twenty-seven tests were conducted on lake ice with a portable ice strength tester, ice strengths in the range 360 to 720 psi were obtained. The tests gave a very consistent mode of failure similar to that suggested by Morgenstern in his theoretical analysis. Almost two decades of strain rate were covered during the tests (10⁻⁴ to 10⁻² sec⁻¹). However maximum ice pressure (ice strength) showed very little sensitivity to strain rate, except for a slight reduction at the higher strain rates. ... (Au)

G-24457

Engineering memorandum : Beaufort Sea summer ice study / by K.G. Nolte [and] R.R.G. Scott, Amoco Canada Petroleum Company Ltd.
[Calgary : Distributed by APOA, 1971].
1 microfiche : ill., figures, tables ; 11x16cm.
(APOA project no. 14 : Beaufort Sea summer ice study. Report)
Appendices.
G G07
CaACU

The study of ice conditions in the Beaufort Sea was accomplished by testing ice floes from a boat and conducting two reconnaissance flights. An unusual heavy concentration of old pack ice was observed in the Mackenzie Bay, a condition which was caused by a severe storm on September 14, 1970. This enabled the testing of floes relatively close to shore, along the boat route from Tuktoyaktuk to Herschel Island All of the floes tested with the exception of Test Floe #1 were smooth ridged, low in salinity, in temperature equilibrium with the surrounding water, and composed of multi-year ice. The average compressive strength of the

floe ice tested was above 300 psi, and the average Brazil tensile strength was 66 psi. All of the floes tested were greater than 13 ft. in thickness. The freeze-up process from the frazil to the nilas stage was observed and because of the relatively fast freeze-up process, additional testing was not possible.
(Au)

G-24465

Model experiments to determine the forces exerted on structures by moving ice fields : final report / by R.Y. Edwards, Jr. [and] J.R. Lewis, ARCTEC, Incorporated.
[Calgary : Distributed by APOA], 1972.
2 microfiches : figures ; 11x16cm.
(APOA project no. 25 : Model tests to simulate the action of ice on fixed structures. Report)
(Progress report - Arctec, Inc., no. 00571- 5) Appendices.
References.
G G16
CaACU

... The three major areas of investigation were (1) interaction of a conical shaped structure with a field of uniformly thick ice; (2) the interaction of a cylindrical shaped structure and uniformly thick ice; (3) the interaction of a conical shaped structure with an ice field containing multi-year type pressure ridges. During each test, load levels on the models were measured and recorded. Wherever possible the experiments were preceded by the development of mathematical models of the expected interactions. (Au)

G-24473

Investigation of sea-bed scouring in the Beaufort Sea (Phase II) / [by] Hunting Geology and Geophysics Limited.
[Calgary : Distributed by APOA], 1973.
1 microfiche : figures, tables ; 11x16cm.
(APOA project no. 32 : Beaufort Sea scour records - Phase II. Report)
References.
G G07
CaACU

Purpose: To study all aspects of sea bottom scouring in selected areas of the Beaufort Sea. A mosaic of a control area surveyed by the Canadian Government in 1971 was constructed from Side Scan Sonar Records. An attempt was made to resurvey this area in 1972 using Side Scan and Echo Sounders and one additional area was similarly surveyed. Mosaics of these areas were constructed. During future projects they will be analyzed to determine the number of new scours added. All data recorded after 1970 was incorporated into a revised analysis to replace that done during APOA Project 19. (Au)

G-24511

Destruction of ice islands by explosives / [by] Malcolm Mellor and Austin Kovacs.
[Calgary : Distributed by APOA], 1972.
1 microfiche : ill., figures ; 11x16cm.
(APOA project no. 36 : Ice islands destruction - Beaufort Sea. Report)
References.
G G08121
CaACU

Purpose: To determine the feasibility of destroying or reducing the size of an ice island threatening a future offshore structure. Three grounded ice islands burg bits in Mackenzie Bay were subjected to explosives set in varying quantities, depths, and patterns. Methods of rapidly drilling and placing explosives were employed. Tests for optimum bench width were conducted. (Au)

G-24538

Results of model ice sheet properties research / by Roderick Y. Edwards, Jr. [and] Thomas V. Kotras, ARCTEC, Inc. [Calgary : Distributed by APOA], 1972. 3 microfiches : figures, tables ; 11x16cm. (APOA project no. 40 : Evaluation of mechanical properties of saline model ice. Report, no. 1,2) Contents: no. 1 Final report. - no. 2 Addendum. References. G G16 CaACU

This report describes the results of experiments to demonstrate that the mechanical properties of model ice sheets formed in the ARCTEC Ice Model Basin may be controlled within the range required for proper modeling of ice sheet-offshore structure interactions. The salinity, temperature, and thickness of model ice sheets were varied widely. The mechanical properties (flexural strength, elastic modulus, and shear strength) were measured in these sheets. The results of the analysis of this data indicate that the ratio of elastic modulus to flexural strength may be maintained at a level in excess of 1000 for flexural strengths as low as 0.1 kg/sq. cm. This implies that modeling ice sheet structure interactions at scales as low as 1/70th is feasible. (Au)

G-25488

The interpretation of ice strength from in-situ indentation tests / by N.R. Morgenstern and J.B. Nuttall. [Calgary : Distributed by APOA], 1971. 1 microfiche : figures, tables ; 11x16cm. (APOA project no. 16 : Theoretical analysis of ice failure. Report, no. 1) References. G G08121 CaACU

... Imperial Oil Ltd. and APOA have requested the writers to conduct a study on Arctic ice along the following lines ... 1. A theoretical analysis of both data from ice pressures on bridge piers and from "Nutcracker" tests, with the aim of investigating the relationship between known mechanical properties of ice and the behaviour observed in these small prototype studies, and 2. if found warranted as the theoretical analysis progresses, a special review of existing experimental data on the strength of ice in the context of the problem, with a view to making recommendations for testing in order to obtain appropriate data if it does not exist. ... This report presents the results of the theoretical study of the "Nutcracker" test and related test configurations. ... The report ends with conclusions regarding the use and limitations of the results presented here together with recommendations for more field and laboratory testing which will explore further the applicability of these results. (Au)

G-25496

Compression tests on fresh water ice / by J.B. Nuttall and N.R. Morgenstern. [Calgary : Distributed by APOA], 1972. 1 microfiche : figures, tables ; 11x16cm. (APOA project no. 16 : Theoretical analysis of ice failure. Report, no. 2) References. G G16 CaACU

Unconfined compression tests and plane strain tests with lateral restraint were carried out on fresh water ice. In all cases the load was applied in the plane of the natural ice sheet. Unconfined test specimens were 4" x 4" x 8" and plane strain specimens 2 1/2" x 6" x 12". At -1.5 deg. C the peak unconfined compressive

strength was found to be about 400 p.s.i. at a strain rate of .0002; at -10 deg. C, 1100 p.s.i. at a rate of .00002. Plane strain tests showed a peak strength of about 1700 p.s.i. at -1.5 deg. C and a strain rate between .0001 and .001. At -10 deg. C the peak strength in plane strain was in excess of 2,400 p.s.i. (Au)

G-25500

Sea ice pressure ridges and ice islands / by Austin Kovacs and Malcolm Mellor, CREARE, Inc. [Calgary : Distributed by APOA], 1971. 3 microfiches : ill., figures, tables ; 11x16cm. (APOA project no. 17 : Beaufort Sea pressure ridge and ice island scouring. Report, no. 1) (Technical note - CREARE, Inc., no. 122) Appendices. References. G G08121 CaACU

The environmental conditions of ice-covered polar seas are described, with special emphasis on the pressure ridges and ice islands encountered in Mackenzie Bay and the Beaufort Sea. Techniques for determining the geometric configurations and the physical and mechanical properties of sea ice structures and ice islands are described. Profiles of pressure ridges were determined by surface surveys, drill hole probes, and side-looking sonar scanning; results are given for several multi-year ridges and one first-year ridge. Supplementary information obtained from dives under the ice is also given. Corresponding data are given for ice islands, with particular attention being given to contact between the ice and the sea bed. Measurements of temperature, salinity, tensile strength and compressive strength are given for ice taken from old pressure ridges, and factors influencing the interpretation of test data are discussed. The main report closes with a brief discussion of some of the findings. The appendices give complete diving reports, and a full report on the performance of the S&N6 Hovercraft. (Au)

G-25518

Sea ice tests / [by J.B. Nuttall]. [Calgary : Distributed by APOA, 1971]. 1 microfiche : ill., figures, tables ; 11x16cm. (APOA project no. 17 : Beaufort Sea pressure ridge and ice island scouring. Report, no. 2) G G08121 CaACU

This report presents the results of tests on Sipre core samples of ice received from Gulf Oil Canada Ltd. on May 6, 1971 and tested in the laboratory of the Civil Engineering Department, University of Alberta. ... Thin sections were made from each of the samples and photographs of these are included here. The small half cylinders were tested for salinity, and crystal orientation was measured for five of the six samples. No strength tests were carried out on these samples. Crystal orientation was found for all six of the short cylindrical samples; all were tested for compressive strength and salinity. The long cylindrical samples were tested for compressive strength, generally two tests from each specimen, and all were tested for salinity. Crystal orientation was measured for 11 of the 15 samples. All samples were stored and tested at -10 deg. C. (Au)

G-25526

Microfaleontologic - mineralogic analysis of recent and samples from ice-scoured surface of Beaufort Shelf / by M.M. Lerand. [Calgary : Distributed by APOA], 1971. 1 microfiche : figure, table ; 11x16cm.

95%

(APOA project no. 17 : Beaufort Sea pressure ridge and ice island scouring. Report, no. 3)
G,B G07
CaACU

Five samples of unconsolidated mud from the Beaufort Sea shelf were analyzed for microfaunal content and clay mineralogy in hopes of discovering some criteria by which the age of ice-scoured trenches could be dated. One sample was recovered from the sediment-water interface in the bottom of a trench, and four samples came from a shallow (48 cm) core adjacent to the trench. ... Although there is some slight similarity of the trench sample (#55) to the two samples from the upper part of the sediment column (0-12, 12-24 cm) adjacent to the trench, the five samples do not represent a statistically valid sample and definite conclusions based on this data are not justified. The samples are all so similar that they may all be assumed to have been taken from a single population of Recent age. The clay mineralogy analysis suggests a similar relationship to that hinted by the micropaleontology. ... (Au)

G-25534
Report on Phase I of Pressure Ridge and Ice Island Study : Evaluation of hovercraft and ice reconnaissance / [by] J. Hnatuk.
[Calgary : Distributed by APOA], 1971.
1 microfiche : figures, map : 11x16cm.
(APOA project no. 17 : Beaufort Sea pressure ridge and ice island scouring. Report, no. 4)
G,L G07
CaACU

The SRN-6 Hovercraft cannot negotiate jagged pressure ridges in excess of four or five feet in subzero temperatures without damage to the existing skirt. The SRN-6 can be used to quickly reach offshore areas where ice is relatively smooth and should provide a suitable means from which to conduct investigations on multi-year ice and ice islands. The vehicle should be equipped with Decca navigation, lights, bunks, and cooking facilities before being used. A means of controlling cabin heat should be provided. The cost will be \$300.00 per hour plus fuel, accommodation, food, and travel. The minimum is three hours per day, averaged over the period. It is recommended that the SRN-6 Hovercraft be used from which to conduct studies of multi-year and single year pressure ridges and ice islands. A route from Inuvik to Mackenzie Bay, around the ice islands northwest of Pullen Island and to Tuktoyaktuk should be followed. Return trips to Inuvik and Tuk as necessary for rest, proper meals, and supplies would be necessary. A fuel cache near Shingle Point or at the mouth of the Middle Channel would be required. A Cessna 180 out of Tuk or Inuvik could be used at 70 cents per mile for reconnaissance and directing the Hovercraft to a specific floe. In the event of failure of the Hovercraft, a 204 Helicopter is available in Inuvik which could be used to rescue personnel or complete the project. (Au)

G-25542
Investigation of sea-bed scouring in the Beaufort Sea / Hunting Geology and Geophysics Ltd.
[Calgary : Distributed by APOA], 1971.
1 microfiche : tables : 11x16cm.
(APOA project no. 19 : Analysis of sea bottom iceberg scouring records. Report)
Appendices.
References.
G G07
CaACU

Side-scan sonar, echo-sounder and seismic profiler records from the Beaufort Sea show conclusive evidence of scouring on the sea-bed. This is generally believed to be due to the

passage of ice-masses. Every third nautical mile of selected records has been analysed by visual and statistical means to determine the origin and rate of scouring. A number of spatial relationships have been established which have a bearing on these problems. These relationships include scour frequency, depth and azimuth. Recommendations are made for further sonar, echo-sounder, sampling, oceanographic, meteorological and radiocarbon work. (Au)

G-25585
Landfast ice movement - Mackenzie Delta 1972 / by K.R. Croasdale [and] L.G. Spedding.
[Calgary : Distributed by APOA], 1972.
3 microfiches : ill., figures, tables : 11x16cm.
(APOA project no. 33 : Land fast ice movement - Beaufort Sea 1971-72. Report)
Appendices.
G G08121
CaACU

The report describes the measurement of the movement of ten sites located on the landfast ice north of Richards Island in the Mackenzie Delta. The work was conducted during the period January to May 1972. The measurements were made with a spring tensioned reel/wire system connecting the ice with the sea bed. At five locations a telemetry system allowed readings to be taken remotely from a master control in Inuvik 80 miles away. Wind and temperature information was also collected. (Au)

G-25593
Discussion of "A review of APOA project 40 report" / by R.Y. Edwards, Jr., ARCTEC, Incorporated.
[Calgary : Distributed by APOA], 1972.
1 microfiche : tables : 11x16cm.
(APOA project no. 40 : Evaluation of mechanical properties of saline model ice. Report, no. 3)
References.
G G16
CaACU

The purpose of this discussion is to reinforce some of ACRE's suggestions about ice modeling and to clarify certain areas in which ACRE's have, we believe, reached incorrect conclusions. The single most important criticism which ACRE's levels at ARCTEC's ice modeling technique is that important model mechanical properties (flexural strength is used as an example in their report) have large scatter and consequently make quantitative use of model force data invalid. We have consequently placed the most emphasis on discussing that area and have treated it first. Second in our discussion is the subject of distortion due to failure to comply with all similitude requirements. Third, we discuss briefly, elements of modeling not dealt with in the report. Here we do not disagree with the importance of some of these elements but must point out that constraints on available resources simply did not permit rigorous examination of load rate on mechanical properties; other elements were not within the scope of the proposed work. ... (Au)

G-25607
The use of model ice to simulate ice action on offshore structures / [by] B. Michel.
[Calgary : Distributed by APOA], 1972.
2 microfiches : figures, tables : 11x16cm.
(APOA project no. 41 : Evaluation of the mechanical properties of Michel's model ice and preliminary ice-structure interaction experiment. Report)
Contents: Pt. 1 Properties of model ice. - Pt. 2 Model ice action on structures.
References.

G G16
CaACU

The most powerful tool to help solve problems of designing marine structures in ice infested waters is that of ice modeling and this report deals with the ability of an artificial material, called here model ice, to simulate real ice acting on these structures. ... It is essentially divided into two parts. In the first part a systematic study of the physical properties of interest of model ice was made, essentially by varying the proportion of the various chemicals making the material, and these properties were related to the corresponding properties of real ice. In the second part, a small exploratory model was built of five types of idealized offshore structures. A model ice sheet was formed in a basin and pushed against these structures to measure the forces and observe the movements of broken ice pieces around them. ... (Au)

G-25658
Landfast ice movement - Mackenzie Delta 1972-73 / by I.G. Spedding.
[Calgary : Distributed by APOA, 1973].
6 microfiches : ill., figures, maps, tables ; 11x16cm.
(APOA project no. 51 : Ice movement in Beaufort Sea 1972-73. Report)
Appendices.
G G08121
CaACU

This report describes the measurement of the movement of fourteen sites located on the landfast ice between Shingle Point in the Mackenzie Bay and Atkinson Point on the Tuktoyaktuk Peninsula. An additional site just outside the landfast ice was also monitored for a short period. This work was conducted during the period of November, 1972 to May, 1973. The measurements were made with a spring tensioned reel/wire system connecting the ice with the sea bed. At 12 locations a telemetry system allowed readings to be taken hourly from a master control in Inuvik, 100 miles away. At the remaining three stations recorders collected the data. Wind and temperature information was also collected. (Au)

G-25666
Small scale, in-situ ice strength tests, March 1973 / FENCO.
[Calgary : Distributed by APOA, 1973].
1 microfiche : ill., figures, tables ; 11x16cm.
(APOA project no. 52 : Crushing strength of ice. Report, no. 1)
Appendices.
Submitted to Imperial Oil Limited.
G G082
CaACU

... the following insitu tests were performed:
- surface jacking tests which caused flaking of the upper portion of a vertical face of ice;
- template jacking tests on a vertical face within the body of the ice layer. Plate jacking tests on vertical faces of the ice were carried out near the surface to cause flaking of the ice surface. These tests are known to give a direct reading of insitu unconfined compressive strength which was on the average 59.5 bars (862 psi) and had a median of 58.4 bars (830 psi). Maximum contact pressures were obtained by jacking a circular template against a vertical face of the ice at a depth sufficient to ensure that local failure of the ice occurred. These tests gave values which have a median value higher than 140 bars (2030 psi) for a short term loading, and which may be estimated at 160 bars (2275 psi). These were carried out on ice for which the median of flaking tests yields 55.6 bars (790 psi). (Au)

G-25674
Ice forces on offshore monopods and piles, September 1973 / FENCO.
[Calgary : Distributed by APOA, 1973].
1 microfiche ; 11x16cm.
(APOA project no. 52 : Crushing strength of ice. Report, no. 2)
Appendix.
G G082
CaACU

This report covers analyses of factors governing ice thrust on vertical faces of structures in contact with ice, both with straight and curved plan sections. The results are related to tests in the field in which insitu properties of ice are measured which have a direct bearing on the magnitude of ice thrust. Field tests which give results applicable for the presented discussion have included two basic types of direct tests with added index tests. A flaking template test gives a measure of unconfined compression and also a direct value for ice pressure on the top and bottom portions of the contact area. These parts break vertically from the ice sheet from the ice thrust. For the top portion of the ice sheet, a flaking test will give a direct reading with minor corrections. For the bottom portion, the value from the flaking test on top of the ice sheet would be modified on the basis of index tests where the relative strength of ice in expanding cavities is recorded. There will be other portions of ice which are pushed out sideways. A measure for the strength in areas thus affected is obtained by template tests on vertical faces of ice. ... (Au)

G-25682
Ice crushing tests 1973 / by T.P. Taylor [Imperial Oil Ltd.].
[Calgary : Distributed by APOA, 1973].
3 microfiches : ill., figures, tables ; 11x16cm.
(APOA project no. 52 : Crushing strength of ice. Report, no. 3)
Appendices.
References.
G G082
CaACU

The attached report describes an experimental programme to determine the crushing strength of ice A total of 38 field tests were conducted on two types of ice, the natural ice sheet of the lake which had predominantly a vertical c-axis and ice grown in test ponds which had a horizontal c-axis. The results of the field tests clearly show that the crushing strength of ice is affected by the size ratio, and that the horizontal c-axis is significantly stronger than the vertical c-axis ice. The results of the laboratory tests are briefly summarized in this report. ... (Au)

G-25690
Compression tests on fresh water ice, 1973 / by J.B. Nuttall, M.R. Morgenstern and W.D. Ruggensack.
[Calgary : Distributed by APOA, 1973].
1 microfiche : ill., figures, tables ; 11x16cm.
(APOA project no. 52 : Crushing strength of ice. Report, no. 4)
References.
G G082
CaACU

This report contains the results of laboratory tests on fresh water ice taken from the Eagle Lake test site used by Imperial Oil Ltd. for large scale indenter tests during the winter of 1972-73. Unconfined compression and plane strain tests were carried out at strain rates of .0001 to .0005 per sec., the most rapid possible with available equipment. Test

9.7%

temperatures ranged from -1.5 to -17 deg. C. Unconfined compression specimens were 4x4x8 inches and plane strain specimens 2 1/2x6x12 inches. ... A limited number of direct shear tests were carried out on 8x8x12 inch specimens at strain rates about 1/10 that used for the compression tests. Test pond ice gave a friction angle of 25° with the shearing plane normal to the ice sheet. (Au)

G-25704

Ice island count, South Beaufort Sea, 1972 / by R. Barton, K.R. Croasdale, J. Mnatiuk [and] J.G. Smith.

[Calgary : Distributed by APOA], 1972.

2 microfiches : ill., figures ; 11x16cm.

(APOA project no. 53 : Count of ice islands - Beaufort Sea 1972. Report)

G G07

CaACU

Better knowledge about the size and distribution of ice islands from year to year is needed to help in decisions concerning methods of exploitation and development in the offshore province. The work covered in this report is a start in the process of collecting yearly counts of ice islands along the coast of the South Beaufort Sea. In May 1972, an aerial reconnaissance flight was made along the shear zone between Cape Bathurst and Cape Halkett. The object of the flight was to record the number and size distribution of the ice islands grounded or trapped in the fast ice of the South Beaufort Sea. A total of 477 aerial photos were taken, these have subsequently been scrutinized. The report presents ice island frequency versus water depth and size for individual legs of the flight. (Au)

G-25712

The extent and growth patterns of landfast ice in the southern Beaufort Sea - Winter 1972-73 / by I.G. Spedding.

[Calgary : Distributed by APOA], 1974.

3 microfiches : ill., figures ; 11x16cm.

(APOA project no. 54 : Ice geology of the southern Beaufort Sea. Report, no. 1)

References.

G G07

CaACU

The growth and extent of the landfast ice in the Beaufort Sea seem to follow a similar pattern each year. To record the progression of the ice out from shore and to record the position and quantity of relevant ice topographical features, seven photographic reconnaissance flights were undertaken. These covered the landfast ice between Herschel Island and Atkinson Point during the period January 27 to June 10, 1973. Imperial Oil's camera-equipped Twin Otter aircraft was used. Preliminary analysis of the photographs to classify the ice surface features into zones has been undertaken and presented in this report. Included also is the profiling of some surface features photographed on one flight. Satellite photographs, visual reconnaissance flight reports, and ground observations from other field work have been used as an aid to interpretation and to give a more comprehensive coverage of the ice conditions through the winter. (Au)

G-25720

Ice island count, southern Beaufort Sea - 1973 / by I.G. Spedding.

[Calgary : Distributed by APOA], 1974.

1 microfiche : ill., figures ; 11x16cm.

(APOA project no. 54 : Ice geology of the southern Beaufort Sea. Report, no. 2)

Appendices.

G G07

CaACU

On May 27th and May 30th 1973 aerial reconnaissance flights were made along the shear zone to cover the area between Point Barrow and Cape Bathurst. This is a follow up of a similar flight flown on May 23rd 1972 to record the size and distribution of ice islands grounded or trapped in the fast ice of the Southern Beaufort Sea. Subsequent analysis of the photographs indicated the presence of 299 ice islands and fragments including sixteen small fragments visually sighted and not recorded on photographs. The ice islands observed this year seem to be the result of the break-up of larger islands grounded in the winter of 1971 - 1972. (Au)

G-25739

Statistical analysis of ice pressure ridge distribution in the southern Beaufort Sea / by R.W. Gladwell.

[Calgary : Distributed by APOA], 1976.

1 microfiche : figures, tables ; 11x16cm.

(APOA project no. 54 : Ice geology of the southern Beaufort Sea. Report, no. 3)

References.

G G07

CaACU

An analytical function for describing the statistical height distribution of ice pressure ridges in the Arctic Ocean is tested and found acceptable for describing ridge distribution in the shallow water of the Southern Beaufort Sea. By comparing the fits of predicted and measured height distributions, the best ratio of keel depth to sail height of ridges in the Southern Beaufort Sea is found to be 3.8. Based on that ratio, less than one percent of pressure ridges in the area northwest of Atkinson Point are grounded. Approximately four percent of those north of Richards Island are grounded. (Au)

G-25755

Mathematical model to describe the behavior of a moving ice field encountering a conical structure. Vol. 1. Revised report / by J. Kwangse Kim [and] Thomas V. Kotras, Arctic Canada Limited.

[Calgary : Distributed by APOA], 1973.

2 microfiches : figures, tables ; 11x16cm.

(APOA project no. 57 : Adfreeze study. Report, no. 1, v. 1)

References.

G G16

CaACU

This report contains the development of two mathematical models describing the behavior of a uniform and ridged ice sheet respectively encountering a conical structure. The purpose is to provide an analytical comparison between - behavior experienced when the structure is "relatively smooth", and - behavior experienced when the structure has ice slabs adfrozen on its surface. The models treat both the structural failure of the ice and its subsequent motion around the structure. In addition to presenting the math models, the results of a physical model test program are presented in the Appendices. These tests were conducted to aid in the development of the math model and also to provide a means of validating the model. (Au)

G-25763

Mathematical model to describe the behavior of a moving ice field encountering a conical structure. Vol. 2. Model tests to assess adfreeze effects / by R.Y. Edwards Jr., P. Turcot, W. Wallace [and] A. Poirer, Arctic Canada Limited.

[Calgary : Distributed by APOA, 1973].

2 microfiches : ill., figures, tables ;

11x16cm.

(APOA project no. 57 : Adfreeze study. Report, no. 1, v. 2)
G G16
CaACU

Volume II of the report ... contains three appendices which describe the results of model tests in artificial ice. Their purpose was to assess the effect of adhesion of ice pieces to the surface of a conical structure upon the modes of failure of the ice cover as it impinges on the cone. An additional purpose was to assess the potential increase in magnitude of forces experienced by the structure due to the ice adhesion phenomenon. The tests were overall successful and despite certain incorrect scale factors provided excellent guidance for the engineers preparing the mathematical model. The results indicate that if an adhesion bond becomes established over the entire frontal area of a conical structure the forces which the cone will experience may increase to six times the level which we would estimate for the structure if adfreeze effects were ignored. (Au)

G-25771

Ice adhesion study : final report / Acres Consulting Services Limited.
[Calgary : Distributed by APOA], 1973.
2 microfiches : ill., figures, tables ; 11x16cm.
(APOA project no. 57 : Adfreeze study. Report, no. 2)
Appendices.
References.
G G16
CaACU

A mathematical investigation on the ice loading on a bottom founded conical structure operating as a drilling platform in 30 to 60 feet of water in the South Beaufort Sea is described. Following the selection of the properties of ice sheets and ridges likely to be encountered in the area of interest, mathematical simulators for the prediction of the forces exerted by these formations on the cone were developed. The simulators incorporate the effects of ice adhesion, friction, and failure and post-failure behaviour of the ice sheet or ridge. Analytical methods based on statics and beam and plate theory were used to determine the sensitivity of the loads to different system parameters including water depth and cone angle. Subsequently, more refined calculations were made using a finite element computer program to model the failure and post-failure behaviour of sheets and ridges acting together. When operating in 30 feet of water loads due to the adhesion of the ice sheet govern. In 60 feet the loadings imposed by healed ridges govern. (Au)

G-25780

Beaufort Sea summer ice testing project / Fenco.
[Calgary : Distributed by APOA], 1973.
12 microfiches : ill., figures, tables ; 11x16cm.
(APOA project no. 60 : Beaufort Sea summer ice testing project. Report)
References.
G G07
CaACU

To study the summer ice properties and the physical parameters of the ice such as surface area, shape, thickness, specific gravity, salinity, temperature and drift velocity of the ice floes. One set of measurements was carried out closely after breakup by July 15 to July 22 and a second set in the open water season from September 18 to September 21. Triangular plate tests, circular plate tests and bore hole jack tests were the insitu tests used to obtain strength parameters. (Au)

G-26476
Island defense system tests / by P.N. Trofimenkoff.

[Calgary : Distributed by APOA], 1976.
2 microfiches : ill., figures, tables ; 11x16cm.
(APOA project no. 111 : Evaluation of ice defence systems for artificial islands. Report)
Appendices.
References.
G G08121
CaACU

A total of 11 tests were conducted. Of these, 5 tests were performed to study the dredged island defense system slots, 2 to study the failure of a wide thermal crack and 4 to study the buckling of ice. The 4 buckling tests were performed on Eagle Lake and the remainder on the Hay River. The analyses of the tests indicate the following: (1) The initial failures of the dredged island defense slots were found to generally depend upon the thickness of the thinnest connecting ice at the slots. The initial failure was generally a bending failure at an average pressure of less than 100 psi. Secondary failure pressures appeared to be rather independent of the slot configurations and did not exceed an ice pressure of 50 psi. (2) The simulated thermal crack failed at approximately 1/3 the load required to fail an integral sheet, although the thickness of the connecting ice at the crack was 1/2 the natural ice thickness. The mode of failure was a bending failure in the connecting ice at the slot. (3) Reasonable agreement was found between elastic buckling theory and experiment for the 4 buckling tests that were performed. The experimental results were found to be very sensitive to the column and boundary conditions, as can be expected from theory. An insufficient number of tests were performed to draw any conclusions regarding the possible dependence of the buckling strength of ice on strain rate and aspect ratio. (Au)

G-26492

Davis Strait ice and oceanographic investigations winter 1976-77 / by Fenco Consultants, Ltd.
[Calgary : Distributed by APOA, 1977].
9 microfiches : ill., figures, tables ; 11x16cm.
(APOA project no. 128 : Davis Strait ice and oceanographic investigations winter 1976-77. Report)
Submitted to Imperial Oil Limited.
Appendices.
G, D G09
CaACU

We submit herewith our final report on the factual results of the ice and oceanographic investigations carried out in the Davis Strait and Cumberland area on the Canadian east coast, during Phase I November - December 1976, and Phase II February 1977. We conducted the following tests and observations: Phase I - 1. Sea ice characteristics, 2. Surface current measurements and ice motion studies, 3. Salinity, temperature and density profiling of the surface waters, 4. Meteorological observations. Phase II - 1. Sea ice characteristics, 2. Ocean current measurements and ice motion studies, 3. Meteorological observations. ... (Au)

G-26557

Report on ice and meteorological observations in the Davis Strait during April, May and June 1977 / MacLaren Atlantic Limited.
[Calgary : Distributed by APOA], 1977.
3 microfiches : ill., figures, maps, tables ; 11x16cm.

(APOA project no. 138 : Environmental investigations and analysis in Davis Strait - second half 1977. Report, no. 13)
Prepared for Imperial Oil Limited.
Appendices.
References.
G, E G09
CaACU

The aims for the ice work were given as carrying out ice observations whenever the ship entered ice during the voyage. Observations were to include: Ice - coverage (in tenths); floe sizes; snow cover; description of raised edges; ridging and rafting; type - multi-year, first year, etc.; slush between floes; specific sightings of multi-year ice, heavy ridging, etc.; some representative photos to be taken. Icebergs - location and description; estimate size wherever possible; photos if possible. ... Meteorological observations were to be taken throughout the cruise at 3-hour intervals in accordance with Atmospheric Environment Services supplementary ship's weather reporting procedures. (Au)

G-26611
Some sea ice cover statistics for the Canadian east coast / J. E. Fraser.
[Calgary : Distributed by APOA], 1975.
1 microfiche : figures, tables ; 11x16cm.
(APOA project no. 138 : Environmental investigations and analysis in Davis Strait - second half 1977. Report, no. 19)
G G09
CaACU

This report sets out the results of a study of sea ice cover on the Canadian east coast. The study area lies along the coasts of Newfoundland and Labrador to about 300 miles offshore, between 45 deg. N and 70 deg. N. The study is based on historical ice charts obtained from Ice Forecasting Central, Department of the Environment, Ottawa. The statistics generated include average, maximum and minimum open water season lengths, and average, earliest and latest break-up and freeze-up dates. All these lengths and dates are relative to 1/10 or greater concentration of sea ice, with the exclusion of new ice or nilas, which is ignored. Also generated are statistics of gross season length for ice concentrations less than or equal to 6/10, and number of lengths of periods of ice concentration greater than 6/10. These statistics are calculated for the area south of 55 deg. N only. (Au)

G-26646
Small prototype cone tests, winter 1973-74 / by P.H. Verity.
[Calgary : Distributed by APOA], 1975.
5 microfiches : ill., figures, tables ; 11x16cm.
(APOA project no. 65 : Small prototype cone test. Report)
Appendices.
G G16
CaACU

A large basin was built to contain water. At one end of the basin was fixed a small Prototype Conical Structure. This structure was a scale model of a proposed concept for offshore drilling in ice infested waters. During the winter, naturally grown ice sheets were moved against the structure by means of a towing system built into the basin. The ice was constrained to fail against the cone which was instrumented to measure the horizontal and vertical forces against it. The effects of variations in ice sheet velocity, ice thickness and ice strength on the forces encountered by the cone were investigated. (Au)

G-26654
Ice crushing tests - 1974 / by T.W. Miller, A.S. McLatchie, R.E. Hedley [and] G.R. Morris.
[Calgary : Distributed by APOA], 1974.
4 microfiches : ill., figures, tables ; 11x16cm.
(APOA project no. 66 : Ice crushing tests 1973-74. Report, no. 1)
Appendices.
References.
G G082
CaACU

This report documents the results of an experimental program to measure the crushing strength of ice. The tests were conducted in fresh water ice on Eagle Lake, near Calgary, Alberta, during the winter of 1974. Even though the data was insufficient to adequately determine the effects of indenter shape, ice-indenter interface bond, and wide indenters, the data does indicate that 1. failure loads tend to increase as average ice temperatures decrease, 2. maximum failure loads occur at moderate loading rates, 3. failure stresses for frozen-in indenters usually exceed 1000 psi at aspect ratios (i.e. ratio of indenter width to ice thickness) near four. ... The main objectives of these tests were to determine the effects of several variables on the apparent ice crushing strength. They are 1. Loading rate (or strain rate), 2. Temperature, 3. Indenter-ice bonding (i.e. perfectly rough with ice shearing at indenter surface, perfectly smooth with zero friction at interface, or in between with finite friction), 4. Shape (i.e. comparison of strengths for flat and round indenters at same aspect ratios), and 5. Large aspect ratios. (Au)

G-26662
Laboratory tests on fresh water ice, 1974 / by N.E. Morgenstern, J.B. Nuttall and D. Sequo.
[Calgary : Distributed by APOA], 1974.
2 microfiches : figures, tables ; 11x16cm.
(APOA project no. 66 : Ice crushing tests 1973-74. Report, no. 2)
Prepared for Imperial Oil Ltd.
References.
G G082
CaACU

This report contains the results of laboratory tests on fresh water ice taken from the Eagle Lake test site ... during the winter of 1973-1974. Unconfined compression and plane strain tests were carried out at strain rates of .00009 to .0008/sec, the most rapid possible with available equipment. Test temperatures ranged from -4.0 to -16.5 deg. C. Unconfined compression specimens of the size 2 x 2 x 4, 4 x 4 x 8, and 6 x 8 x 16 inches and plane strain specimens 2 1/2 x 6 x 12 inches were tested. ... The anisotropic strength of the ice was determined in a limited number of tests. The results showed an anticipated variation in the compressive strength depending on the direction of load in relation to the plane of the ice sheet. A study of strength variation with sample size has also been undertaken. (Au)

G-26670
Landfast ice movement - Mackenzie Delta 1973-74 / by L.G. Spedding.
[Calgary : Distributed by APOA], 1975.
4 microfiches : figures, charts, tables ; 11x16cm.
(APOA project no. 67 : Ice movement in the Beaufort Sea, 1963/74. Report)
Appendices.
G G08121
CaACU

The movement of the landfast ice is primarily dependent on wind. ... Winds under 5 mph and

changes in wind direction are enough to keep the ice in motion. This motion is of a cyclic nature and can be correlated to wind velocity increases and decreases. In storms or periods with winds over 15 mph, movements up to 5 feet per hour around the Barrier Islands can be expected. After January movements closer to shore will decrease. The motion becomes more severe as one nears the shear zone. Ice motion at the shear zone generally seems to occur during storms and is generally in the direction of the wind. Movements up to 12 feet per hour can be expected. The fast ice seems to act as an elastic material. ... Wind stress causes movement of the ice and on removal of this stress the ice usually returns to near its initial position causing the observed cyclic type motions. ... (Au)

G-26689

Investigations into the feasibility of producing pressure ridge/ice sheet systems with synthetic ice / by R. Edwards, R. Abdelnour [and] W. Wallace, Arctic Canada Limited.
[Calgary : Distributed by APOA], 1975.
1 microfiche : ill., figures, tables ; 11x16cm.
(APOA project no. 68 : Properties of wax model ice ridges. Report)
References.
G G16
CaACU

This report describes the results of experimental investigations undertaken by ARCTEC CANADA LIMITED on behalf of APOA to assess the feasibility of using synthetic ice to form models of systems of pressure ridges and uniform ice fields. The investigations were divided into the following categories: 1. Solving logistical problems associated with forming ridges, 2. Assessing the properties of thin and very thick layers of synthetic ice poured from identical batches to determine if flexural properties vary with "ice" thickness, 3. Determining that an adequate bond can be established between model ice sheets and model ridges using practical techniques. (Au)

G-26697

An analytical study of ice scour on the sea bottom / FENCO.
[Calgary : Distributed by APOA], 1975.
5 microfiches : figures, tables ; 11x16cm.
(APOA project no. 69 : An analytical study of ice scour. Report)
Appendices.
References.
G G37
CaACU

... The study covers all aspects of scouring; a review of literature; environmental factors required for study; types of ice formations; marine sediments; plus several idealistic mathematical models to predict scour for different situations. In particular, a dynamical model has been developed (by solving the basic equations of motion of a body being driven into a sloping sea bed) and the solutions compared with other simpler model solutions which use either energy conservation or static equilibrium conditions. Finally, suggestions for model tests are given which could be used to verify the mathematical solutions presented here. ... (Au)

G-26719

Model experiments to determine the forces exerted on structures by moving ice fields (comparison with small prototype test results) / by R.Y. Edwards, Jr., W.G. Wallace [and] R. Abdelnour, Arctic Canada Limited.
[Calgary : Distributed by APOA], 1975.
1 microfiche : figures, tables ; 11x16cm.
(APOA project no. 77 : Modelling of small cone

prototype tests. Report)
Appendices.
G G16
CaACU

Forty-two tests were conducted which consisted of forcing large slabs of synthetic model ice against right circular cones with a slope of 45 deg. There were four model cones which were 1/5th, 1/10th, 1/20th and 1/30th scale models of the prototype tested in the Imperial Oil Ltd. outdoor ice basin. We attempted to scale down the diameter of the prototype cylindrical access tower but due to restrictions in standard stock sizes and the Teflon thickness, this was not achieved exactly in the model tests. ... The model ice sheets ranged in ice thickness between 0.29 and 1.25 inches, in flexural strength 3.58 and 14.21 psi and in elastic modulus from 649 psi to 24293 psi. The ratio of elastic modulus to flexural strength ranged from 180 to 2970. Only for one test series did E/c fall below 1000. ... One of the objectives of this program was to compare for identical conditions, the vertical and horizontal forces measured during ice field impingement. This objective was not achieved. ... (Au)

G-26727

Arctic environmental observations - M/V Arctic Explorer / Marine Environmental Services Limited.
[Calgary : Distributed by APOA, 1974].
2 microfiches : ill., tables ; 11x16cm.
(APOA project no. 78 : Environmental data gathering program - Baffin Bay, Davis Strait and Arctic Islands. Report)
G,D,E G39
CaACU

The purpose of this project was to obtain meteorological, oceanographic and ice data in the study region. A trained meteorological, oceanographic and ice observer was placed aboard the M/V Arctic Explorer while it was conducting seismic surveys in Baffin Bay and the eastern Arctic Islands during the 1974 open water season. The data collected has been processed and summarized into an environmental data report. (Au)

G-26751

Ice island count - Southern Beaufort Sea / by L.G. Spedding.
[Calgary : Distributed by APOA, 1975-1977].
4 microfiches : ill., figures, tables ; 11x16cm.
(APOA project no. 99 : Ice island count - Southern Beaufort Sea 1974, 1975 and 1976. Report, no. 1, 2, 3)
Contents: no.1 - 1974. - no.2 - 1975. - no.3 - 1976.
References.
G G37
CaACU

Purpose: To record the invasion of ice islands and ice fragments into the coastal waters of the Southern Beaufort Sea. Because of their large size and thickness, they could present severe problems to offshore operations. Collection of this type of data on a yearly basis is considered necessary to a meaningful risk analysis of the collision of ice islands with fixed structures. (Au)

G-29190

An investigation of multi-year pressure ridges and shore pile-ups / by A. Kovacs, D. Dickins and E. Wright, NORCOR Engineering and Research Limited.
[Calgary : Distributed by APOA], 1975.
1 microfiche : ill., photos ; 11x16cm.
(APOA project no. 89 : Study of the thickness

of multi-year pressure ridges. Report)
References.
G G07
CaACU

This report presents the findings of a field study designed to generate fundamental data on multi-year pressure ridges and floes in the near shore zone of the Beaufort Sea. The programme investigated the geometry of 11 floating multi-year ridges or ridge fragments, the sail height and keel depth of four multi-year ridge fragments, and the cross sections of two large shore ice pile-ups. Most of the ridges were situated within a 20 mile radius of Sachs Harbour, N.W.T. Measurements were made during the period from May 4 to May 18, 1975. ... (Au)

G-29939

The nutcracker ice strength tester and its operation in the Beaufort Sea / K.R. Croasdale. ([Proceedings] - IAHR Symposium : Ice and its Action on Hydraulic Structures, 1st, Reykjavik, Iceland, 7-10 Sept., 1970. [Delft : S.N., 1971], section 6.4, ill.) (APOA project no. 1 : Nutcracker ice strength tests, 1969-70. Report, no. 2) References.
G G16
CaACU

Growing energy consumption and dwindling reserves in the populated regions is spurring the search for oil in the frontier areas of the far North. This paper describes the work sponsored by several Canadian oil companies aimed at providing ice strength data for the design of offshore structures for Arctic waters. The design and operation of a novel ice testing device is described. Some of the results obtained during tests in January and February of 1970 are presented and discussed. (Au)

G-30040

Distribution of the ice thickness in the Beaufort Sea / Rene O. Ramseier, Malcolm R. Vant, Lyn D. Arseneault, Lawrence Gray, Robert B. Gray [and] Walter J. Chudoblak. Victoria, B.C. : Beaufort Sea Project, Dept. of the Environment, 1975. 98p. : ill., maps ; 28cm. (Technical report - Canada. Beaufort Sea Project, no. 30) (APOA project no. 72 : Beaufort Sea Environmental Program. Report, no. 30) Cover title: Distribution of sea ice thickness in the Beaufort Sea. Bibliography: p.24-28.
G G07
CaACU

Although it was not possible to measure sea ice thickness directly, monthly maps indicating the distribution of first-year and multiyear ice for the entire Beaufort Sea region were prepared from Nimbus 5 passive microwave imagery. Detailed investigation of the shear zone was performed using 13.4 GHz scatterometer and X-band SLR imagery for April 1975. A description of the various sensors employed and an outline of the development of a UHF radar for direct measurement of sea ice thickness are included. (Au)

See Also : P-30295, Q-15490, Q-15504, Q-15547, Q-16241, Q-19364, Q-24449, Q-26450, Q-30244

H - BOTANY

H-11622

Biological productivity of the southern Beaufort Sea : phytoplankton and seaweed studies / [by] Stephen I.C. Hsiao. Victoria, B.C. : Beaufort Sea Project, Dept. of the Environment, 1976. ii, 59p. : charts, map, tables ; 28cm. (Technical report - Canada. Beaufort Sea Project, no. 12c) (APOA project no. 72 : Beaufort Sea Environmental Program. Report, no. 12c) Bibliography: p.31-35.
H G07
CaACU

Standing stock and in situ primary productivity of the southern Beaufort Sea phytoplankton were determined. ... Possible reasons for a greater standing stock and primary productivity at inshore stations are discussed. ... Diatoms were more sensitive than flagellates when they were exposed to crude oils, Primary production of seaweed was severely inhibited by all types of crude oil at relatively low concentrations. (Au)

H-11754

Nitrogen fixation in Arctic marine sediments / [by] R. Knowles. Victoria, B.C. : Beaufort Sea Project, Dept. of the Environment, 1975. 44p. : map, figures, tables ; 28cm. (Technical report - Canada. Beaufort Sea Project, no. 9) (APOA project no. 72 : Beaufort Sea Environmental Program. Report, no. 9) Bibliography: p.37-41.
H G07
CaACU

Nitrogen fixation was measured in grab and core samples of sediments from the Beaufort Sea and Eskimo Lakes. The indirect assay involving the reduction of acetylene to ethylene was used. Very low rates, of the order of 25 mg N/square meter year, were detected in untreated sediments. Activity was markedly stimulated by addition of glucose, sucrose, lactose, mannitol and malate, much less by acetate, and negligible activity was supported by N-acetylglucosamine, the chitin monomer. ... (Au)

H-30147

Nutrient limitations to plant production in two tundra communities / Richard W. Haag. (Canadian journal of botany, v. 52, no. 1, Jan. 1974, p. 103-116, tables) (APOA project no. 37 : Arctic environmental research, tundra and ecological studies on the Mackenzie Delta and Devon Island. Report) References.
H G08121
CaACU

Nitrogen and phosphorus nutrition were investigated as limiting factors to primary production in a lowland wet sedge meadow and an upland birch-willow-heath community. Response to nitrogen fertilization in both communities, including increased protein content and dry weight production, indicates that nitrogen supply limits production in both soils. In the upland community, phosphorus supply does not limit production, but in the lowland sedge meadow, dilution of the soil solution may decrease phosphorus availability and render this element limiting to production. Nitrogen, if available, can be taken up and metabolized into organic compounds despite low soil

temperatures. Phosphorus metabolism may be directly limited by low soil temperatures and low available nitrogen levels. Low soil temperature exerts an indirect limitation on plant production through limitation of organic matter decomposition and microbial nitrification, thus limiting the rate of nitrogen cycling. ... (Au)

H-30155

Arctic plant communities east of the Mackenzie Delta / Ian G.W. Corns.
(Canadian journal of botany, v. 52, no. 7, July 1974, p.1731, map, tables (part. fold.))
(APOA project no. 37 : Arctic environmental research, tundra and ecological studies on the Mackenzie Delta and Devon Island. Report)
References.
H G08121
CaACU

Tundra vegetation was analyzed on the basis of 64 sampled and 12 described stands representing a wide variety of plant community types immediately east of the Mackenzie Delta, Northwest Territories. Five main types (Tall Shrub-Heath, Medium Shrub (alder), Low Shrub-Heath, Herb-Low Shrub-Heath, and Herb) and 11 subgroups were distinguished and classified on the basis of floristic similarity using a two-dimensional ordination and by physiognomy. A total of 70 species were sampled or observed in the stands. ... The areal extent of each major community type was determined using aerial photography for Richards Island, Caribou Hills, Eskimo Lakes, Tuktoyaktuk, and Atkinson Point study areas. (Au)

H-30163

Changes in Arctic Ericophorum Tussock communities following fire / Ross W. Wein and L.C. Bliss.
(Ecology, v. 54, no. 4, Summer 1973, p. 845-852, photos., tables)
(APOA project no. 37 : Arctic environmental research, tundra and ecological studies on the Mackenzie Delta and Devon Island. Report)
References.
H,J G08121
CaACU

... Plant succession following fire was unique in that no new species invaded the area. Growth came principally from root stocks protected by the organic surface. Cottongrass and Carex spp. were the first to show regrowth following a June fire at one site. The role of cottongrass seedlings in colonizing these tussock communities was minor, because few seedlings older than 1 year were found on any of the sites. Epilobium angustifolium ssp. angustifolium and some Calamagrostis canadensis ssp. canadensis originated from seed although most plants of the latter species had long vigorous rootstocks. ... Annual plant production had almost recovered after two growing seasons, and nutrient content of the plants was higher in the burned areas. ... (Au)

H-30180

Cotton grass (Eriophorum vaginatum) germination requirements and colonizing potential in the Arctic / Ross W. Wein and D.A. MacLean.
(Canadian journal of botany, v. 51, no. 12, Dec. 1973, p.2509-2513, graphs)
(APOA project no. 37 : Arctic environmental research, tundra and ecological studies on the Mackenzie Delta and Devon Island. Report)
References.
H G08121
CaACU

Germination requirements of cotton grass (Eriophorum vaginatum L.) were investigated to determine its potential for reseeding disturbed areas of the arctic tundra. Maximum seed

production was 15.7 kg/ha, although production and viability varied widely. There was no seed dormancy and temperatures of 25-30 deg. C produced maximum germination rates. A light treatment enhanced germination but was not required. Cotton grass seed germinated under less favourable moisture conditions than several other native grasses that strongly invade disturbed arctic sites. Loss of viability during storage under room conditions was high for the first 10 months, yet 27.6-52.5 % of the seed remained viable at 19 months. The role that this species could play in revegetation is discussed. (Au)

H-30198

Functional effects of vegetation on the radiant energy budget of boreal forest / Richard W. Haag and L.C. Bliss.
(Canadian geotechnical journal, v. 11, no. 3, Aug. 1974, p. 374-379, ill.)
(APOA project no. 37 : Arctic environmental research, tundra and ecological studies on the Mackenzie Delta and Devon Island. Report)
References.
H,C,E G08121
CaACU

In contrast to tundras, where the mass of vegetation is low and its effect on energy exchange relatively small, boreal forest vegetation exerts a more important buffering effect on energy flux to and from the ground surface. Air movement below the canopy is reduced, and a relatively high proportion of solar radiation is absorbed by the canopy directly, to be lost as sensible or latent heat. Removal of the buffer provided by stratified vegetation results in increased soil heat flux and ground temperatures, and increased depth of the active layer, which in areas of ice rich permafrost can lead to surface subsidence. (Au)

H-30260

Eriophorum vaginatum L. / by Ross W. Wein.
(Journal of ecology, v. 61, 1973, p. 601-615, ill., maps)
(APOA project no. 37 : Arctic environmental research, tundra and ecological studies on the Mackenzie Delta and Devon Island. Report)
At head of title: Biological flora of the British Isles.
H G081
CaACU

Describes the geographical distribution, physiology, response to biotic factors, morphology, and phenology of cotton-grass in the British Isles and the circumpolar regions. (ASTIS)

H-30341

Energy budget changes following surface disturbance to upland tundra / by Richard W. Haag and L.C. Bliss.
(Journal of applied ecology, v. 11, 1974, p. 355-374, ill., graphs, tables)
(APOA project no. 37 : Arctic environmental research, tundra and ecological studies on the Mackenzie Delta and Devon Island. Report)
References.
H,C,E G08121
CaACU

... The present study was undertaken to determine how the relationships between the components of energy dissipation in a native upland low shrub-heath tundra are altered by surface disturbance, and the effects of such alteration on the physical environment. The disturbances investigated were a winter road, controlled oil spill, tundra fire, and reseeded plots on a section of winter road. The study area is located at 69 deg. 27 sec. N, 133 deg.

9.1

00 sec. W, 1 km south of the Imperial Oil Base Camp at Tuktoyaktuk, N.W.T., in hummocky low shrub-heath tundra (Au)

H-30350

Revegetation studies - Norman Wells, Inuvik and Tuktoyaktuk, N.W.T. and Prudhoe Bay, Alaska : application to the proposed pipeline route / Prepared by Helios Hernandez.
[Winnipeg : Environment Protection Board, 1973].
vii, 127p. : ill., tables : 28cm.
(Towards an environmental impact assessment of the portion of the Mackenzie gas pipeline from Alaska to Alberta. Appendix V: revegetation / Environment Protection Board. Interim report - Environment Protection Board, no. 3)
(APOA project no. 37 : Arctic environmental research, tundra and ecological studies on the Mackenzie Delta and Devon Island. Report)
Prepared for the Environment Protection Board.
H.O. G08121
CaACU

Data are presented from August 1972 analyses for a variety of reseeding plots established at Norman Wells, Inuvik and Tuktoyaktuk, N.W.T. and Prudhoe Bay, Alaska in the early summers of 1970, 1971 and 1972. The four sites are in the northern boreal forest, boreal forest to tundra transition, upland dwarf shrub-heath tundra and coastal wet sedge polygon tundra respectively. ... Eight different fertilizer treatments were tested over the years of this study. ... Tentative and preliminary revegetation techniques and seed mixes are proposed. (Au)

See Also : J-29920, Q-11657, Q-15504, Q-30120, Q-30139, Q-30171

1 - ZOOLOGY

I-9784

Bowhead and white whales in the southern Beaufort Sea / [by] Mark A. Praker, David E. Sergeant and Wyt Hoek.
Sidney, B.C. : Dept. of Fisheries and the Environment, Beaufort Sea Project, 1970.
vii, 114p. : ill., maps (part. fold.), tables : 28cm.
(Technical report - Canada. Beaufort Sea Project, no. 4)
(APOA project no. 72 : Beaufort Sea Environmental Program. Report, no. 4)
Bibliography: p.92-96.
I G07
CaACU

The purpose of this report is to describe the biology of bowhead and white whales of the southeast Beaufort Sea and to assess the possible effects of oil and gas exploration on the whales. ... (Au)

I-11614

Biological productivity of the southern Beaufort Sea : zoobenthic studies / [by] J.W. Wacasey.
Victoria, B.C. : Beaufort Sea Project, Dept. of the Environment, 1975.
39p. : maps, tables : 28cm.
(Technical report - Canada. Beaufort Sea Project, no. 12b)
(APOA project no. 72 : Beaufort Sea Environmental Program. Report, no. 12b)
References.
I G07
CaACU

Baseline data obtained from a sampling program carried out from 1971 through 1975, primarily during the open water season, demonstrate the

existence of zonation of zoobenthos across the shelf of the southern Beaufort Sea. These zones, which can be characterized physically and biologically, are designated: (1) Estuarine Zone, (2) Transitional Zone, (3) Marine Zone, and (4) Continental Slope Zone. ... (Au)

I-19356

Arctic marine resources : harvest and utilization panel / by R.R. Trudeau.
(Proceedings - Arctic Environmental Workshop, 7th, Fairmont Hot Springs, B.C., April 12-15, 1978 / Edited by S. James [and] D. Mackay.
Toronto : Institute for Environmental Studies of the University of Toronto, [1978].
Publication - Toronto. University. Institute for Environmental Studies, EE 8, p. 86-102)
References.
I G081
CaACU

The objective ... will be to assess from existing data the current status of the Arctic Marine resources, their present level of harvest, their importance to the people who live in the Arctic, and the impact to be expected on this resource from the search for, and ultimate production of, hydrocarbon resources. ... (Au)

I-21300

Mackenzie Delta project : final report / Environmental Research Associates.
[Calgary : Distributed by APOA, 1970].
1 microfiche : 11x16cm.
(APOA project no. 11 : Mackenzie Delta ornithological study. Report)
References.
I G08121
CaACU

Purpose: To delineate important and critical nesting, moulting, gathering ground, staging and migration routes of the birds in the Mackenzie Delta region. The study area was later expanded to include the coastal region from Herschel Island to the Baillie Islands and north to the bird sanctuary of Banks Island. Field work was conducted in four stages to coincide with major changes in ornithological activities such as spring arrival, nesting, moulting and fall staging. The project started in June, 1970, and was completed in October of the same year. ... report provides estimates of bird numbers and describes the habits of migratory and other species of birds that were observed. Some preliminary assessments of the potential impact of oil exploration and production on birds which utilize the study area are included. (Au)

I-25232

Report on the Davis Strait aerial survey 77-1 / MacLaren Atlantic Limited.
[Calgary : Distributed by APOA], 1977.
1 microfiche : figures, maps : 11x16cm.
(APOA project no. 127 : Winter environmental investigations in Davis Strait - 1977. Report, no. 1)
Prepared for Imperial Oil Ltd., Aquitaine Co. of Canada Ltd. and Canada Cities Services Ltd.
I G09
CaACU

... Aerial survey was chosen as the most effective census technique for determining mammal and bird distribution and abundance. ... Both visual and photographic records were made. Visual records yielded the best data for birds and photographic records for mammals. ... (Au)

I-25275

Report on biological literature review of Ungava Bay and Hudson Strait / MacLaren Atlantic Limited.

[Calgary : Distributed by APOA], 1977.
2 microfiches : figures, maps, tables ;
11x16cm.

(APOA project no. 138 : Environmental investigations and analysis in Davis Strait - second half 1977. Report, no. 9)
Prepared for Imperial Oil Ltd., Aquitaine Co. of Canada Ltd. and Canada Cities Services Ltd.
I, J G08125
CaACU

... The report is divided into five sections: Plankton, Benthos, Fish and Fisheries, Birds, and Mammals. Spatial and temporal distributions, trophic relations, and, where relevant, reproductive ecology are considered. ... The literature collected was extensive, but not necessarily exhaustive. The main source material was published within the last three decades, although a number of older papers and expedition reports were included when relevant. ... (Au)

I-25283

Report on marine benthic invertebrates of the southern Davis Strait and Ungava Bay / MacLaren Marex Inc.

[Calgary : Distributed by APOA], 1978.
3 microfiches : figures, maps, tables ;
11x16cm.

(APOA project no. 138 : Environmental investigations and analysis in Davis Strait - second half 1977. Report, no. 10)
Prepared for Imperial Oil Ltd., Aquitaine Co. of Canada Ltd. and Canada Cities Services Ltd.
Appendices.
References.
I G09
CaACU

This report contains the results of analyses of benthic invertebrate samples taken ... in the southern Davis Strait and Ungava Bay in August-September, 1977. In comparison with more temperate waters, the study area had a similar benthic invertebrate abundance, a lower productivity of several mollusc species, and an equal or higher diversity of benthic communities. Four substrate types were observed in the study area. These were gravel, mixed gravel-rock-sand, fine sand with varying portions of silt and clay, and silt. ... (Au)

I-26395

Report on aerial surveys 77-2, 77-3, 77-4 : studies of seabirds and marine mammals in Davis Strait, Hudson Strait and Ungava Bay / MacLaren Atlantic Limited.

[Calgary : Distributed by APOA], 1978.
8 microfiches : ill., figures, tables ;
11x16cm.

(APOA project no. 138 : Environmental investigations and analysis in Davis Strait - second half 1977. Report, no. 5, 5A)
Prepared for Imperial Oil Ltd., Aquitaine Co. of Canada Ltd. and Canada Cities Services Ltd.
Supplements APOA project no. 134.
References.
Contents: no. 5 Report. - no. 5A Appendix A, sea bird distribution maps.
I G09
CaACU

Four aerial surveys were flown during mid-June to late September, 1977, in the Davis Strait, eastern Hudson Strait and Ungava Bay regions of the eastern Canadian Arctic. Preliminary data were collected on abundance, distribution, species composition and ecological relationships of both seabirds and marine mammals Data were obtained utilizing a sampling system based on coastal and offshore

transects. (Au)

I-26409

Report on preliminary nearshore environmental studies on southeast Baffin Island / MacLaren Atlantic Limited.

[Calgary : Distributed by APOA], 1977.
3 microfiches : ill., figures, tables ;
11x16cm.

(APOA project no. 138 : Environmental investigations and analysis in Davis Strait - second half 1977. Report, no. 6)
Prepared for Imperial Oil Ltd., Aquitaine Co. of Canada Ltd. and Canada Cities Services Ltd.
Appendices.
References.
I G08124
CaACU

... Marine mammals, birds, fish, zooplankton and benthic macrophytes and fauna were studied at six specific locations. ... Attempts were made to sample in both exposed regions, unprotected from ice scour and the open sea, and unexposed regions, in sheltered inlets, in order to compare the composition and abundance of the biota. ... (Au)

I-26425

Revised biological literature of the Davis Strait region / MacLaren Atlantic Limited.

[Calgary : Distributed by APOA], 1978.
3 microfiches : figures, maps, tables ;
11x16cm.

(APOA project no. 138 : Environmental investigations and analysis in Davis Strait - second half 1977. Report, no. 8)
Prepared for Imperial Oil Ltd., Aquitaine Co. of Canada Ltd. and Canada Cities Services Ltd.
Revises APOA project no. 126 : Biological literature of the Davis Strait region, MacLaren Atlantic Limited
I G09
CaACU

... The report is a revised version of "Biological Literature Review of the Davis Strait Region for Imperial Oil Limited, January, 1977". It contains information acquired since that time through more extensive literature searches. ... This report is now divided into five sections representing the subjects covered: Plankton, Benthos, Fish and Fisheries, Birds and Mammals. ... (Au)

I-29963

Seabirds of the southeastern Beaufort Sea.

Victoria, B.C. : Beaufort Sea Project, Dept. of the Environment, 1975.

2 vol. : ill., maps, tables ; 28cm.

(Technical report - Canada. Beaufort Sea Project, no. 3a, 3b)

(APOA project no. 72 : Beaufort Sea Environmental Program. Report, no. 3a, 3b)

Title varies: A study of seabirds in the coastal Beaufort Sea area, 1972 and 1974.

Bibliography: p. 194-201.

Contents: no. 3a Summary report / by Thomas W. Parry. - no. 3b Aircraft and group observations in 1972 and 1974 / Gary F. Searing, W. John Richardson, LGL Limited; Ernie Kuyt and Tom W. Barry, Canadian Wildlife Service.

I G07
CaACU

... Various survey methods were employed to determine temporal and spatial distribution of seabirds. From several points along the coast we made counts of spring migrants. Aerial surveys were used to learn the distribution and concentration of seabirds using open leads in the ice and throughout the open water season. Aerial surveys were also used to sample the coastal breeding and molting species. Aerial surveys in the fall sought to locate

concentrations in the littoral zone. ... Data on the distribution and movements of seabirds and other birds in the southeastern Beaufort Sea area were gathered during 1972 and 1974. Data collected during offshore aerial surveys conducted over the Beaufort Sea during 1974 were analysed in relation to ice-cover conditions; the results of such analyses indicated the distributions and movements of birds offshore during a year of above-average ice cover. It was found that the distributions of most species are related to the amount of ice cover present and that birds generally prefer areas of at least partly open water. Maps of species distributions and abundances in relation to ice-cover conditions were prepared for offshore areas. ... (Au)

I-29971

Bird migration along the Beaufort Sea coast : radar and visual observations in 1975 / W. John Richardson, Michael R. Morrell and Stephen R. Johnson, IGL Limited.
Victoria, B.C. : Beaufort Sea Project, Dept. of the Environment, 1975.
ii, 131p. : ill., photos., tables : 28cm.
(Technical report - Canada. Beaufort Sea Project, no. 3c)
(APOA project no. 72 : Beaufort Sea Environmental Program. Report, no. 3c)
Bibliography: p.117-122.
I G07
CaACU

Bird distribution within and the patterns and timing of movements over the south-central Beaufort Sea and northern Yukon were studied from 9 May to 9 July 1975. ... Birds often flew east and west more or less parallel to the coast on a broad front. Such flights often extended over the southern Beaufort Sea to the limit of detectability (55 km or more offshore) and across the width of the North Slope. However, there was usually some degree of concentration along the shore, and on some occasions few birds were aloft more than 15 or 20 km offshore. Small numbers of birds were occasionally detected flying northwest and east over the British Mountains. Until late May, both eastward and westward movement were usually of low density; thereafter, movement in both directions was denser, although still variable in density from hour to hour and day to day. ... (Au)

I-29980

Fishes of the Yukon coast / R.E. Kendel, R.A.C. Johnston, H. Lobsiger and M.D. Kuzak.
Victoria, B.C. : Beaufort Sea Project, Dept. of the Environment, 1975.
xi, 114p. : ill., maps, photos., tables : 28cm.
(Technical report - Canada. Beaufort Sea Project, no. 6)
(APOA project no. 72 : Beaufort Sea Environmental Program. Report, no. 6)
Bibliography: p.41-45.
I G0811
CaACU

The purpose of this study was to collect baseline information regarding the inshore fisheries resource and the aquatic environment of the western coastal Beaufort Sea, and to identify areas that could be critically affected by a major oil spill. We present data collected from April 1974 to September 1975. The study area included the coastal sea out to 7 km offshore, lagoons, bays and estuaries, bounded by the Blow River delta on the east and by Welles Point, Herschel Island, on the northwest. Of 21 species of fish recorded within the study area 6 species represented 95% of the total catch in 1974. These were least cisco (*Coregonus sardinella*), Arctic cisco (*Coregonus autumnalis*), Arctic char (*Salvelinus alpinus*), fourhorn sculpin (*Myoxocephalus*

quadricornis quadricornis), boreal smelt (*Osmerus eperlanus*), and humpback or lake whitefish (*Coregonus clupeaformis*). Of these only the fourhorn sculpin is considered a marine species, the remainder being anadromous species. ... Some of the life history information is presented along with a discussion of the available literature for each species. Age-length relationships, sex ratios and age at maturity are also presented for the most common species. (Au)

I-29998

Fishes of the outer Mackenzie Delta / R. Percy. Victoria, B.C. : Beaufort Sea Project, Dept. of the Environment, 1975.
vi, 114p. : ill., maps, tables : 28cm.
(Technical report - Canada. Beaufort Sea Project, no. 8)
(APOA project no. 72 : Beaufort Sea Environmental Program. Report, no. 8)
Bibliography: p.49-54.
I G08121
CaACU

Baseline information was gathered in 1974 and 1975 on 23 species of fresh-water, anadromous and marine fishes in the outer Mackenzie Delta and nearshore Beaufort Sea. The biological data presented include numerical abundance, summer and winter distributions, nursery areas, food habits, migration and age-length relationships. The possible impact of offshore exploratory drilling to the fish resources is discussed. Although the major impact would arise from an oil well blowout, the cumulative effects of other disturbance factors, such as seismic activity, disposal of drilling fluids and "housekeeping waters" will also be significant over the long term. ... (Au)

I-30325

The distribution and abundance of seals in the eastern Beaufort Sea / Ian Stirling, Ralph Archibald and Douglas DeMaster.
Victoria, B.C. : Beaufort Sea Project, Dept. of the Environment, 1975.
56p. : ill., graphs, maps, tables : 28cm.
(Technical report - Canada. Beaufort Sea Project, no. 1)
(APOA project no. 72 : Beaufort Sea Environmental Program. Report, no. 1)
Bibliography: p.56-58.
I G07
CaACU

The two main seal species which occur in the Beaufort Sea are the ringed seal (*Phoca hispida*) and the bearded seal (*Erignathus barbatus*). ... In a randomly stratified aerial survey, conducted in 1974, we counted 41,982 ringed seals and 2,759 bearded seals. In an identical survey, conducted in 1975, we counted 21,661 ringed seals and 1,197 bearded seals, which indicated a substantial decline in the total population size. ... Substantial reductions in pup productivity, pup survival, ovulation rate, and pregnancy rate were also recorded in 1974 and 1975, compared with available data from the same population in earlier years and from other studies. It appeared that these changes were caused by abnormally heavy sea ice conditions in 1974. ... Neither ringed nor bearded seals were distributed randomly over depth but their distributions were different. Bearded seals were more strongly associated with shallow water areas. Ringed seal pupping habitat is widely distributed in the inshore fast ice areas of the western Arctic. Bearded seal pupping habitat is mainly restricted to the offshore moving lead areas north of the mainland coast and west of Banks Island. Both ringed and bearded seals concentrate in the moving lead areas during the winter. (Au)

I-30333

The distribution and abundance of polar bears in the eastern Beaufort Sea / Ian Stirling, Dennis Andriashek, Paul Latour and Wendy Calvert. Victoria, B.C. : Beaufort Sea Project, Dept. of the Environment, 1975.

59p. : ill., graphs, maps, photos., tables ; 28cm.

(Technical report - Canada. Beaufort Sea Project, no. 2)

(APOA project no. 72 : Beaufort Sea Environmental Program. Report, no. 2)

Bibliography: p. 53-55.

I G07

CaACU

This report presents baseline information on the biology, distribution, and abundance of polar bears in the Beaufort Sea; identifies critical feeding and denning areas; and makes recommendations relative to projected industrial activity and future research requirements. From October 1970 through July 1975, 425 polar bears were tagged in the western Arctic. Subsequent to tagging, 25 polar bears were shot, 51 were recaptured, and 117 sightings were made of tagged bears (with numbers painted on them, up to two months after tagging). ... Seasonal movements in the population were largely determined by ice conditions. ... Five sea-ice habitat types for polar bears were described. ... The population of polar bears in the study area in 1974 was estimated as 1,521. Crude estimates of the population size in 1975 indicated that the total could be as low as 1,000 individuals. Recommendations for the protection of the critical feeding and maternity denning areas were made as were recommendations for future monitoring and research needs. (Au)

See Also : J-25224, J-25810, J-29920, Q-11592, Q-12980, Q-12998, Q-13005, Q-13013, C-13021, Q-13048, Q-26484, Q-30279, T-15512, T-26417

J - ECOLOGY (includes ENVIRONMENTAL PROTECTION)

J-11606

Biological productivity of the southern Beaufort Sea : the physical-chemical environment and the plankton / [by] E.H. Grainger.

Victoria, B.C. : Beaufort Sea Project, Dept. of the Environment, 1975.

52p. : maps ; 28cm.

(Technical report - Canada. Beaufort Sea Project, no. 12a)

(APOA project no. 72 : Beaufort Sea Environmental Program. Report, no. 12a)

Bibliography: p. 75-82.

J G07

CaACU

... Information was gathered on water temperature, salinity, light, dissolved oxygen, nitrate, phosphate, silicate, chlorophyll, particulate and dissolved organic carbon, bacteria and benthic and planktonic plants and animals. The object of the exercise was to define the present, relatively undisturbed Beaufort Sea biological system, to try to develop an understanding of its structure, in relation to the major variables of the present time, and in response to anticipated changes of the future resulting from oil exploitation. ... (Au)

J-16233

Distribution of tar and particulate pollutants along the Beaufort Sea coast / [by] C.S. Wong, D. Macdonald and W.J. Cretney.

Victoria, B.C. : Beaufort Sea Project, 1976.

96p. : ill., figures, maps, tables ; 28cm.

(Technical report - Canada. Beaufort Sea Project, no. 13)

(APOA project no. 72 : Beaufort Sea Environmental Program. Report, no. 13)

References.

J G081

CaACU

... The objectives of the study are: (1) to establish the baseline distribution of particulate pollutants, especially for tar and plastics, in the present-day Beaufort Sea marine environment, (2) to establish areas with natural seepage of crude oil and (3) to establish the chemical characteristics of hydrocarbons in the present-day beach sediment, nearshore sediment and marine organisms, including fish. ... (Au)

J-25224

Biological literature review of the Davis Strait region / MacLaren Atlantic Limited.

[Calgary : Distributed by APOA], 1977.

1v. (various pagings) : maps, tables ; 28cm.

(APOA project no. 126 : Biological literature review of Davis Strait. Report)

Prepared for Imperial Oil Limited.

Revised by APOA project no. 138, Report no. 8:

Revised biological literature of the Davis Strait region, MacLaren Atlantic Limited

J, I G09

CaACU

This report attempts to review and comment on the biological literature of Davis Strait and to compile a rough biological inventory of the area. Such an inventory is of obvious relevance to possible oil exploration activities in the area. ... there was a deliberate attempt to concentrate on bird and mammal literature as these groups are of most concern in the area. The other groups, such as fish and benthos, etc., are not neglected, but the review may be less thorough in these subject areas. ... (Au)

J-25240

Report on cruise 77-1, February, 1977 :

Environmental aspects of the cruise to Davis Strait and the Labrador Coast / MacLaren Atlantic Limited.

[Calgary : Distributed by APOA], 1977.

3 microfiches : figures, maps, tables ;

11x16cm.

(APOA project no. 127 : Winter environmental investigations in Davis Strait - 1977. Report, no. 2)

Prepared for Imperial Oil Ltd., Aquitaine Co. of Canada Ltd. and Canada Cities Services Ltd.

References.

J, D G09

CaACU

A cruise was carried out in February, 1977, in the Davis Strait, with additional observations being made along the Labrador Coast. The primary purpose was to record the distribution of mammals and birds in the area, especially relative to the ice front. Salinity, temperature, plant nutrient, chlorophyll, phytoplankton, zooplankton, fish eggs and larvae, and benthic samples and observations were collected as well to provide winter data on all these aspects. ... (Au)

J-25259

Report on biological cruises, offshore cruises

77-2 and 77-3, April-June, 1977 in the Davis Strait / MacLaren Atlantic Limited.

[Calgary : Distributed by APOA], 1978.

12 microfiches : figures, maps, tables ;

11x16cm.

(APOA project no. 134 : Late winter and spring investigations in Davis Strait - 1977. Report no. 1, 1A)

Prepared for Imperial Oil Ltd., Aquitaine Co. of Canada Ltd. and Canada Cities Services Ltd. References.

Contents: no. 1 Report. - no. 1A Appendix.

J,D G09

CaACU

Two cruises were carried out in the Davis Strait in the spring of 1977 Both cruises sampled for phytoplankton (microscopic floating plants), zooplankton (small weakly swimming animals and feeding on the phytoplankton or each other) and fish eggs and larvae. Supporting physical oceanographic (salinity-temperature-depth) and inorganic plant nutrient data were obtained as well. ... (Au)

J-25267

Report on biological studies, offshore cruise 77-4 through 77-7, July-December, 1977 in the Davis Strait / MacLaren Atlantic Limited.

[Calgary : Distributed by APOA], 1978.

15 microfiches : figures, maps, tables ; 11x16cm.

(APOA project no. 130 : Environmental investigations and analysis in Davis Strait - second half 1977. Report, no. 4, 4A)

Prepared for Imperial Oil Ltd., Aquitaine Co. of Canada Ltd. and Canada Cities Services Ltd. References.

Contents: no. 4 Report. - no. 4A Appendix.

J,D G09

CaACU

... The biological programme was designed to obtain biological environmental baseline data in the marine ecosystem in the Davis Strait. The 1977 open sea studies provided descriptive information on the annual cycles of phytoplankton, zooplankton, fish eggs and larvae, supporting physical oceanographic and nutrient chemical data, and marine bird and mammal observations. ... A limited amount of fish data was obtained as well. (Au)

J-25810

Report on biological literature review of the Labrador Sea region / MacLaren Atlantic Limited.

[Calgary : Distributed by APOA], 1977.

3 microfiches : figures, maps, tables ; 11x16cm.

(APOA project no. 138 : Environmental investigations and analysis in Davis Strait - second half 1977. Report, no. 2)

Prepared for Imperial Oil Ltd., Aquitaine Co. of Canada Ltd. and Canada Cities Services Ltd. J,I G09

CaACU

This report reviews the information available in the open scientific literature on the biological resources of the seas off coastal Labrador. ... The report is divided into five sections: Plankton, Benthos, Fish and Fisheries, Birds and Mammals. Spatial and temporal distributions, trophic relations and, where relevant, reproductive ecology are considered. ... The main source material was published within the last three decades, although a number of older papers and expedition reports were included when relevant. An important function of the report was identification of data gaps. ... (Au)

J-26506

Report on Cruise II, July, 1976. Environmental aspects of Imperial Oil cruise to Flemish Pass and Davis Strait / MacLaren Atlantic Limited.

[Calgary : Distributed by APOA], 1976.

2 microfiches : figures, tables ; 11x16cm.

(APOA project no. 135 : Biological studies in the vicinity of Hudson Strait, Davis Strait and Labrador Sea area - 1976. Report, no. 1)

Prepared for Imperial Oil Limited. References.

J,D G09

CaACU

The environmental program included observations and sampling for salinities, temperatures, plant nutrients (nitrate, nitrite, ammonium, phosphate, and silicate), phytoplankton (species numbers and identifications, chlorophyll a and phaeo-pigments), zooplankton and fish eggs, benthic organisms, marine birds and mammals. The program was designed to give as broad a picture as possible of the marine ecosystem in these locations within the necessarily limiting constraints of the program. In summarizing the results, the data have been dealt with from the south to the north. (Au)

J-26522

Report on Cruise III, October-November, 1976 and Cruise IV, November-December, 1976.

Environmental aspects of the Imperial Oil cruises to Davis Strait, Hudson Strait, and Flemish Pass / MacLaren Atlantic Limited. [Calgary : Distributed by APOA], 1977.

5 microfiches : figures, tables ; 11x16cm.

(APOA project no. 135 : Biological studies in the vicinity of Hudson Strait, Davis Strait and Labrador Sea area - 1976. Report, no. 3)

Prepared for Imperial Oil Limited.

Appendices.

References.

J,D G09

CaACU

Both cruises extended the results of the preliminary program developed on Cruise II. ... The environmental program for Cruise III included observations and sampling for marine birds and mammals, nutrients and salinities, phytoplankton (chlorophyll-phaeophytin and cell identifications and counts, zooplankton, fish eggs and larvae, and benthic organisms. Most environmental stations were supported with salinity-temperature-depth information. ... The data, as a whole, provide information on the seasonal occurrence and horizontal and vertical distributions of phytoplankton, zooplankton, and fish eggs and larvae. These can be related to water structure and water masses. Information is also provided on distributions of benthic organisms, and seasonal and geographical distributions of marine birds and mammals. (Au)

J-26530

Report on primary data collected for the 1977 Davis Strait biological programme and analyzed prior to December, 1977 / MacLaren Atlantic Limited.

[Calgary : Distributed by APOA], 1977.

8 microfiches : figures, maps, tables ; 11x16cm.

(APOA project no. 138 : Environmental investigations and analysis in Davis Strait - second half 1977. Report, no. 3, v. 1-2)

Prepared for Imperial Oil Ltd., Aquitaine Co. of Canada Ltd. and Canada Cities Services Ltd. J,D G09

CaACU

The aim of the primary data report is to make available the unpublished data used in the compilation of the impact statement. Brief descriptions of sampling methods used for the temperature-salinity data and for the aerial surveys have been included as these methods have not yet been published. Remaining descriptions of sampling methods and listings of data are found in published works referenced in the impact statement. The data presented here will appear also in the appropriate future publications together with critical discussions of data and methods, where applicable. Three

lots of data from the two 1976 cruises and the first 1977 cruise have also been included. An error was discovered in the chlorophyll calculation method, so all previous data were corrected prior to use in the impact statement. ... The complete marine mammal sighting data for the first 1977 cruise, Cruise 77-1, are also included in tabular form to make the data presentation consistent with data tabulation on subsequent cruises. ... (Au)

J-29920

Truelove Lowland, Devon Island, Canada : a high Arctic ecosystem / Edited by L.C. Bliss. Edmonton : University of Alberta Press, [c1977].
xxi, 714 : ill., maps, photos., graphs, tables : 24cm.
(APOA project no. 55 : Arctic environmental research 1973 (Devon Island IEP project). Report)
ISBN J-88864-314-5
References.
J,H,I G08124
CaACU

... The book is organized into sections dealing with the various categories of research. The abiotic components are studied first: micrometeorological studies are included in this section. The vegetation is dealt with next with the following papers on the primary producers: lowland sedge moss communities, cushion plant communities, dwarf shrub communities, bryophyte vegetation, and lichens. Further papers are devoted to the primary production processes: evapotranspiration, biological nitrogen fixation, and photosynthesis. There are five papers each on the invertebrate and vertebrate consumers, and three on microbiology and decomposition. The book concludes with papers on the limnology of three lakes, on ecosystem models, the Inuit, and industrial development. (Au)

J-30112

Northern ecosystem and northern development / R.W. Wein [and] L.C. Bliss.
(CIM bulletin, v. 64, no. 712, Aug. 1971, p. 74-76, photos.)
(APOA project no. 37 : Arctic environmental research, tundra and ecological studies on the Mackenzie Delta and Devon Island. Report)
References.
J G081
CaACU

Northern ecosystems are dominated by a harsh physical environment which dictates a need for biological adaptation. As yet, it is unknown just how these adapted plants and animals will tolerate industrial development. Our work, sponsored by university, government and industry, is part of an effort to evaluate this developmental impact. ... (Au)

See Also : C-30236, D-26514, H-30163, I-25275, L-25623, L-25631, L-25640, L-29947, L-29955, Q-12939, Q-12947, Q-12955, Q-12963, Q-12971, Q-13030, Q-13528, Q-15555, Q-18155, Q-19348, Q-19364, Q-19372, Q-19801, Q-25291, Q-25798, Q-26700, Q-29890, Q-29912, Q-30366, Q-30074, Q-30082, Q-30090, Q-30201, Q-30210, Q-30228, Q-30252, Q-30287, Q-30805, Q-30821, Q-30856, Q-30864, Q-30872, S-30830, X-30317

K - MEDICINE, HUMAN PHYSIOLOGY, AND PUBLIC HEALTH

K-24554

Laboratory testing of commercial Arctic clothing submitted by the Arctic Petroleum Operators' Association / by R.W. Nolan [Defence Research Establishment Ottawa].
[Calgary : Distributed by APOA], 1973.
2 microfiches : tables : 11x16cm.
(APOA project no. 45 : Arctic clothing study. Report, no. 2,3)
(DREO technical memorandum, no. 73- 4)
Report no. 3 is Addendum no. 1 to DREO technical memorandum, no. 73- 4.
References.
K,Q G081
CaACU

Eight types of commercial parka and three types of military outfit have been tested in a laboratory for both behaviour and properties under Arctic conditions, and resistance to tearing. From the laboratory tests, two types of commercial parka were chosen and tested in the field along with the military outfits. Field tests were conducted by having drilling and seismic crew personnel wear the clothes during their normal work and observing their behaviour and recording their comments. (Au)

K-25550

A study of the clothing problems of the oil operating crews in the Arctic / by S.H.H. Pang and A.R. Lock, Defence Research Establishment Ottawa.
[Calgary : Distributed by APOA], 1972.
2 microfiches : tables : 11x16cm.
(APOA project no. 24 : Arctic clothing study. Report)
(Report - Canada. Defence Research Establishment Ottawa)
Appendices.
With Lewis, Ronald E.F. Arctic oil drilling operations : some human factors engineering observations.
K,Q G081
CaACU

A study has been conducted ... to investigate the problems related to clothing and protective equipment that arise during various Arctic oil operations. Visits were made to a number of Arctic operating sites to observe the men working and discuss with them their clothing problems. Additionally, a number of clothing ensembles were supplied to APOA for a small scale field trial. In an attempt to obtain more information about the clothing problems, questionnaires were sent to the oil operators via APOA. The clothing system currently used by the oil crews is inadequate in one way or another; therefore, most men require improved clothing and protective equipment to a varying degree. The clothing system should be warm, lightweight, unrestrictive and durable as well as being oil and water repellent. However, the area of immediate concern is head (face) and hand protection. As far as body clothing design is concerned, a two-piece trim fitting clothing ensemble would be best for the majority of operations carried out in a drilling or seismic operation. Recommendations are made with respect to the short and long term applied research required to solve the clothing-related problems which were identified. ... (Au)

K-25615

A study of Arctic clothing for oil operating crews / by S.H.H. Pang and A.R. Lock, Defence Research Establishment Ottawa.
[Calgary : Distributed by APOA], 1973.
1 microfiche : tables : 11x16cm.

(APOA project no. 45 : Arctic clothing study. Report, no. 1)
(DREC report, no. 680)
Appendices.
References.
K,C G08121
CaACU

A study has been conducted ... to investigate the suitability of an experimental clothing ensemble and certain experimental and modified Canadian Forces (CF) equipment as well as standard and commercial parkas, for the environmental protection of seismic and drilling crews in the Arctic. ... It was concluded that none of the trial clothing will be entirely suitable for the oil crews unless some modifications are made. Among the trial clothing the Eskimo style pile-insulated garment was found to be best suited for the majority of oil crew workers. The treated CF coveralls proved to be an effective oil and water repellent garment. The CF mukluks were found to be suitable for the seismic crews; and the modified CF face mask proved to be better than commercially available face masks. It is recommended that investigation should be carried out to determine if some of the standard and modified CF items could be made available to the oil crews and if some of the modifications to the various types of clothing could be incorporated by the manufacturers. (Au)

L - COMMUNICATIONS AND TRANSPORTATION

L-21270

Preliminary Arctic engineering study of surface transport vehicles / prepared by J.E. Rymes Engineering Ltd.
[Calgary : Distributed by APOA], 1970.
5 microfiches : ill. : 11x16cm.
(APOA project no. 7 : Cross-country vehicle study. Report)
Appendices.
References.
L,C G08121
CaACU

The object of this study is to outline in a preliminary engineering sense the state of the art of surface transport vehicles and equipment now considered to be production hardware. Also included are those vehicles and equipment that are being considered for production in the foreseeable future. Our study at this time will be somewhat restrictive as our investigation will be related only to the low Arctic region with particular emphasis on the Mackenzie River delta area. At the same time, the vehicles and equipment selected will be primarily concerned with seismic and geophysical activities although in many instances, some of the vehicles may also be used for general Arctic transport work. Since a study of the state of the art of off highway vehicles generally implies some areas of dissatisfaction with current designs, accordingly our study will reflect on the general manner in which the selected vehicles are designed and to comment on what has been done to accommodate them for Arctic use. ... (Au)

L-24562

Arctic winter evaluation study of transportation equipment / prepared by J.E. Rymes Engineering Ltd.
[Calgary : Distributed by APOA], 1973.
4 microfiches : ill., figures : 11x16cm.
(APOA project no. 49 : Study of Arctic transportation equipment - Mackenzie Delta. Report)
Prepared for Gulf Oil Canada Limited.

References.
L,Q G08121
CaACU

The purpose of the study was to evaluate the effectiveness of the equipment being utilized for rig moves and logistic operations in the Mackenzie Delta. In general, the report examines in some detail the type and mix of equipment being utilized in northern operations, studies the problems and failures of the equipment and discusses possible methods of resolving the problems including improved maintenance techniques and design improvements. In addition, the study reviews and discusses potential uses of new equipment and more effective uses of existing equipment. (Au)

L-24716

Arctic winter test and evaluation of Kenworth Truck Model 553A / prepared by J.E. Rymes Engineering Ltd.
[Calgary : Distributed by APOA], 1972.
5 microfiches : ill., figures : 11x16cm.
(APOA project no. 21 : Evaluation of desert type 6 x 6 oilfield truck in Arctic conditions. Report, no. 1-3)
References.
Contents: no.1 Initial stage. - no.2 Mid-winter stage. - no.3 Late winter stage.
L,Q G08121
CaACU

A 6 x 6 oilfield truck with large low pressure tires was purchased for cross-country hauling in the Mackenzie Delta area during the winter. This project was designed to evaluate the vehicle's cross-country mobility, its overall performance as an oilfield truck in winter conditions, and the performance of various mechanical components. In particular, the behaviour of the tires in snow was observed and recommendations for tire design were made for work in unprepared terrain. ... (Au)

L-25623

Inspection of winter roads, Mackenzie Delta, following spring thaw, 1973 / by Muskeg Research Institute, [University of New Brunswick].
[Calgary : Distributed by APOA], 1973.
1 microfiche : ill. : 11x16cm.
(APOA project no. 48 : Documentation of vehicular traffic on Mackenzie Delta tundra - 1972. Freeze-up and 1973 thaw. Report, no. 1)
L,J G08121
CaACU

... At no point along the winter roads did terrain disturbance of environmental or ecological significance occur. In the future, provided adequate snowfall occurs and sufficient snow cover can be maintained on the road right-of-way, it may be possible to reduce terrain disturbance on winter roads to an even lower level should this be desirable. (Au)

L-25631

Winter road preparation and commencement of traffic in the Mackenzie Delta / by Muskeg Research Institute, University of New Brunswick.
[Calgary : Distributed by APOA], 1972.
1 microfiche : ill., figures : 11x16cm.
(APOA project no. 49 : Documentation of vehicular traffic on Mackenzie Delta tundra - 1972. Freeze-up and 1973 thaw. Report, no. 2)
Contents: Pt. 1 Use of Rolligon for winter road preparation. - Pt. 2 Commencement of regular traffic on winter roads on Richards Island.
L,J G08121
CaACU

... In the interest of avoiding unnecessary environmental disturbance ... it is important

to schedule the commencement of winter road preparation in such a way that ground conditions are taken into account. ... This part of the report describes the results of an experimental operation carried out to evaluate the application of a Rolligon RD85 vehicle in preparing a winter road on Richards Island ... and moving equipment at the earliest date during freeze-up while avoiding disturbance of the tundra surface. (Au)

L-25640

Factors affecting use of winter roads during spring thaw / [by] Muskeg Research Institute, University of New Brunswick.
[Calgary : Distributed by APOA], 1973.
1 microfiche : ill., figures ; 11x16cm.
(APOA project no. 48 : Documentation of vehicular traffic on Mackenzie Delta tundra - 1972. Freeze-up and 1973 thaw. Report, no. 3)
L,J G08121
CaACU

... In the interest of avoiding unnecessary environmental disturbance ... it is important to schedule the commencement of winter road preparation in such a way that ground conditions are taken into account. ... This part of the report describes the results of an experimental operation carried out to evaluate the application of a Rolligon RD85 vehicle in preparing a winter road on Richards Island ... and moving equipment at the earliest date during freeze-up while avoiding disturbance of the tundra surface. (Au)

L-25747

Technical specifications of a large Arctic truck for Imperial Oil Limited, Calgary, Alberta / prepared by J.E. Rymes Engineering Ltd.
[Calgary : Distributed by APOA], 1973.
3 microfiches : figures ; 11x16cm.
(APOA project no. 56 : Preparation of specifications for large Arctic truck. Report)
Prepared for Imperial Oil Limited.
References.
L,Q G081
CaACU

Purpose: To prepare a set of technical specifications for a large Arctic truck (Kenworth Model 953A), to ensure that recommended improvements were incorporated into any new units ordered by participants in this project. Discussions were held with various field operators to determine the most desirable features for optimum winter truck operations. (Au)

L-27545

Statistical study of passage into the Beaufort Sea via Point Barrow / by S.E.G. Wilson.
[Calgary : Distributed by APOA], 1977.
2 microfiches : figures, tables ; 11x16cm.
(APOA project no. 113 : Passage into Beaufort Sea via Point Barrow. Report)
Appendices.
References.
L G07
CaACU

The purpose of this study was to determine the probability of successfully transporting a large, deep draft vessel from the Pacific Ocean, via Point Barrow, Alaska, to MacKenzie Bay in the Southeast Beaufort Sea, during any given summer season. Specifically, the purpose was to evaluate transportation through those areas where the transportation depends on sea ice conditions, for minimum water depths of 20, 30, and 40 feet. ... For the most realistic cases (i.e. 3 knots in open water, 2 knots in 1 to 3 tenths ice cover, 1 knot in 4 to 6 tenths ice cover, 0 otherwise, for minimum water depths of 20, 30, and 40 feet) the simulations

showed success in every year but 1975, of the 16 years 1962 to 1977, inclusive, for a probability of success of 94%. This compares well to the estimates of experienced people, who suggested probabilities of success between 88% and 97%. The simulations confirm the expected result that the higher the vessel speed, the lower the minimum water depth, and the greater the capacity for travel through ice, the greater will be the success rate for a given starting date, and the shorter the average travel time. (Au)

L-29947

Immediate effects of wheeled vehicle traffic on tundra during the summer / J.R. Radforth, Muskeg Research Institute, Univ. of New Brunswick.
[Ottawa : Dept. of Indian Affairs and Northern Development, 1973].
v, 32p. : ill., photos. ; 28cm.
(APOA project no. 38 : APOA-DIAND transportation study. Report, no. 1)
([Report] - Canada. Arctic Land Use Research Program, ALUR 72-73- 12)
(North of 60)
Prepared under contract for the Arctic Land Use Research Program.
References.
L,J G08121
CaACU

Field tests were conducted at Tununuk (Bar C) on Richards Island, N.W.T., in July 1972 to determine the immediate effects on the tundra surface of operating wheeled vehicles during the summer. Four vehicles were operated on four test sites and the sites were photographed and described by use of the MRI Tundra Disturbance Classification System. The results were compared with those of tracked vehicle tests conducted earlier at the same sites. Although the terrain responded differently to different wheeled vehicle types it was apparent that vehicles with large soft tires created less disturbance than tracked vehicles of the same weight. The test sites should be inspected at two year intervals to confirm predictions of long term effects of wheeled vehicle traffic. (Au)

L-29955

Long term effects of summer traffic by tracked vehicles on tundra / J.R. Radforth, Muskeg Research Institute, Univ. of New Brunswick.
[Ottawa] : Information Canada, 1973.
iv, 60p. : ill., photos. (part. col.), tables ; 28cm.
(APOA project no. 38 : APOA-DIAND transportation study. Report, no. 2)
(Report - Canada. Task Force on Northern Oil Development, no. 73- 22)
([Report] - Canada. Arctic Land Use Research Program, ALUR 72-73- 13)
Prepared under contract for Arctic Land Use Research Program.
Cover title: Effects of summer traffic on tundra.
References.
L,J G08121
CaACU

In 1970 tests were carried out with tracked vehicles on test sites at Tuktoyaktuk and Tununuk, N.W.T., and at Shingle Point, Y.T. ... During the summer of 1972, the test sites were visited to observe the development of new vegetation on the disturbed ground, and measure changes in rut depth and frost depth in the tracks left by the vehicles. ... The major conclusions of the study are as follows: 1. The amount of vegetative regrowth on a disturbed site is dependent on the level of disturbance initially inflicted upon the site. Lower levels of disturbance result from low numbers of passes and from use of light weight vehicles.

2. Thermokarst is related to disturbance level but, for all terrain types tested, stabilizes within two years following disturbance so that the new permafrost table beneath the vehicle rut is roughly equal to its original depth below the undisturbed ground surface. (Au)

See Also : G-25534

Q - PETROLEUM, NATURAL GAS, AND PIPELINES

Q-11592

The effect of contact and ingestion of crude oil on ringed seals of the Beaufort Sea / [by] Thomas G. Smith and Joseph R. Geraci. Victoria, B.C. : Beaufort Sea Project, Dept. of the Environment, 1975.
ii, 66p. : ill., tables ; 28cm.
(Technical report - Canada. Beaufort Sea Project, no. 5)
(APCA project no. 72 : Beaufort Sea Environmental Program. Report, no. 5)
Cover title: Effect of contact and ingestion of crude oil on ringed seals.
References.
Q,I G07
CaACU

... This paper attempts to evaluate the effects of crude oil on ringed seals primarily, and on harp seal whitecoat pups. Studies were conducted on both the effect of immersion in oil and ingestion of oil on wild and captive seals (Au)

Q-11657

Biodegradation of crude petroleum by the indigenous microbial flora of the Beaufort Sea / [by] J.N. Bunch and R.C. Harland. Victoria, B.C. : Beaufort Sea Project, Dept. of the Environment, 1976.
iii, 52p. : graphs, tables ; 28cm.
(Technical report - Canada. Beaufort Sea Project, no. 13)
(APCA project no. 72 : Beaufort Sea Environmental Program. Report, no. 13)
Bibliography: p.42-44.
Q,H G07
CaACU

... The objectives of this study were to: 1. determine if a biodegradation potential exists in the south Beaufort Sea. 2. determine rates of degradation at various temperatures including 0 deg. C by various cultures isolated. 3. determine optimum temperatures for oil degradation and the requirements for nitrogen and phosphorus at optimal and sub-optimal temperatures. 4. determine, if possible, in situ rates of biodegradation. (Au)

Q-12939

[Report] - Industry/Government Working Group in Disposal Waste Fluids from Petroleum Exploratory Drilling in the Canadian North. [Edmonton : Environmental Protection Service, Environment Canada, 1974-76].
12v. : ill., tables, graphs, figures, maps ; 28cm.
Publisher varies.
Studies were jointly funded by Arctic Petroleum Operators Association and the Federal Government.
Appendices.
References.
Q,J G081
CaACU

A series of thirteen reports investigating the pollution problems associated with present methods of handling sump and drilling fluids

from offshore and onshore drilling operations, and the development of effluent standards for disposal of these fluids. (ASTIS)

Q-12947

Summary report of industry/government research on pollution from drilling wastes / by Industry/Government Working Group "A" under the auspices of the Arctic Petroleum Operators Association and Environment Canada. [Edmonton : Environmental Protection Service, Environment Canada], 1976.
1v. (various pagings) : tables ; 28cm.
[[Report] - Industry/Government Working Group in Disposal Waste Fluids from Petroleum Exploratory Drilling in the Canadian North, v. 1)
Bound with Stanley Associates Engineering, A review of research on pollution aspects of drilling and sump fluids.
References.
Q,J G081
CaACU

Presents the Group's Terms of reference, Magnitude of pollution problem statement, General recommendations, a list of accompanying Research reports, and the Interim guidelines for disposal of waste fluids from petroleum exploratory drilling in the Canadian North. (ASTIS)

Q-12955

Water pollution characteristics of drilling wastes from land based exploratory northern drilling operations / by W.J. Bryant, [and] S.E. Hrukey. [Edmonton] : Environmental Protection Service, Northwest Region, 1975.
1v. (unpaged) : ill., figures, tables ; 28cm.
[[Report] - Industry/Government Working Group in Disposal Waste Fluids from Petroleum Exploratory Drilling in the Canadian North, v. 3)
Appendices.
References.
Q,J G08121
CaACU

... drilling sump fluids possess chemical characteristics such as high dissolved, total suspended and volatile suspended solids, barium, aluminum, chromium, potassium and chemical oxygen demand which are capable of creating water pollution problems. Screening of the chemical characteristics in relation to acute lethal toxicity results failed to identify any one single parameter responsible for acute lethal toxicity in all samples, but several parameters were implicated for various samples. (Au)

Q-12963

Monitoring of two exploratory drilling sites in the shallow regions of Mackenzie Bay / by S.E. Hrukey [and] J.D. McMullen. [Edmonton] : Environmental Protection Service, Northwest Region, Environment Canada, 1975.
1v. (unpaged) : figures, tables ; 28cm.
[[Report] - Industry/Government Working Group in Disposal Waste Fluids from Petroleum Exploratory Drilling in the Canadian North, v. 4)
Appendices.
References.
Q,J G08121
CaACU

Discusses drilling operations, waste inventory, and receiving water monitoring from Inmerk B-48 and Adgo F-28, two offshore drilling operations from artificial islands in Mackenzie Bay. (ASTIS)

Q-12971

Drilling fluids wastes characteristics from drilling operations in the Canadian North / [by] Clark A. Siferd.
[Edmonton : Environmental Protection Service, Northwest Region, Environment Canada], 1975.
130p. : graphs, figures, maps ; 28cm.
[[Report] - Industry/Government Working Group in Disposal Waste Fluids from Petroleum Exploratory Drilling in the Canadian North, v. 5)
Appendices.
References.
Q,J G081
CaACU

Drilling muds from sampling sites in the Mackenzie Delta, Sabine Peninsula, Fyn Point, and Hudson Bay areas are subjected to chemical testing, toxicity testing, monitoring of mud chemical usage, water usage and waste streams, chemical oxygen demand-solids testing, oil and grease experiment, and microbial testing.
(ASTIS)

Q-12980

Acute toxicity of discharged drilling muds from Immerk B-48, Beaufort Sea to rainbow trout, *Salmo gairdneri* (Richardson) / by R.H. Weir, W.H. Lake [and] B.T. Thackeray.
Edmonton : Environmental Protection Service, Bioassay Laboratory, 1974.
37p. : tables ; 28cm.
[[Report] - Industry/Government Working Group in Disposal Waste Fluids from Petroleum Exploratory Drilling in the Canadian North, v. 6)
Appendices.
References.
Q,I G08121
CaACU

... This study was undertaken to gather preliminary acute toxicity information on the drilling fluid discharge of an active well. ... Acute toxicity bioassay procedures involved exposing rainbow trout (*Salmo gairdneri* Richardson) to varying concentrations of drilling fluid discharge under static conditions for 96 hours. ... (Au)

Q-12998

Acute toxicity of ten selected Arctic drilling sumps to rainbow trout, *Salmo gairdneri* (Richardson) / by R.H. Weir, W.H. Lake [and] B.T. Thackeray.
Edmonton : Environmental Protection Service, Bioassay Laboratory, 1974.
27p. : tables ; 28cm.
[[Report] - Industry/Government Working Group in Disposal Waste Fluids from Petroleum Exploratory Drilling in the Canadian North, v. 7)
Appendices.
References.
Q,I G081
CaACU

... Ten representative sumps were chosen for bioassay testing The ten samples were bioassayed for acute toxicity. Test procedures involved exposing rainbow trout (*Salmo gairdneri* Richardson) to various concentrations of sump fluid under static conditions for 96 hours. ... (Au)

Q-13005

Acute toxicity of drilling fluids to rainbow trout *Salmo gairdneri* (Richardson) / by B. Moore, A. Beckett [and] R.H. Weir.
Edmonton : Environmental Protection Service, Aquatic Toxicology Laboratory, 1975.
ix, 93p. : graphs, tables ; 28cm.
[[Report] - Industry/Government Working Group in Disposal Waste Fluids from Petroleum

Exploratory Drilling in the Canadian North, v. 8)
Bibliography: p.85-87.
Q,I G081
CaACU

A one year program was carried out from May, 1974 to May, 1975 to determine the acute toxicity of drill fluids from selected exploratory Arctic rigs to Rainbow Trout. A 96 hour static bioassay, without replacement, was used to assess the sample's toxicity. The sample concentration causing 50% mortality at 96 hours ... was determined. All except one sample proved to be acutely toxic within 96 hours. ... Conclusions and recommendations were made with regards to drill fluid toxicity in the Arctic based on the samples tested. (Au)

Q-13013

Acute toxicity of drilling components to rainbow trout *Salmo gairdneri* (Richardson) / by A. Beckett, B. Moore [and] R.H. Weir.
Edmonton : Environmental Protection Service, Aquatic Toxicology Laboratory, 1975.
ix, 88p. : figure, table ; 28cm.
[[Report] - Industry/Government Working Group in Disposal Waste Fluids from Petroleum Exploratory Drilling in the Canadian North, v. 9)
Bibliography: p.86-88.
Q,I G081
CaACU

Acute toxicity testing on rainbow trout (*Salmo gairdneri* Richardson) was conducted for 34 selected drilling components. From this testing, the concentration at which 50% mortality would occur in a population of trout in 96 hours, the 96 hr. lethal concentration to 50% mortality (96 hr. LC50) was determined for each component. ... It was concluded that these components can add to the toxicity of drilling fluids and that their use in the Canadian Arctic should be carefully controlled. (Au)

Q-13021

Marine toxicity studies on drilling fluid wastes / prepared by Division of Applied Biology, B.C. Research.
[Edmonton : Environment Canada, Environmental Protection Service, 1975].
ii, [28]p. : tables ; 28cm.
[[Report] - Industry/Government Working Group in Disposal Waste Fluids from Petroleum Exploratory Drilling in the Canadian North, v. 10)
References.
Q,I G08121
CaACU

The acute toxicity of seven Arctic drilling fluid wastes to freshwater and seawater-acclimated salmonid fishes and to four intertidal invertebrate species (worms, clams, crabs and shrimp) was determined in freshwater and seawater 96-hr LC50 static bioassays. ... (Au)

Q-13030

A preliminary study of the effects of oil well drilling sump fluids on some aquatic organisms of the Mackenzie Delta / by M.J. Hardin.
[S.l.] : Northwest Territories District Office, Environmental Protection Service, Northwest Region, Dept. of the Environment, [1976].
iii, 65p. : ill, figures, tables ; 28cm.
[[Report] - Industry/Government Working Group in Disposal Waste Fluids from Petroleum Exploratory Drilling in the Canadian North, v. 11)
References.
Q,J G08121
CaACU

95/

Studies were done to determine the toxic effects of four oil well drilling suspensions fluids on phytoplankton, chironomids, amphipods and fish from the Mackenzie Delta, N.W.T. Different levels of toxicity were detected in these wastes, and the organisms showed different degrees of sensitivity to the toxicants. (Au)

Q-13048

The effect of a drilling waste on the survival and emergence of the chironomid - Chironomus tentans (Fabricius) / by Andrew Didiuk and Dennis G. Wright.

[S.L.] : Fisheries and Marine Service, Resource Management Branch, Aquatic Toxic Studies Division, 1975.

iv, 19p. : graphs, tables ; 28cm.

([Report] - Industry/Government Working Group in Disposal Waste Fluids from Petroleum Exploratory Drilling in the Canadian North, v. 12)

References.

Q, I G39121

CaACU

... Laboratory studies were conducted to assess the effects of deposition of thin (1, 3 and 7 mm) layers of drilling wastes on the survival of larvae of the chironomid Chironomus tentans (Fabricius), using the emergence of adults as an index of survival. An average of 84% of the organisms emerged as adults from control tanks. Populations treated with 1 mm, 3 mm or 7 mm layers of drilling wastes achieved only 61%, 47% or 12% emergence, respectively. (Au)

Q-13331

The Canadian oil industry's scientific activities in the Arctic offshore / by A.E. Pallister.

Revised.

[Calgary] : Pallister Resource Management Ltd., 1977.

[23] leaves ; 28cm.

Presentation to Oil/Environment - 1977, an international symposium, Recovery of oiled northern marine environments, Halifax, Nova Scotia.

References.

Q G081

CaACU

Discusses the problem of oil pollution in cold water environments resulting from oil spills and increased drilling activity in Canadian Arctic waters. Summarizes the petroleum industries' activities in the Canadian Arctic, e.g. ice engineering research and environmental research. Includes a list of the Arctic Petroleum Operators Association projects released from confidential status at this time. (ASTIS)

Q-13528

A preliminary assessment of water pollution from abandoned oil and gas drilling sumps in the Northwest Territories / by S.E. Hruday, J. Michalchuk, J.D. McMullen.

[Edmonton] : Environmental Protection Service, Northwest Region, Environment Canada, 1974.

iii, [63]p. : ill., figures, tables ; 28cm.

([Report] - Industry/Government Working Group in Disposal Waste Fluids from Petroleum Exploratory Drilling in the Canadian North, v. 2)

Appendices.

References.

Q, J G08121

CaACU

..., this study was undertaken ... to assess the magnitude of any water pollution problems associated with abandoned (reclaimed) sumps in the Mackenzie Delta and Arctic Islands. The assessment was to be based on determining whether pollutant leaching from abandoned sumps

into subsurface and surface waters occurs. (Au)

Q-15490

The movement of oil under sea ice / [by] L.W. Rosenegger.

Victoria, B.C. : Beaufort Sea Project, 1975.

81p. : ill., figures, tables, charts ; 28cm.

(Technical report - Canada. Beaufort Sea Project, no. 28)

(APOA project no. 72 : Beaufort Sea Environmental Program. Report, no. 28)

Appendices.

Bibliography: p. 20-23.

Q, G G01

CaACU

This report presents the results of laboratory tests to determine the interfacial tension and motion of crude oil bubbles under sea ice. ... An assessment has also been made of: a) the ability of oil to penetrate sea ice from beneath, b) the equilibrium thickness of a crude oil film on water under arctic conditions, and c) the redistribution of solutes in the oil. (Au)

Q-15504

Light intensity and primary productivity under sea ice containing oil / [by] W.A. Adams.

Victoria, B.C. : Beaufort Sea Project, 1975.

156p. : ill., figures, charts, tables ; 26cm.

(Technical report - Canada. Beaufort Sea Project, no. 29)

(APOA project no. 72 : Beaufort Sea Environmental Program. Report, no. 29)

Bibliography: p. 34-39.

Q, G, H G08121

CaACU

... The scope of the present impact study is limited to assessment of some physical and chemical parameters of the ice covered Arctic sea subjected to under-ice crude oil discharges, especially those parameters which strongly influence marine plant growth such as light intensity. These have been correlated with algal activity, diversity, and abundance. ... (Au)

Q-15520

Hydrodynamics of an oilwell blowout / [by] D.R. Topham.

Victoria, B.C. : Beaufort Sea Project, 1975.

52p. : ill., figures, tables ; 23cm.

(Technical report - Canada. Beaufort Sea Project, no. 33)

(APOA project no. 72 : Beaufort Sea Environmental Program. Report, no. 33)

References.

Q G07

CaACU

... The work described in this report concerns the behaviour of the oil/gas mixture as it leaves the pipe exit, its transport to the sea surface, and the locally induced water flows. ... Two separate experiments were undertaken, a full-scale simulation of the gas bubble plume in 60 m of seawater using air compressors, and a tank experiment investigating the behaviour of gas/oil mixtures at an underwater pipe exit. As these two experiments were separate investigations, they are presented as self-contained sections and the major consequences are delineated in a separate section describing a probable blowout scenario. (Au)

Q-15547

Oil, ice and climate in the Beaufort Sea / [by] E.K. Walker.

Victoria, B.C. : Beaufort Sea Project, 1975.

40p. : figures, tables ; 28cm.

(Technical report - Canada. Beaufort Sea

Project, no. 35)
(APCA project no. 72 : Beaufort Sea
Environmental Program. Report, no. 35)
Bibliography: p.35-39.
Q,G,E G07
CaACU

The amount of crude oil which may be released to the environment during drilling in the Beaufort Sea is estimated. The effects of oil in terms of the Beaufort Sea surface heat budget are briefly discussed. Considering the amount of oil likely to be released in exploratory drilling, its movement, and its effect on the surface heat budget, it is estimated that to important climatic effects are likely. (Au)

Q-15535

Hydrocarbon levels in the marine environment of the southern Beaufort Sea / [by] C.S. Wong, W.J. Cretney, P. Christensen and B.W. Macdonald.
Victoria, B.C. : Beaufort Sea Project, 1976.
113p. : figures, map, tables ; 28cm.
(Technical report - Canada. Beaufort Sea Project, no. 38)
(APCA project no. 72 : Beaufort Sea Environmental Program. Report, no. 38)
Bibliography: p.108-113.
Q,J G07
CaACU

... The objectives of the investigation are:
(1) to establish the baseline hydrocarbon levels in the Southern Beaufort Sea drilling area by measuring classes of hydrocarbons and identifying some specific hydrocarbons in sea water, marine organisms, fish and surface sediments, (2) to assess the origin of present day hydrocarbons, whether anthropogenic or naturally-occurring, and (3) to understand the probable hydrocarbon pathways in case an oil spill or blow-out occurs in the area. ... (Au)

Q-15836

Through the looking glass : a review of an Industry/Public Interface Program in Canada's North / by Mary Collins, Mary Collins Consultants Limited.
Calgary : Pallister Resource Management Ltd., 1976.
17 leaves : ill. : 28cm.
Cover title.
Presentation to Beaufort Sea Symposium, University of Calgary.
Q G0812
CaACU

... The program was carried out on behalf of the petroleum industry's participation in the Beaufort Sea Project, The purpose of the information program was to develop a two way communication process about the environmental program between the public - particularly the people of the north - and industry. ... (Au)

Q-16241

The interaction of crude oil with Arctic sea ice / H&ACOR Engineering and Research Limited.
Victoria, B.C. : Beaufort Sea Project, 1975.
[200]p. : ill., figures, tables ; 28cm.
(Technical report - Canada. Beaufort Sea Project, no. 27)
(APCA project no. 72 : Beaufort Sea Environmental Program. Report, no. 27)
Appendices.
References.
Q,G G08121
CaACU

Presents a detailed study of petroleum pollution of sea ice and ice-covered waters by investigating several areas of oil and ice interaction: the plume, area of contamination,

incorporation, migration, effect of oil on ice growth, effect of oil on ice depletion, clean-up, and environmental impact. (ASTIS)

Q-18155

Proceedings - Arctic Environmental Workshop, 7th, Fairmont Hot Springs, B.C., April 12-15, 1978 / edited by S. Jones [and] D. Mackay.
Toronto : Institute for Environmental Studies of the University of Toronto, [1978].
iii, 161p. : figure ; 28cm.
(Publication - Toronto. University. Institute for Environmental Studies, EE 8)
Sponsored by the Arctic Petroleum Operators' Association and the Canadian Petroleum Association.
References.
Q,J G081
CaACU

Reviews current petroleum techniques and technologies now in use in the Arctic offshore, including underwater well completion, artificial islands, drilling vessel types and Beaufort Sea drilling. Environmental concerns studied include resources utilization, oil spills, and environmental regulatory processing. A list of registrants is provided. (ASTIS)

Q-19313

Arctic islands underwater completions / [by] I. J. Franklin.
(Proceedings - Arctic Environmental Workshop, 7th, Fairmont Hot Springs, B.C., April 12-15, 1978 / Edited by S. Jones [and] D. Mackay.
Toronto : Institute for Environmental Studies of the University of Toronto, [1978].
Publication - Toronto. University. Institute for Environmental Studies, EE 8, p. 19-24, ill., figures)
Q G08125
CaACU

... To date all of the significant gas reserves in the Arctic Islands have been found under, or extend under, the ice covered waters; Accordingly, Panarctic developed an offshore ice platform drilling system that was ... developed by "poor boy" modifications to two existing land drilling rigs The system has been established to be viable and significantly low in cost relative to alternatives available for offshore exploration procedures. ... (Au)

Q-19321

Technology update - artificial islands in the Beaufort Sea / [by] D. Garratt.
(Proceedings - Arctic Environmental Workshop, 7th, Fairmont Hot Springs, B.C., April 12-15, 1978 / Edited by S. Jones [and] D. Mackay.
Toronto : Institute for Environmental Studies of the University of Toronto, [1978].
Publication - Toronto. University. Institute for Environmental Studies, EE 8, p. 25-38, ill.)
Q G07
CaACU

... I will briefly outline the physical environmental conditions to which the islands are exposed; describe how the island design contends with the environmental conditions; and, finally touch on some of the construction and operational constraints in building artificial islands in the area. (Au)

Q-19330

Drilling vessel types / [by] C. Ple.
(Proceedings - Arctic Environmental Workshop, 7th, Fairmont Hot Springs, B.C., April 12-15, 1978 / Edited by S. Jones [and] D. Mackay.
Toronto : Institute for Environmental Studies of the University of Toronto, [1978].

Publication - Toronto. University. Institute for Environmental Studies, EE 8, p. 39-46, ill.)
Q G09
CaACU

Describes the different kinds of drilling vessels used by Total Eastcan for offshore drilling in the Labrador Sea. These vessels have to cope with icebergs in the area. (ASTIS)

Q-19348

Offshore Environmental Studies Panel / by G. Reapel [and N.B. Snow].
(Proceedings - Arctic Environmental Workshop, 7th, Fairmont Hot Springs, B.C., April 12-15, 1978 / Edited by S. James [and] D. Mackay.
Toronto : Institute for Environmental Studies of the University of Toronto, [1978].
Publication - Toronto. University. Institute for Environmental Studies, EE 8, p. 74-85)
Contents: - Introduction, by G. Reapel. - Results of panel discussions, by N.B. Snow.
Q,J G081
CaACU

States the results of six questions compiled for discussion by the Panel at the workshop. Areas of discussion include the scientific and industry goals in environmental studies; the optimum time frame for environmental studies; the importance of the types of study; the validity of an impact measurement approach vs. prediction; the merits of short-term vs. long-term impact studies; the usefulness of environmental study guidelines on assessment and review process. (ASTIS)

Q-19364

Oilspill workshop / by A.S. Telford [and D.E. Thornton].
(Proceedings - Arctic Environmental Workshop, 7th, Fairmont Hot Springs, B.C., April 12-15, 1978 / Edited by S. James [and] D. Mackay.
Toronto : Institute for Environmental Studies of the University of Toronto, [1978].
Publication - Toronto. University. Institute for Environmental Studies, EE 8, p. 103-117)
Contents: - Introduction, by A.S. Telford. - Results of panel discussions, by D.E. Thornton.
Q,J,G G081
CaACU

... items we will consider are spill conditions and logistics. ... methods of monitoring slick movement, ice movement, weather conditions and seastate. ... oil-ice interaction, spreading of oil between floes, slick movement and rates of evaporation and dispersion. ... tests to determine the effectiveness of in-situ burning, and the effectiveness of dispersants and whether we should perform any equipment tests at a spill site. ... (Au)

Q-19372

A review of the offshore environmental legislation and regulatory processes / by Murray J. Morison [and] Harry E. Palmer.
(Proceedings - Arctic Environmental Workshop, 7th, Fairmont Hot Springs, B.C., April 12-15, 1978 / Edited by S. James [and] D. Mackay.
Toronto : Institute for Environmental Studies of the University of Toronto, [1978].
Publication - Toronto. University. Institute for Environmental Studies, EE 8, p. 118-132)
Q,J G081
CaACU

The purpose ... is to review the legislation and governmental procedures dealing with offshore drilling north of the 60th parallel. Our workshop will discuss the legislation and the processes that lead up to the approval of

an offshore drilling program and we will review the appropriateness of selected environmental operating conditions as they appear in the drilling authorities. ... (Au)

Q-19798

Beaufort Sea drilling / [by] M.B. Todd.
(Proceedings - Arctic Environmental Workshop, 7th, Fairmont Hot Springs, B.C., April 12-15, 1978 / Edited by S. James [and] D. Mackay.
Toronto : Institute for Environmental Studies of the University of Toronto, [1978].
Publication - Toronto. University. Institute for Environmental Studies, EE 8, p. 47-66)
Q G07
CaACU

Describes the drilling program jointly undertaken by Canadian Marine Drilling and Dore Petroleum in the Beaufort Sea. Describes oil-spill countermeasures, blowout preventer protection, mooring systems, well planning and design, drilling equipment, and support services that enable the two companies to carry out their drilling and exploration programs. (ASTIS)

Q-19801

A biologist looks at oil in the sea / [by] K.H. Mann.
(Proceedings - Arctic Environmental Workshop, 7th, Fairmont Hot Springs, B.C., April 12-15, 1978 / Edited by S. James [and] D. Mackay.
Toronto : Institute for Environmental Studies of the University of Toronto, [1978].
Publication - Toronto. University. Institute for Environmental Studies, EE 8, p. 67-73)
Q,J G081
CaACU

Describes the effect of oil spills on marine life. (ASTIS)

Q-21288

Arctic drilling operations guide / [Arctic Petroleum Operators' Association].
[Calgary : Distributed by APOA, 1970?].
4 microfiches : 11x16cm.
(APOA project no. 8 : APOA Drilling Committee. [Report])
Q G081
CaACU

The APOA Drilling Committee was formed early in 1970 to act as a technical advisory group on Arctic operating problems generally common to member companies who were, or expect to be, involved in drilling operations in the Arctic. The problems to be dealt with included well control and blowout prevention, safety practices, environmental control, construction, communications and navigation, transportation and other drilling operations. It was agreed that an "APOA Drilling Guide" would be used to publish the technology selected by the committee. Preventative maintenance and planning were to be stressed. ... (Au)

Q-23345

Feasibility study exploratory drilling systems Beaufort Sea / by Acres/Santa Fe Fomeroy Arctic Services.
[Calgary : Distributed by APOA, 1971].
7 microfiches : ill. : 11x16cm.
(APOA project no. 12 : Feasibility study of exploratory drilling in the Beaufort Sea. Report)
Contents: - v.1. Final report. - v.2. Appendices.
Q G07
CaACU

... The study area was confined to within the 200 ft. isobath, stretching east-west from Cape

Bathurst to Herschel Island, encompassing therefore, both polar pack ice and shore-fast ice. The project was started in November 1970 and was completed in October 1971. Design criteria were developed for eight design zones within the study area In the first part of the study some 59 alternate designs for year-round concepts were developed and seven seasonal concepts were considered. In the case of year-round concepts, preliminary designs for concepts were provided together with fairly comprehensive cost estimates for concepts, ancillary and support units such as dredges, derrick barges, supply boats, etc. Also considered were methods of construction, logistics problems and preliminary schedules for final design and construction, transportation and operation. Problems of mobilizing a major structure in the Arctic or round Point Barrow and those of Arctic field construction were investigated. ... In the second part of the study a more detailed study was performed on a conical structure for a maximum water depth of 120 ft. A detailed cost estimate was worked out to include all charges for design, construction, towing, insurance and ancillary equipment. (Au)

Q-24449

Arctic drilling barge study / Westburne - Foundation - Sedco.
[Calgary : Distributed by APOA, 1971].
4 microfiches : diagrams, tables ; 11x16cm.
(APOA project no. 13 : Arctic drilling barge study. Report, no. 1)
Appendices.
References.
Q,G G07
CaACU

Purpose: To determine the best configuration for a self-contained exploratory drilling barge capable of offshore drilling in the Beaufort Sea for the maximum number of days during what is known as the "open water season". It must also be able to work through the longer winter season either by transferring equipment to a land site, or by drilling with the vessel frozen into a sheltered harbour, or both. Estimate the capital and operating costs involved and provide an overall daily operating cost based on two and five year contracts. The study includes the following main sections: (1) Study of ice conditions and development of criteria for design, operation and access. (2) Preliminary design of drilling equipment, living quarters, barge, mooring system and wellhead equipment. (3) Operating efficiency, logistics and costs. .. The study ... covers the Beaufort Sea within the 600 foot isobath from the coastline to 70 deg. N and from a line 139 deg. W to a line 128 deg. W. The prime work area is in water depths less than 250 feet with maximum interest in areas with water depths between 60 feet and 150 feet. ... (Au)

Q-24461

Northern oil and gas production related employment opportunities : the impact of Mackenzie Delta production / by Denis DePape, Boreal Institute for Northern Studies, University of Alberta.
[Calgary : Distributed by APOA], 1973.
4 microfiches : charts, map ; 11x16cm.
(APOA project no. 34 : Northern resources research project. Report)
References.
Q,R G08121
CaACU

Purpose: Study of the actual and potential economic benefits of oil, gas and minerals to northern settlements. Systems analysis of the economics of resources in the north, the contribution they are making to northern livelihood and ways of increasing this contribution. Analysis of labour requirements

and skills locally available. The study will be primarily based on the collection and interpretation of existing data. (Au)

Q-24520

Arctic offshore pipeline feasibility study in Mackenzie River Delta area / [by] R.J. Brown and Associates.
[Calgary : Distributed by APOA], 1973.
9 microfiches : figures, maps, tables ; 11x16cm.
(APOA project no. 39 : Arctic offshore pipeline feasibility study. Report)
Q G08121
CaACU

Purpose: To determine the technical feasibility of installing pipelines offshore Mackenzie Delta to the 150' water depth contour. Estimates of installation costs are to be provided in order to establish economic feasibility. Laybarge, Pull, and Reel-barge pipelaying methods are to be considered; limits of technical applicability for each method are to be established and problems identified. Thermal effects of the pipeline will be examined and adequate measures to prevent melting of any existing offshore permafrost will be considered. The study will analyze available scour information, evaluate risk and determine pipeline burial requirements and costs. Trenching techniques form an important aspect of the study. The project is essentially a feasibility study of Arctic offshore pipelines and not a detailed design for a specific line and route. ... (Au)

Q-25291

Oil and the ecology of the Arctic / [by] L.C. Bliss.
(Papers - Symposium on the Tundra Environment, Winnipeg, 3 June, 1970. Proceedings and transactions. Series 4 - Royal Society of Canada, v. 7 [i.e. 8], 1970, p. 1-12, figures)
(APOA project no. 37 : Arctic environmental research, tundra and ecological studies on the Mackenzie Delta and Devon Island. Report)
Reference.
Q,J G081
CaACU

... Associated with these oil discoveries and that of natural gas in the arctic islands, there has been a great concern for ecology in the arctic. ... The purpose of this paper is to discuss the ecological problems presented by large-scale arctic operations and the means of lessening the impact of these operations so as to maintain a favourable arctic environment for future generations. (Au)

Q-25569

Beaufort Sea exploratory drilling system / Westburne - Sedco.
[Calgary : Distributed by APOA], 1971.
2 microfiches : figures, tables ; 11x16cm.
(APOA project no. 30 : Beaufort Sea exploratory drilling systems. Report, no. 1)
Q G07
CaACU

... The purpose of this study is to investigate, compare and recommend the most advantageous drilling system for use in the block blocks of the Southern Beaufort Sea Consideration must be given to the maximum operating time coupled with the minimum capital and operating cost, with top priority always given to safety - both to personnel and to the environment. More specifically, the object of this study is to: 1. Review environmental data and reports furnished by bonus block companies. 2. Study, evaluate and recommend a drilling system. 3. Estimate capital and equipment

costs, plus estimated operating and standby day rates calculated on a five-year program. 4. Forecast drilling days in the specific areas of interest. 5. Evaluate relative safety of operations. 6. Evaluate various exploratory drilling plans for summer and winter drilling. ... (Au)

Q-25577

Study of Beaufort Sea exploratory drilling systems / prepared by Global Marine Inc. [Calgary : Distributed by APOA], 1971. 2 microfiches : figures, tables ; 11x16cm. (APOA project no. 30 : Beaufort Sea exploratory drilling systems. Report, no. 2) Prepared for Gulf Oil Canada. Q G07 CaACU

... Safety of the environment, personnel, well and vessels has received primary consideration. This is reflected in the recommendations of equipment and techniques. ... The environmental considerations are discussed and certain characteristics are quantified by hindcast techniques or actual measurement. A matrix presents the candidate drilling systems and summary results of the evaluation. The Ice Breaking Drilling Ship (IBDS) design considerations, approach and development are described. Consideration is also given to the ship's non-arctic deployment. Representative ship equipment selections, special features, outfitting, drilling and subsea equipment are included. A Safety Intelligence Room (SIR) is described, encompassing the vessel's communication and intelligence center. Ice detection, identification and tracking systems will receive data and a central plot will be established, integrated communications and environmental (meteorological) reports will also be handled in this area. One of the most important and least predictable duties of the support vessels will be to encounter and divert moving ice floes which present a potential hazard to the moored drilling ship. An analysis of this situation is included. ... (Au)

Q-25798

1972-1974 environmental program Mackenzie Delta, N.W.T., Canada / F.F. Slaney and Company Limited. [Calgary : Distributed by APOA], 1974. 37 microfiches : ill., figures, maps, tables ; 11x16cm. (APOA project no. 61 : Environmental impact assessment program, Mackenzie Delta - Phase II. Report) Contents: - v.1. Meteorology and climate. - v.2. Hydrology. - v.3. Landform and vegetation. - v.4. Birds. - v.5. Mammals. - v.6. Aquatic resources. - v.7. Environmental quality. - v.8. Winter study supplement. - v.9. Impact assessment. References. Q,N G08121 CaACU

Purpose: To assess the impact on the local ecology of possible hydrocarbon development in the Mackenzie Delta area. The study will supply environmental advice and services based primarily upon an assessment of potential impact of the construction, operation and maintenance of natural gas production, processing and associated gathering facilities on the local resources and important ecological systems. A comprehensive projection of the type and extent of environmental impact will be prepared at the conclusion of the study. (Au)

Q-26450

Some aspects of weathering and burning of crude oil in a water-and-ice environment / by J. Belicek and J. Overall, NORCOR Engineering and Research Limited. [Calgary : Distributed by APOA], 1976. 1 microfiche : ill., figures, tables ; 11x16cm. (APOA project no. 107 : Some aspects of weathering and burning of crude oil in water and ice environment. Report) Prepared for Canadian Marine Drilling Limited. References. Q,G G08121 CaACU

This report summarizes results of field experiments designed to demonstrate some practical aspects of weathering and burning of crude oil in a water-and-ice environment. The program investigated: (1) weathering and burning characteristics of light (Norman Wells) and heavy (Swan Hills) crude oil; (2) effectiveness of burning as a method of clean-up as compared to weathering and losses through evaporation; (3) methods of ignition; (4) effectiveness of fire promotive and wicking agents; (5) characteristics of unburned residue. Experiments were carried out during the period from April 28 to May 28, 1976 at Yellowknife, N.W.T. (Au)

Q-26468

In-situ burning of the products of a subsea blowout / by Arctic Canada Limited, T. Brzustowski and K. Aziz. [Calgary : Distributed by APOA], 1977. 2 microfiches : figures, tables ; 11x16cm. (APOA project no. 108 : In-situ burning of the products of a subsea blowout. Report) Submitted to Canadian Marine Drilling Ltd. Appendices. References. Q G16 CaACU

1. A 2,500 or 1,000 bbl/dy blowout at a GOP = 800 scfm/bbl will form a froth or slug flow, and the oil will rise to the sea surface in a floating layer rather than mixing in the water column as emulsified drops. 2. In 60 m deep water, the expected gas flow from a blowout will burn at the surface in calm conditions. 3. Over open water, the standard gas flow will burn in winds to 25 knots. 4. The flame from the standard gas flow will resist ice floes up to 250 m in diameter. 5. The wave ring surrounding a blowout will retain an annular oil layer with diameter approximating the water depth, a width approximating 1/10th the water depth and less than 1 cm thick. As further oil is added, it will leak outward. 6. The slick thus retained will ignite and burn strongly. 7. The gas flare will not normally keep the oil alight, but the oil fire will be very hardy and will throw sparks to ignite the gas and gas-flarewarmed oil pools. (Au)

Q-26484

Preliminary tests of bird-scare devices on the Beaufort Sea coast / by P. Lynn Sharp, LGL Limited, environmental research associates. [Calgary : Distributed by APOA], 1978. 2 microfiches : ill., figures, tables ; 11x16cm. (APOA project no. 114 : Preliminary tests of bird scare devices on the Beaufort Sea coast. Report) Prepared for Canadian Marine Drilling Ltd. Appendices. References. Q,I G07 CaACU

In the event of an oil spill or blow-out in the Beaufort Sea, the number of water birds that become oiled could be reduced by the activation

of a contingency plan that includes effective means of both dispersing birds from the area and deterring birds from entering the area. This study was conducted during July and August 1977 to test the effectiveness of three devices to deter and/or disperse water birds (primarily moulting waterfowl) from a semi-enclosed bay on the Beaufort Sea coast. The devices tested were a propane-operated cannon, an Av-alarm electronic sound-generating system, and a helicopter. ... The cannon appeared to be more effective than the Av-alarm in terms of deterring swimming birds. The birds appeared to accommodate quite quickly (2-3 days) to the two devices. Neither device was very effective against flying birds. The helicopter may be an efficient device for dispersing birds that are capable of flight; it appears to be feasible but less efficient for flightless birds. The report also comments on methods of employing deterrent and/or dispersant devices for the purpose of contingency planning. (Au)

Q-26573

Preliminary study of the fate of oil from a subsea blowout on the east coast / by A.S. Telford [and] M. Metge.
[Calgary : Distributed by APOA], 1977.
1 microfiche : figures, table : 11x16cm.
(APOA project no. 138 : Environmental investigations and analysis in Davis Strait - second half 1977. Report, no. 15)
References.
Q G09
CaACU

In open water, because of dispersive mechanisms and water currents, oil from a subsea blowout in the Davis Strait will be completely dispersed within less than thirty miles from the blowout source most of the time (65%). Within thirty miles of the blowout, some oil will be visible sporadically in thin films. A significant proportion of the hydrocarbons will be separated from the rising blowout plume by horizontal currents. When an ice cover is present, oil droplets from the blowout will probably coalesce to form thin films between the ice floes. The oil will weather and be pumped onto the edge of floes where it will be mixed with ice and snow. When floes containing oil reach the edge of the pack, the oil will be released progressively and dispersed naturally into the water column in small concentrations. The possibility of oil from a blowout contacting the shore line is remote because of dispersive mechanisms, current direction, prevailing winds, and location and movement of the pack. The oil from a blowout will always move in a southerly direction. In both open water and ice cover situations, containment and recovery with conventional booms and skimmers will be ineffective, if not impossible, even under favorable wave conditions, which would be about 35% of the time in the open season. (Au)

Q-26700

Summer environmental program - Mackenzie River Estuary / F.F. Slaney and Company Limited.
[Calgary : Distributed by APOA], 1975.
13 microfiches : ill., figures, maps, tables : 11x16cm.
(APCA project no. 76 : Summer environmental studies - East Mackenzie Bay - Mackenzie Delta. Report)
Contents: - v.1. Aquatic studies. - v.2 Terrestrial studies. - v.3 Marine mammal studies.
Appendices.
References.
Q,J G08121
CaACU

The overall purpose of the 1974 summer program was to assess the effects upon the environment of artificial island construction F.F.

Slaney & Company conducted a multi-disciplinary environmental study program that focused on past, present and possible future island construction sites. The integrated program consisted of eight study disciplines. Physical Oceanography, Water Chemistry, Plankton, Benthos, Fisheries, Avifauna, Terrestrial Mammals, Marine Mammals. Also included were less extensive observations of meteorology and climate. All studies were designed to integrate with, or supplement, existing information and ongoing work by other groups. (Au)

Q-26743

Tests of the Arctic Boat configuration of the Lockheed Clean Sweep oil recovery system in a broken ice field / by L.A. Schultz, Arctic Canada Limited.
[Calgary : Distributed by APOA], 1976.
2 microfiches : ill., figures, tables : 11x16cm.
(APOA project no. 97 : Tests of the Arctic Boat configuration of the Lockheed Clean Sweep system in a broken ice field. Report)
Submitted to Canadian Marine Drilling Limited.
References.
Q G081
CaACU

... The Arctic Boat configuration tested showed a great tendency towards drum jamming and a far greater tendency towards ice rafting than was the case for the unmodified device. ... The oil recovery performance tests also indicated that the performance of the unit is highly dependent upon operating conditions. Major parameters beyond the control of the operator include the oil thickness, the viscosity of the oil, the size of the broken ice pieces, the concentration of the broken ice pieces, and environmental conditions such as temperature, wind, waves, and currents. To optimize the oil recovery performance of the device, the operator must carefully select the operator controlled variables including the speed of the unit relative to that of the slick, and the speed of drum rotation. ... A very brief open burn test of the crude oil indicated that the spill volume could be reduced to about 12.5% of the original volume through open burning of the oil. The residue remaining, however, is a solid at a temperature of 32 deg. F. It was judged that the recovery of such a residue would not be a favorable application for the Lockheed Clean Sweep unit tested. (Au)

Q-26760

Proposal to evaluate an oil containment boom for use in ice-infested waters / by Arctic Canada Limited.
[Calgary : Distributed by APOA], 1975.
1 microfiche : figures : 11x16cm.
(APOA project no. 100 : Evaluation of the Bennett Canmar oil containment boom. Report, no. 1)
Submitted to Canmar Drilling Ltd.
References.
Q G07
CaACU

This proposal presents a methodology for testing a new type of oil containment boom which has been recently developed by Bennett Pollution Controls Ltd. and Canmar Drilling Ltd. The tests proposed will allow a conservative evaluation of the maximum sea state in which the boom can contain oil. The test series will include various endurance tests in a cold-environment of the boom materials. Finally, tests will be conducted to evaluate the boom's icing tendencies in a simulated sea state. It should be noted that the tests proposed herein are not construed as a complete evaluation of the Arctic boom. The tests are designed to provide answers to three questions: 1. What sea states can the boom

function in? 2. Are its materials suitable for their intended use? 3. Will the boom's performance be seriously degraded in icing conditions? ... (Au)

Q-26778

Evaluation of the Bennett-Canmar oil containment boom / by J.P. Nadreau, W. G. Wallace [and] R.Y. Edwards, Jr., Arctic Canada Limited. [Calgary : Distributed by APOA], 1976. 1 microfiche : figures, tables ; 11x16cm. (APOA project no. 100 : Evaluation of the Bennett Canmar oil containment boom. Report, no. 2) Report submitted to CANMAR Drilling Ltd. Q G07 CaACU

... The purpose of this study was to evaluate the behavior of the boom and of its components in Arctic conditions. The tests were to be used in three ways: 1. As a basis for modifications to the boom to improve its effectiveness. 2. As a basis for comparative evaluation for purchase. 3. As documentation of the suitability of the boom as a major component of a Beaufort Sea oil spill contingency plan. In order to document the boom characteristics, the test program has been conducted to provide data on: 1. The response of the boom in various sea states. 2. The tensile strength of the boom. 3. The ability of the boom to pass ice floes. 4. The suitability of the boom materials for intended service and environment. The tests concerning the boom behavior took place in the Vancouver area and the materials endurance tests in Laval University's cold rooms (Quebec). (Au)

Q-29858

APOA review / Arctic Petroleum Operators' Association. v.1, no.1 (Feb. 1978)- . [Calgary : APOA Information Service, 1978-]. ill. : 28cm. Q G061 CaACU

Disseminates information about member companies of the APOA and petroleum exploration activity in the Canadian Arctic. Features summaries of selected APOA reports. Selected articles from the Review are translated into Inuktitut. (ASTIS)

Q-25890

Proceedings - Arctic Environmental Workshop, 6th, Fairmont Hot Springs, B.C., April 17-20, 1977 / Edited by J.G. Gainer, W.J. Logan [and] E. Mackay. Ontario : Institute for Environmental Studies, [1977]. iii, 129p. : ill., maps, tables ; 28cm. (Publication - Toronto. University. Institute for Environmental Studies, EE 6) Sponsored by the Arctic Petroleum Operators' Association and the Canadian Petroleum Association. References. Q,J G081 CaACU

... A number of invited papers on general aspects of Petroleum development (particularly oil) in the Canadian North were followed by Workshop Sessions in which groups addressed the issues of Environmental Assessment, Offshore Environmental Concerns, and Oil Spill Technology for shorelines, open water and in the presence of ice. Environmental assessment procedures were discussed and the suggestions made for improvement. Attempts were made to determine the fate, behaviour and effects of oil, to identify gaps in knowledge and assemble lists of needed research and development

projects. ... (Au)

Q-29904

Second interim report to APOA Steering Committee, Beaufort Sea Environmental Program, on public interface project, July 1, 1974 to January 31, 1975 / by M. Collins, Mary Collins Consultants Ltd. [and] A.E. Pallister, Pallister Resource Management Ltd. [S.l. : s.n.], 1975. 1 vol. (various pagings) ; 28cm. Appendix B: Northern development and the native people, a literature review of current opinions and issues / by Walter D. Brust. - Prepared for Pallister Resource Management Ltd. Prepared for APOA project no. 72: Beaufort Sea Environmental Program. References. Q,I G081 CaACU

... 18 companies which have provided over \$4 million towards the funding of the environmental studies through the Arctic Petroleum Operators Association undertook a Public Interface Project. The Project, carried out in three overlapping phases, was commenced on July 1st, 1974. This report describes the activities and results during the first 7 months to January 31st, 1975. ... The main body of the report reviews the original plans, how they have been carried out, and provides an evaluation of the Project together with recommendations for future actions. ... (Au)

Q-29912

Shoreline oil spill protection and cleanup strategies : southern Beaufort Sea / P.W. Korbet. [Calgary : Distributed by APOA], 1979. 2 vol. : ill., maps ; 23x29cm. (APOA project no. 136 : Beaufort Sea shoreline study, Komakuk Beach to Baillie Islands. Report, no. 2) References. Contents: Manual. - Appendix. Q,J G081

The "Shoreline Oil Spill Protection and Cleanup Strategies: Southern Beaufort Sea" has been prepared to help the On-Scene Commander selectively appoint limited resources to the most important coastal areas in order to minimize environmental damage in the event of an oil spill. This report aids oil spill response preplanning by: (1) establishing the relative importance of all sensitive coastal regions between the Alaska-Yukon border (141 deg. W) and the Baillie Islands (120 deg. W); and (2) recommending oil spill protection and cleanup strategies for each of these coastal regions. The report is divided into two separate volumes. The first volume discusses the process that was followed to develop this work. Arctic oil spill countermeasures are evaluated and the shoreline ranking system is discussed in detail. ... The second volume, a manual, has been designed for the On-Scene Commanders use, in a format that is brief, concise, and easy to use. Details on oil spill countermeasures, logistics, and environmental sensitivities in the study area are documented on maps, overlays and supporting text. Two summers of fieldwork were required to collect the site specific and operational information pertinent to oil spill response. ... (Au)

Q-30058

Oil spill countermeasures for the southern Beaufort Sea / W.J. Logan, D.E. Thornton and S.L. Ross. Victoria, B.C. : Beaufort Sea Project, Dept. of the Environment, 1975. 2 vol. : ill., maps, graphs, tables ; 28cm. (Technical report - Canada. Beaufort Sea

Project, no. 31a, 31b)
(APOA project no. 72 : Beaufort Sea
Environmental Program. Report, no. 31a, 31b)
Bibliography: p. 124-126.
Contents: no. 31a Report. - no. 31b Appendix.
Q G07
CaACU

This report discusses the feasibilities of controlling and cleaning up an oil spill in the Beaufort Sea as a result of an exploratory well blowout. It is likely that, in waters with up to 10% ice concentrations, currently available oil spill countermeasures equipment and techniques could be employed in sea conditions up to Beaufort 3. No equipment is available for use in higher sea conditions. If the blowout were to occur in the landfast ice zone, oil that would accumulate at the under-ice surface during winter could be incinerated in place when the oil migrates to the ice surface in the springtime. No viable techniques or proven countermeasures equipment are available for use in the seasonal pack, shear zone and the polar pack zone. The cleanup and restoration of oil contaminated shorelines would be limited to sand beaches and to a lesser extent, shingle beaches, which together comprise 37% of the Beaufort Sea shoreline. Remote sensing of oil spills, although untried in the arctic environment, would be limited to periods of good visibility. In general, the logistical base required to support an effective oil spill countermeasures operation is not available in the areas adjoining the Beaufort Sea. (Au)

Q-30066
Biological implications of natural disposal of oil in the marine environment / J.H. Vanderbeulen.
(Proceedings - Arctic Environmental Workshop, 6th, Fairmont Hot Springs, B.C., April 17-20, 1977 / Edited by J.G. Gainer, W.J. Logan [and] D. Mackay. Ontario : Institute for Environmental Studies, [1977]. Publication - Toronto. University. Institute for Environmental Studies, EE 6, p. 11-26, ill.)
References.
Q,J G08
CaACU

With the sinking of the tanker ARROW on February 4, 1970 and with the release of nearly two and a half million gallons of Bunker C fuel oil into Chedabucto Bay waters, Canada entered the modern age of the oil-spill. ... I want to take you through a seven-year long follow-up study, with emphasis on the self-cleaning potential of this bay and on the biological recovery of its biota. ... (Au)

Q-30074
Resources and planning of the federal government for oil spill countermeasures in the Beaufort Sea / by S.L. Ross.
(Proceedings - Arctic Environmental Workshop, 6th, Fairmont Hot Springs, B.C., April 17-20, 1977 / Edited by J.G. Gainer, W.J. Logan [and] D. Mackay. Ontario : Institute for Environmental Studies, [1977]. Publication - Toronto. University. Institute for Environmental Studies, EE 6, p. 27-42, ill.)
Q,J G07
CaACU

My responsibility in this presentation is to outline the activities in the Federal Government directly related to the development of an oil spill countermeasures capability in the Arctic, and in particular, in the southern Beaufort Sea. ... I would like to ... outline what these activities are; briefly explain the thinking and history that has led to present programs; discuss the apparent and/or real problems that have to be solved; and finally

make a case for better coordination of government and industry planning and efforts in this area. ... (Au)

Q-30082
The physical environment of the Beaufort Sea related to oil, ice and water interactions / by A.R. Milne.
(Proceedings - Arctic Environmental Workshop, 6th, Fairmont Hot Springs, B.C., April 17-20, 1977 / Edited by J.G. Gainer, W.J. Logan [and] D. Mackay. Ontario : Institute for Environmental Studies, [1977]. Publication - Toronto. University. Institute for Environmental Studies, EE 6, p. 43-53, maps)
Q,J G07
CaACU

A main reason for this workshop is to stimulate new ideas and concepts for oil spill countermeasures in the Beaufort Sea. ... I will cover, briefly, the main features of its physical marine environment in relationship to oil pollution which could result from a subsea oil-well blowout. ... (Au)

Q-30090
Workshop on Arctic offshore environmental concerns
(Proceedings - Arctic Environmental Workshop, 6th, Fairmont Hot Springs, B.C., April 17-20, 1977 / Edited by J.G. Gainer, W.J. Logan [and] D. Mackay. Ontario : Institute for Environmental Studies, [1977]. Publication - Toronto. University. Institute for Environmental Studies, EE 6, p. 65-78)
Q,J G07
CaACU

... the Arctic Offshore was defined as those Canadian Arctic waters of the Beaufort Sea, those surrounding the Arctic Islands, Hudson Bay, Hudson Strait and the Paffin Bay, Davis Strait and Labrador Sea regions. The session was subdivided into four topic areas, the first three being established on the basis of predetermined "questions" and the fourth dealing with the Eastern Arctic Marine Environmental Study. ... (Au)

Q-30104
Workshop on oil spill technology.
(Proceedings - Arctic Environmental Workshop, 6th, Fairmont Hot Springs, B.C., April 17-20, 1977 / Edited by J.G. Gainer, W.J. Logan [and] D. Mackay. Ontario : Institute for Environmental Studies, [1977]. Publication - Toronto. University. Institute for Environmental Studies, EE 6, p. 79-112, ill.)
Contents. - Open water. - Shorelines. - Ice. - Concluding remarks.
Q - G07
CaACU

Presents several different countermeasures available in combatting oil spills in open water, oil spills on shorelines, interaction of oil spills and sea ice, and an oil well blowout under an Arctic Island ice platform. (ASTIS)

Q-30120
Experimental crude oil spills on Arctic plant communities / by Ross W. Wein and L.C. Bliss.
(Journal of applied ecology, v. 10, 1973, p. 671-682, tables)
(APOA project no. 37 : Arctic environmental research, tundra and ecological studies on the Mackenzie Delta and Devon Island. Report)
References.
Q,H G08121
CaACU

9.1

... The objectives of this study were to determine the initial and long-term effects of crude oil on the survival and re-invasion of Low Arctic plant species. Supplementary measurements of thermal and moisture balances in the soil aided interpretation of the plant responses. The research was conducted at three sites in north-western Canada just to the east of the Mackenzie Delta. Inuvik is located 115 km from the Arctic Coast, Tuktoyaktuk is on the coast and Tununuk Point is about midway between the two. ... The community types, soil surface characteristics, maximum active layer depths, plot sizes, and date of oil application are given ... (Au)

Q-30139

Plant community responses to disturbances in the western Canadian Arctic / L.C. Bliss and Ross W. Wein.
(Canadian journal of botany, v. 50, no. 5, May 1972, p. 1097-1109, photos., tables)
(APOA project no. 37 : Arctic environmental research, tundra and ecological studies on the Mackenzie Delta and Devon Island. Report)
Paper presented at the Symposium: Aspects of Northern Botany, Univ. of Alberta, June 20-24, 1971.
References.
Q.H G0812
CaACU

... Fire stimulated the growth and flowering of *Eriophorum vaginatum* subsp. *spissum* and *Calamagrostis canadensis*. The recovery of dwarf heath shrubs from rhizomes was relatively rapid while lichens and mosses showed no early recovery. Crude oil spilled in different plant communities killed the leaves of all species, yet regrowth occurred on some woody species the same summer and more species showed regrowth the second summer. Oil spilled in early winter (October) and in wet sedge communities in summer appeared to be most detrimental. Percentage plant removal has been significantly reduced with changed seismic technology in the past 6 years. Native species, often from rhizomes, reinvade all lines though recovery on peats and by native grasses appears most rapid. Winter roads of compacted snow were less detrimental to wetland sedge communities than to upland dwarf shrub-sedge-heath ones. ... The different plant community-topographic-soil-ground ice landscape units or system respond differentially to the different surface disturbances tested to date. This is true in both the Low and High Arctic.
(Au)

Q-30171

Will oil spills damage Arctic tundra? / by Ross W. Wein.
(Oilweek, v. 21, no. 46, Jan. 4, 1971, p. 13-14)
(APOA project no. 37 : Arctic environmental research, tundra and ecological studies on the Mackenzie Delta and Devon Island. Report)
Q.H G08121
CaACU

... Experimental areas in the Mackenzie Delta were located at Inuvik, Tuktoyaktuk and Tununuk Point (on the southern tip of Richard Island). Five landscape units (vegetation-soils-topography-permafrost conditions) were selected as study sites. At each site crude oil was applied in the spring, summer, and late fall. The last treatment was applied when the snow cover was eight inches deep. ... In conclusion it should be pointed out that although oil spills on land have occurred many times before and have been studied scientifically, we do not know how much of this information is applicable to the Arctic tundra. ... (Au)

Q-30201

Ecological problems associated with Arctic oil and gas development / L.C. Bliss and R.W. Wein.
(Proceedings - Canadian Northern Pipeline Research Conference, Ottawa, 2-4 Feb., 1972 / Edited by R.F. Legget and I.C. MacFarlane. Ottawa : National Research Council, 1972. Technical memorandum - Canada. National Research Council. Associate Committee on Geotechnical Research, no. 104, p. 65-77)
(APOA project no. 37 : Arctic environmental research, tundra and ecological studies on the Mackenzie Delta and Devon Island. Report)
References.
Q,J G081
CaACU

... Data will be presented from some of the ecological research being conducted by government agencies, industry, and university groups to determine the environmental limits of Arctic exploration, oil and gas field development, and the impact of pipelines on arctic and subarctic ecosystems. Preliminary comparisons on seismic operations, use of summer and winter roads, revegetation trials and recovery of vegetation from spillage of crude oil or diesel fuel can now be made with landscape units of the Delta and, in some cases, between the Delta and the Arctic Islands. ... (Au)

Q-30210

Biological considerations for construction in the Canadian permafrost region [1] / Ross W. Wein [and] L.C. Bliss.
(Permafrost : North American contribution / International Conference on Permafrost, 2d, Yakutsk, U.S.S.R., July 13-28, 1973. Washington, D.C. : National Academy of Sciences, 1973, p. 767-770)
(APOA project no. 37 : Arctic environmental research, tundra and ecological studies on the Mackenzie Delta and Devon Island. Report)
References.
Q,J G081
CaACU

Announcement of petroleum discoveries in Alaska and the Canadian Mainland Arctic and the Arctic islands precipitated many questions about the biological consequences of northern developments. ... This paper considers biological problems that are related to northern construction in light of recent studies. These studies have been sponsored by government ..., industry ..., and the University of Alberta. (Au)

Q-30228

The ecological impact of northern petroleum development / L.C. Bliss [and] E.B. Peterson.
(Le pétrole et le gaz Arctiques : problèmes et perspectives = Arctic oil and gas : problems and possibilities, rapports scientifiques / Fondation française d'études nordiques, congrès international, 5e, Le Havre, 2-5 mai, 1973. Publiés sous la direction de Jean Malaurie. Paris : [Mouton & Co., c1975]. Contribution - Paris. Université. Ecole des hautes études en sciences sociales. Centre d'études arctiques, no. 12, v. 2, p. 505-537)
(APOA project no. 37 : Arctic environmental research, tundra and ecological studies on the Mackenzie Delta and Devon Island. Report)
Bibliography: p. 530-537.
Q,J G081
CaACU

... The objective of this paper is to present biological information from land, fresh water, and marine environments on how these systems may react to various perturbations associated with the exploration, development and transportation phases of arctic oil and gas

development. This paper will not discuss the ecological effects of northern mining activities. For the petroleum industry most emphasis in this paper will be upon the ecological effects of the exploration phase but much of the information can be extrapolated to the development and transportation phases. (Au)

Q-30244

APOA description of research projects / [Arctic Petroleum Operators' Association].
[Calgary : Distributed by APOA, 1978?].
16 microfiches ; 11x16cm.
Index.
Hard copy also available.
Q,3,X G081
CaACU

This brochure has been compiled to provide APOA members and other interested parties with a description of APOA projects. It is intended that it be periodically updated with inserts as projects are undertaken. The operator of each project, who can provide additional details if required, is listed. Tables of Contents from available reports are included. Those reports which are confidential are so indicated. A list of projects showing the project number, operator, number of participants, title, status, total cost and cost to the next participant is included. For the sake of completeness a brief history of APOA, the organization, a list of member companies, a charter and representation on government committees and working groups is included. (Au)

Q-30252

A biologist explains why we must plan now to protect the Arctic / L.C. Bliss.
(Science forum 15, v. 3, no. 3, June 1970, p. 3-8, photos.)
(APOA project no. 37 : Arctic environmental research, tundra and ecological studies on the Mackenzie Delta and Devon Island. Report)
Q,J G081
CaACU

Briefly reviews the environmental problems associated with oil and gas exploration in the Canadian Arctic: the possibility of oil spills from supertankers, heated oil pipelines in permafrost, fragility of tundra ecology, the Mackenzie Valley pipeline, and land use patterns and wildlife resources. (ASTIS)

Q-30279

Effects of crude oils on Arctic marine invertebrates / J.A. Percy and T.C. Mullin.
Victoria, B.C. : Beaufort Sea Project, Dept. of the Environment, 1975.
iv, 1167p. : ill., graphs, tables ; 28cm.
(Technical report - Canada. Beaufort Sea Project, no. 11)
(APOA project no. 72 : Beaufort Sea Environmental Program. Report, no. 11)
Bibliography: p. 115-122.
Q,I G081
CaACU

... This study addresses itself primarily to the question of just how susceptible certain invertebrate components of the marine inshore ecosystem are to significant disruption by oil pollution. ... Oil-animal interactions in three distinct habitats are considered, namely, the sub-ice, the neritic and the benthic habitats. Biological effects of three general types are examined; short term lethal effects, sublethal physiological effects and sublethal behavioral effects. Considerable variability in the responses of different species occurred in all three categories. ... Behavioral studies were carried out to investigate the responses of several species to the presence of crude oil masses, crude oil tainted food and crude oil

contaminated sediment. None of the species examined were attracted by the oil. ... Possible long-term ecological consequences of these behavioral responses are discussed in detail. (Au)

Q-30287

Proceedings - Conference on the Environmental Effects of Oil and Salt Water Spills on Land, Banff, Nov. 6-7, 1975.
[Edmonton : Alberta Environment Research Secretariat, 1976?].
327p. : ill., graphs, tables ; 28cm.
Travel assistance grant provided by the Arctic Petroleum Operators' Association.
Sponsored by the Univ. of Calgary, Grants Office and the Alberta Environment Research Secretariat.
References.
Q,J G08
CaACU

The purpose of the Conference ... was interdisciplinary discussion of recent and future needed research on the effects, clean-up, and restoration of land and groundwater contaminated by oil and/or salt water spills. This collection of reprints contains those papers submitted for inclusion herein as well as summaries of four discussions held concurrently at the end of the conference. A list of all papers presented appears in the original conference program in Appendix B. ... (Au)

Q-30309

Interim report to APOA Steering Committee, Beaufort Sea Environmental Program, of [sic] the design of a public interface project / by M. Collins, Mary Collins Consultants Ltd. [and] R.J. Orange, Pallister Resource Management Ltd. [S.l. : s.n., 1974].
37 leaves : 28cm.
Prepared for APOA project no. 72: Beaufort Sea Environmental Program
Bibliography: leaves 33-36.
Q,T G081
CaACU

... The purpose of this Interim Report is to update the understanding of the concerns and perceptions of the various publics. In so doing, it provides a "Design" for future communication activities which will be directed to developing a climate of mutual understanding between all those with an interest in the long term status of the Beaufort Sea. This work is particularly oriented toward the environmental surveys being conducted by the federal Department of the Environment and members of the Arctic Petroleum Operators Association. ... Public attitudes, particularly in the potentially affected communities, has been examined. Our description and assessment of these attitudes and apprehensions are described (Au)

Q-30805

Proceedings - Arctic Environmental Workshop, 8th, Fairmont Hot Springs, B.C., May 7-9, 1979 / Edited by S.J. Jones.
Calgary : Arctic Institute of North America, 1979.
171p. : ill. (part. fold.) ; 28cm.
(Special publication - Arctic Institute of North America)
Sponsored by the Arctic Petroleum Operators' Association and the Canadian Petroleum Association.
Q,J G081
CaACU

The Proceedings provide a record of the presentations and discussions at the Eighth Annual Arctic Environmental Workshop These

annual workshops were initiated by industry in 1971 to facilitate frank discussion between industry, government, northern residents, academics and public interest groups of environmental issues related to hydrocarbon exploration and development in the Canadian Arctic. ... the emphasis today is on offshore developments, refined technologies as well as acceptance and efficient cooperation in meeting environmental responsibilities. To this end, the theme of the 1979 Workshop was "Environmental Studies: Review and Forecast". ... (Au)

Q-30813

Frontier exploration - hydrocarbon reserve potential / R.A. Meneley.
(Proceedings - Arctic Environmental Workshop, 8th, Fairmont Hot Springs, B.C., May 7-9, 1979. Calgary : Arctic Institute of North America, 1979, p. 20-27)
Q G081
CaACU

... the oil industry has come a long way in the exploration of the Canadian frontiers: - in their capability to operate efficiently in increasingly harsh environments; - in their knowledge of the geology of the frontier basins and the habitat of oil and gas in those basins; and most of all, - industry is learning and more readily accepting the need to operate in such a manner so as to minimize the environmental and social consequence of conducting exploration activities. Four large frontier areas in Canada are the most attractive areas in which major frontier oil discoveries can be anticipated: Labrador offshore, Baffin Bay, Offshore Beaufort, Arctic Islands (Au)

Q-30821

Arctic marine environmental studies / Allen R. Milne.
(Proceedings - Arctic Environmental Workshop, 8th, Fairmont Hot Springs, B.C., May 7-9, 1979. Calgary : Arctic Institute of North America, 1979, p. 28-43, ill., map)
References.
Q,J G081
CaACU

In this paper the author reviews three major environmental studies: The Beaufort Sea Project; Eastern Arctic Marine Environmental Studies (EAMES); and, Offshore Labrador Biological Studies (CLABS). He discusses the Environmental Assessment and Review Process (EARP), the Initial Environmental Evaluation (IEE) and the Environmental Impact Statement (EIS) and their particular place in off-shore oil and gas projects. (ASTIS)

Q-30848

An offshore deep well exploration experience : the Chevron Acadia (1978) project / E.E. Godly.
(Proceedings - Arctic Environmental Workshop, 8th, Fairmont Hot Springs, B.C., May 7-9, 1979. Calgary : Arctic Institute of North America, 1979, p. 61-77, ill. (1 fold.))
Q,R G11
CaACU

A summary of Chevron Standard Limited's experience from pre-permit approvals through to the actual drilling in an offshore drilling project carried out in offshore Nova Scotia waters in 1978. (ASTIS)

Q-30856

Oil spill workshop : shoreline protection and cleanup.
(Proceedings - Arctic Environmental Workshop, 8th, Fairmont Hot Springs, B.C., May 7-9, 1979.

Calgary : Arctic Institute of North America, 1979, p. 79-87)
Q,J G02
CaACU

In keeping with the theme of this year's workshop, "Arctic Environmental Studies Review and Forecasts [sic]", the session on shoreline protection and cleanup addressed two topics. Initially a review of accomplishments in the field since the 1977 workshop was made. Finally, the presently perceived needs for shoreline protection and cleanup technology were assessed and recommendations for future studies were made. ... (Au)

Q-30864

Environmental studies panel workshop.
(Proceedings - Arctic Environmental Workshop, 8th, Fairmont Hot Springs, B.C., May 7-9, 1979. Calgary : Arctic Institute of North America, 1979, p. 88-98)
Q,J G081
CaACU

The panel discussion was concerned not with the specifics of individual environmental studies but with their history of use, how they are planned and what their objectives are with reference to offshore oil and gas activities. (ASTIS)

Q-30872

Socio-economic/environmental impact assessment panel.
(Proceedings - Arctic Environmental Workshop, 8th, Fairmont Hot Springs, B.C., May 7-9, 1979. Calgary : Arctic Institute of North America, 1979, p. 101-156, ill., maps)
With "Sequence of events concerning exploratory drilling in the Beaufort Sea and Davis Strait regions" / by Catherine Weisenberger, p.106-124.
Q,J,R G081
CaACU

The panel, using the discussion format and case studies, concerned itself with man's actions with reference to the petroleum industry on a) the environment, and on b) the cultural, social and economic conditions including policies, legislation, programs, projects or operational procedures in the Canadian Arctic. Two mini workshops developed from this and the results of each are presented. (ASTIS)

See also : H-30350, K-24554, K-25550, K-25615, L-21270, L-24562, L-24716, L-25747, X-19275

R - GOVERNMENT, ECONOMIC CONDITIONS, AND SOCIAL CONDITIONS

See also : Q-24401, Q-30848, Q-30872

S - LAND USE, LAND MANAGEMENT, AND REGIONAL PLANNING

S-30830

Natural areas of Canadian significance / T. Heggie
(Proceedings - Arctic Environmental Workshop, 8th, Fairmont Hot Springs, B.C., May 7-9, 1979. Calgary : Arctic Institute of North America, 1979, p. 44-60, maps)
S,J G081
CaACU

In January, 1978, Mr. Hugh Faulkner, the

Minister of Indian and Northern Affairs, announced his interest in assessing the feasibility of establishing five new National Parks and one National landmark in northern Canada. ... the six areas ... are: The Northern Yukon; Bathurst Inlet; Wager Bay; Banks Island; northern Ellesmere Island area; and the pingos of Tuktoyaktuk Peninsula. ... Parks Canada has initiated discussions with all interested parties These ... are forecasted to continue until late 1980, at which time the input to that date will be assessed (Au)

T - NATIVE PEOPLES (except ARCHAEOLOGY (use U))

T-15512

The socio-economic importance of wildlife resource utilization in the southern Beaufort Sea / [by] William D. Brakel.
Victoria, B.C. : Beaufort Sea Project, 1977.
91p. : maps, tables ; 28cm.
(Technical report - Canada. Beaufort Sea Project, no. 32)
(APOA project no. 72 : Beaufort Sea Environmental Program. Report, no. 32)
Appendices.
References.
T.I G0812
CaACU

This study considers the socio-economic importance of fishes, beluga or white whales, seals, white fox and polar bears to Inuit, Metis and Indians living adjacent to the Beaufort Sea. Factors considered as 'socio-economically important' include the level and distribution of local and export sales, domestic uses of wildlife harvests, employment and income. ... (Au)

T-26417

Report on Inuit natural resource use in south-east Baffin region / MacLaren Atlantic Limited.
[Calgary : Distributed by APOA], 1978.
3 microfiches : figures, maps, tables ; 11x16cm.
(APOA project no. 138 : Environmental investigations and analysis in Davis Strait - second half 1977. Report, no. 7)
Prepared for Imperial Oil Ltd., Aquitaine Co. of Canada Ltd. and Canada Cities Services Ltd.
References.
T.I G08124
CaACU

Animal resource use, present and historic, is examined for five southeast Baffin Island communities. In all communities, ringed seal were found to be the single largest component of the harvest and were hunted on a year-round basis. The most important fish species utilized, often to the exclusion of other available species, was the Arctic char. The Common Eider was the most important bird species used. The latter two species are seasonally important. ... (Au)

See Also : G-29904, G-30309

X - GENERAL

X-7773

ASTIS current awareness bulletin / Arctic Science and Technology Information System.
May/June 1978- .
[Calgary] : Arctic Institute of North America, 1978- .
28cm.
(APOA project no. 98 : Arctic Science and Technology Information System)
ISSN 0705-8454
Bi-monthly.
Cover title.
Continues Arctic Institute of North America. Library accessions list.
X G01
CaACU

The aim of the Arctic Science and Technology Information System (ASTIS) is to make researchers more aware of available information about Arctic regions. The ASTIS project and the AINA Library have developed a multipurpose bibliographic database which provides printed and on-line information retrieval services, and which also serves as the catalogue of the Library. Each issue of the ASTIS Current Awareness Bulletin contains all material entered into this database during the preceding two months. Documents are grouped by broad subject areas and are indexed by broad geographic areas. Short abstracts are provided for all documents. (ASTIS)

X-19275

APOA project report / Arctic Petroleum Operators' Association.
Project no. 1 (1970)- .
[Calgary : Distributed by APOA, 1970-].
ill. ; 11x16cm.
Microfiche.
X,Q G081
CaACU

Reports on research projects conducted cooperatively by members of the Arctic Petroleum Operators' Association. Research has been directed towards obtaining engineering and environmental data, and towards adapting established operating techniques and designing new equipment to meet the unique operating conditions of the Arctic. The findings of each APOA research project remain the property of the companies that have financed the particular study for five years, after which time they become publicly available. (ASTIS)

X-30317

The coast and shelf of the Beaufort Sea, proceedings / Symposium on Beaufort Sea Coast and Shelf Research, San Francisco, January 7-9, 1974. Edited by John C. Reed [and] John E. Sater. Technical editor, Wade W. Gunn
[Arlington, Va. : Arctic Institute of North America], 1974 [c1975].
750p. : ill., maps ; 26cm.
(APOA project no. 63 : Arctic Institute of North America Beaufort Sea Symposium. Report)
References.
I,J,D G07
CaACU

... the Symposium would: (1) Outline the present state of knowledge. (2) Define still-existing problems. (3) Interrelate the works of various disciplines in a synthesis of the region's environment and processes. ... Presentations at the Symposium were grouped into three broad disciplinary categories: air-ice-water, geology, and biology. One day was given over to each category. The sequence

of presentations at the Symposium has been adhered to in compiling this volume. Two hours of each day's session were devoted to commentaries on the theme papers, general discussion, and questions from the floor. While a verbatim transcript of these exchanges is lacking, written questions and statements were solicited and are included here, together with the response they elicited. ... (Au)

See Also : Q-30244

Y - MISCELLANEOUS

Y-29866

The Arctic Science and Technology Information System / C.R. Goodwin.

[S.l. : s.n.], 1978.

11 leaves ; 28cm.

(APOA project no. 98 : Arctic Science and Technology Information System. Report)
Paper presented at the seventh Northern Libraries Colloquy, Paris, Sept. 19-23, 1978.

Y G02

CaACU

This paper describes the design and development of the Arctic Science and Technology Information System at the Arctic Institute of North America. ASTIS is a flexible multi-purpose bibliographic database, which functions as both the catalogue of the AINA Library, and as an abstracting and indexing service that provides printed and on-line information retrieval services. A brief technical description of the database is presented. This is followed by a description of the products and services which have been implemented during the first four months of system operation, and of those which are currently under development. (Au)

ACUTE TOXICITY OF DISCHARGED DRILLING MUDS FROM IMMERK B-48, BEAUFORT SEA TO RAINBOW TROUT, SALMO
GAIRDNERI (RICHARDSON) Q-12980

ACUTE TOXICITY OF DRILLING COMPONENTS TO RAINBOW TROUT SALMO GAIRDNERI (RICHARDSON) Q-13013

ACUTE TOXICITY OF DRILLING FLUIDS TO RAINBOW TROUT SALMO GAIRDNERI (RICHARDSON) Q-13005

ACUTE TOXICITY OF TEN SELECTED ARCTIC DRILLING SUMP TO RAINBOW TROUT, SALMO GAIRDNERI (RICHARDSON)
Q-12998

ADFREEZE STUDY G-25755, G-25763, G-25771

ADJEX BULLETIN, NO. 33, SEPT. 1976, P. 1-52, ILL., TABLES, CHARTS G-3530

ANALYSIS OF OCEAN CURRENTS, DAVIS STRAIT - 1977 D-27553

ANALYSIS OF SEA BOTTOM ICEBERG SCOURING RECORDS G-25542

ANALYTICAL STUDY OF ICE SCOUR G-26697

ANALYTICAL STUDY OF ICE SCOUR ON THE SEA BOTTOM G-26657

APOA DESCRIPTION OF RESEARCH PROJECTS Q-30244

APOA DRILLING COMMITTEE Q-21288

APOA PROJECT NO. 1 : NUTCRACKER ICE STRENGTH TESTS, 1969-70. REPORT, NO. 1 G-19291

APOA PROJECT NO. 1 : NUTCRACKER ICE STRENGTH TESTS, 1969-70. REPORT, NO. 2 G-29939

APOA PROJECT NO. 2 : BEAUFORT SEA - ICE MOVEMENT AND CURRENT SURVEY - 1970. REPORT, NO. 1
G-19283

APOA PROJECT NO. 2 : BEAUFORT SEA - ICE MOVEMENT AND CURRENT SURVEY - 1970. REPORT, NO. 2
G-19305

APOA PROJECT NO. 2 : BEAUFORT SEA - ICE MOVEMENT AND CURRENT SURVEY - 1970. REPORT, NO. 3
G-21237

APOA PROJECT NO. 3 : OCEAN FLOOR SAMPLING BEAUFORT SEA 1970. REPORT, NO. 1 D-21245

APOA PROJECT NO. 3 : OCEAN FLOOR SAMPLING BEAUFORT SEA 1970. REPORT, NO. 2 G-21237

APOA PROJECT NO. 4 : GEOLOGICAL ANALYSIS OF OCEAN FLOOR SAMPLES. REPORT, NO. 1 D-21253

APOA PROJECT NO. 4 : GEOLOGICAL ANALYSIS OF OCEAN FLOOR SAMPLES. REPORT, NO. 2 C-21261

APOA PROJECT NO. 7 : CROSS-COUNTRY VEHICLE STUDY. REPORT L-21270

APOA PROJECT NO. 8 : APOA DRILLING COMMITTEE. [REPORT] Q-21288

APOA PROJECT NO. 9 : NUTCRACKER ICE STRENGTH TESTS, 1970-71. REPORT G-21296

APOA PROJECT NO. 11 : MACKENZIE DELTA ORNITHOLOGICAL STUDY. REPORT I-21300

APOA PROJECT NO. 12 : FEASIBILITY STUDY OF EXPLORATORY DRILLING IN THE BEAUFORT SEA. REPORT
Q-23345

APOA PROJECT NO. 13 : ARCTIC DRILLING BARGE STUDY. REPORT, NO. 1 Q-24449

APOA PROJECT NO. 14 : BEAUFORT SEA SUMMER ICE STUDY. REPORT G-24457

APOA PROJECT NO. 16 : THEORETICAL ANALYSIS OF ICE FAILURE. REPORT, NO. 1 G-25488

APOA PROJECT NO. 16 : THEORETICAL ANALYSIS OF ICE FAILURE. REPORT, NO. 2 G-25496

APOA PROJECT NO. 17 : BEAUFORT SEA PRESSURE RIDGE AND ICE ISLAND SCOURING. REPORT, NO. 1 G-25500

APOA PROJECT NO. 17 : BEAUFORT SEA PRESSURE RIDGE AND ICE ISLAND SCOURING. REPORT, NO. 2 G-25518

APOA PROJECT NO. 17 : BEAUFORT SEA PRESSURE RIDGE AND ICE ISLAND SCOURING. REPORT, NO. 3 G-25526

APOA PROJECT NO. 17 : BEAUFORT SEA PRESSURE RIDGE AND ICE ISLAND SCOURING. REPORT, NO. 4 G-25534

APOA PROJECT NO. 19 : ANALYSIS OF SEA BOTTOM ICEBERG SCOURING RECORDS. REPORT G-25542

APOA PROJECT NO. 21 : EVALUATION OF DESERT TYPE 6 X 6 OILFIELD TRUCK IN ARCTIC CONDITIONS. REPORT, NO.
1-3 L-24716

APOA PROJECT NO. 24 : ARCTIC CLOTHING STUDY. REPORT K-25550

APOA PROJECT NO. 25 : MODEL TESTS TO SIMULATE THE ACTION OF ICE ON FIXED STRUCTURES. REPORT
G-24465

APOA PROJECT NO. 30 : BEAUFORT SEA EXPLORATORY DRILLING SYSTEMS. REPORT, NO. 1 Q-25569

APOA PROJECT NO. 30 : BEAUFORT SEA EXPLORATORY DRILLING SYSTEMS. REPORT, NO. 2 Q-25577

APOA PROJECT NO. 32 : BEAUFORT SEA SCOUR RECORDS - PHASE II. REPORT G-24473

APOA PROJECT NO. 33 : LAND FAST ICE MOVEMENT - BEAUFORT SEA 1971-72. REPORT G-25585

APOA PROJECT NO. 34 : NORTHERN RESOURCES RESEARCH PROJECT. REPORT Q-24481

APOA PROJECT NO. 35 : ENVIRONMENTAL STUDY OF THE BAFFIN BAY-DAVIS STRAIT REGION. REPORT, NO. 1
D-24490

APOA PROJECT NO. 35 : ENVIRONMENTAL STUDY OF THE BAFFIN BAY-DAVIS STRAIT REGION. REPORT, NO. 2
D-24503

APOA PROJECT NO. 36 : ICE ISLANDS DESTRUCTION - BEAUFORT SEA. REPORT G-24511

APOA PROJECT NO. 37 : ARCTIC ENVIRONMENTAL RESEARCH, TUNDRA AND ECOLOGICAL STUDIES ON THE MACKENZIE
DELTA AND DEVON ISLAND. REPORT C-30236, H-30147, H-30155, H-30163, H-30180, H-30198, H-30260,
H-30341, H-30350, J-30112, C-25291, Q-30120, Q-30139, Q-30171, Q-30201, Q-30210, Q-30228,
Q-30252

APOA PROJECT NO. 38 : APOA-DIAND TRANSPORTATION STUDY. REPORT, NO. 1 L-29947

APOA PROJECT NO. 38 : APOA-DIAND TRANSPORTATION STUDY. REPORT, NO. 2 L-29955

APOA PROJECT NO. 39 : ARCTIC OFFSHORE PIPELINE FEASIBILITY STUDY. REPORT Q-24520

APOA PROJECT NO. 40 : EVALUATION OF MECHANICAL PROPERTIES OF SALINE MODEL ICE. REPORT, NO. 1,2
G-24538

APOA PROJECT NO. 40 : EVALUATION OF MECHANICAL PROPERTIES OF SALINE MODEL ICE. REPORT, NO. 3
G-25593

APOA PROJECT NO. 41 : EVALUATION OF THE MECHANICAL PROPERTIES OF MICHEL'S MODEL ICE AND PRELIMINARY
ICE-STRUCTURE INTERACTION EXPER G-25607

APOA PROJECT NO. 42 : MACKENZIE DELTA GRAVEL INVENTORY. REPORT B-24546

APOA PROJECT NO. 45 : ARCTIC CLOTHING STUDY. REPORT, NO. 1 K-25615

APOA PROJECT NO. 45 : ARCTIC CLOTHING STUDY. REPORT, NO. 2,3 K-24554

APOA PROJECT NO. 48 : DOCUMENTATION OF VEHICULAR TRAFFIC ON MACKENZIE DELTA TUNDRA - 1972. FREEZE-UP AND
1973 THAW. REPORT, NO. 1 L-25623

APOA PROJECT NO. 48 : DOCUMENTATION OF VEHICULAR TRAFFIC ON MACKENZIE DELTA TUNDRA - 1972. FREEZE-UP AND
1973 THAW. REPORT, NO. 2 L-25631

APOA PROJECT NO. 48 : DOCUMENTATION OF VEHICULAR TRAFFIC ON MACKENZIE DELTA TUNDRA - 1972. FREEZE-UP AND
1973 THAW. REPORT, NO. 3 L-25640

APOA PROJECT NO. 49 : STUDY OF ARCTIC TRANSPORTATION EQUIPMENT - MACKENZIE DELTA. REPORT L-24562

APOA PROJECT NO. 51 : ICE MOVEMENT IN BEAUFORT SEA 1972-73. REPORT G-25658

APOA PROJECT NO. 52 : CRUSHING STRENGTH OF ICE. REPORT, NO. 1 G-25666

APOA PROJECT NO. 52 : CRUSHING STRENGTH OF ICE. REPORT, NO. 2 G-25674

APOA PROJECT NO. 52 : CRUSHING STRENGTH OF ICE. REPORT, NO. 3 G-25682

APOA PROJECT NO. 52 : CRUSHING STRENGTH OF ICE. REPORT, NO. 4 G-25690

APOA PROJECT NO. 53 : COUNT OF ICE ISLANDS - BEAUFORT SEA 1972. REPORT G-25704

APOA PROJECT NO. 54 : ICE GEOLOGY OF THE SOUTHERN BEAUFORT SEA. REPORT, NO. 1 G-25712

APOA PROJECT NO. 54 : ICE GEOLOGY OF THE SOUTHERN BEAUFORT SEA. REPORT, NO. 2 G-25720
 APOA PROJECT NO. 54 : ICE GEOLOGY OF THE SOUTHERN BEAUFORT SEA. REPORT, NO. 3 G-25739
 APOA PROJECT NO. 55 : ARCTIC ENVIRONMENTAL RESEARCH 1973 (DEVON ISLAND IBP PROJECT). REPORT
 J-29920
 APOA PROJECT NO. 56 : PREPARATION OF SPECIFICATIONS FOR LARGE ARCTIC TRUCK. REPORT L-25747
 APOA PROJECT NO. 57 : ADFREEZE STUDY. REPORT, NO. 1, V. 1 G-25755
 APOA PROJECT NO. 57 : ADFREEZE STUDY. REPORT, NO. 1, V. 2 G-25763
 APOA PROJECT NO. 57 : ADFREEZE STUDY. REPORT, NO. 2 G-25771
 APOA PROJECT NO. 60 : BEAUFORT SEA SUMMER ICE TESTING PROJECT. REPORT G-25780
 APOA PROJECT NO. 61 : ENVIRONMENTAL IMPACT ASSESSMENT PROGRAM, MACKENZIE DELTA - PHASE II. REPORT
 Q-25798
 APOA PROJECT NO. 63 : ARCTIC INSTITUTE OF NORTH AMERICA BEAUFORT SEA SYMPOSIUM. REPORT X-30317
 APOA PROJECT NO. 65 : SMALL PROTOTYPE CONE TEST. REPORT G-26646
 APOA PROJECT NO. 66 : ICE CRUSHING TESTS 1973-74. REPORT, NO. 1 G-26654
 APOA PROJECT NO. 66 : ICE CRUSHING TESTS 1973-74. REPORT, NO. 2 G-26662
 APOA PROJECT NO. 67 : ICE MOVEMENT IN THE BEAUFORT SEA, 1963/74. REPORT G-26670
 APOA PROJECT NO. 68 : PROPERTIES OF WAX MODEL ICE RIDGES. REPORT G-26689
 APOA PROJECT NO. 69 : AN ANALYTICAL STUDY OF ICE SCOUR. REPORT G-26697
 APOA PROJECT NO. 70 : WIND/WAVE HINDCAST, CANADIAN BEAUFORT SEA. REPORT D-25801
 APOA PROJECT NO. 72 : BEAUFORT SEA ENVIRONMENTAL PROGRAM Q-29904, Q-30309
 APOA PROJECT NO. 72 : BEAUFORT SEA ENVIRONMENTAL PROGRAM. REPORT, NO. 1 I-30325
 APOA PROJECT NO. 72 : BEAUFORT SEA ENVIRONMENTAL PROGRAM. REPORT, NO. 2 I-30333
 APOA PROJECT NO. 72 : BEAUFORT SEA ENVIRONMENTAL PROGRAM. REPORT, NO. 3A, 3B I-29963
 APOA PROJECT NO. 72 : BEAUFORT SEA ENVIRONMENTAL PROGRAM. REPORT, NO. 3C I-29971
 APOA PROJECT NO. 72 : BEAUFORT SEA ENVIRONMENTAL PROGRAM. REPORT, NO. 4 I-9784
 APOA PROJECT NO. 72 : BEAUFORT SEA ENVIRONMENTAL PROGRAM. REPORT, NO. 5 Q-11592
 APOA PROJECT NO. 72 : BEAUFORT SEA ENVIRONMENTAL PROGRAM. REPORT, NO. 6 I-29980
 APOA PROJECT NO. 72 : BEAUFORT SEA ENVIRONMENTAL PROGRAM. REPORT, NO. 8 I-29998
 APOA PROJECT NO. 72 : BEAUFORT SEA ENVIRONMENTAL PROGRAM. REPORT, NO. 9 H-11754
 APOA PROJECT NO. 72 : BEAUFORT SEA ENVIRONMENTAL PROGRAM. REPORT, NO. 10 Q-11657
 APOA PROJECT NO. 72 : BEAUFORT SEA ENVIRONMENTAL PROGRAM. REPORT, NO. 11 Q-30279
 APOA PROJECT NO. 72 : BEAUFORT SEA ENVIRONMENTAL PROGRAM. REPORT, NO. 12A J-11606
 APOA PROJECT NO. 72 : BEAUFORT SEA ENVIRONMENTAL PROGRAM. REPORT, NO. 12B I-11614
 APOA PROJECT NO. 72 : BEAUFORT SEA ENVIRONMENTAL PROGRAM. REPORT, NO. 12C H-11622
 APOA PROJECT NO. 72 : BEAUFORT SEA ENVIRONMENTAL PROGRAM. REPORT, NO. 13 J-16233
 APOA PROJECT NO. 72 : BEAUFORT SEA ENVIRONMENTAL PROGRAM. REPORT, NO. 15 F-6793
 APOA PROJECT NO. 72 : BEAUFORT SEA ENVIRONMENTAL PROGRAM. REPORT, NO. 16 D-30007
 APOA PROJECT NO. 72 : BEAUFORT SEA ENVIRONMENTAL PROGRAM. REPORT, NO. 17 D-4766
 APOA PROJECT NO. 72 : BEAUFORT SEA ENVIRONMENTAL PROGRAM. REPORT, NO. 18 D-30015
 APOA PROJECT NO. 72 : BEAUFORT SEA ENVIRONMENTAL PROGRAM. REPORT, NO. 19 D-30023
 APOA PROJECT NO. 72 : BEAUFORT SEA ENVIRONMENTAL PROGRAM. REPORT, NO. 20 E-11630
 APOA PROJECT NO. 72 : BEAUFORT SEA ENVIRONMENTAL PROGRAM. REPORT, NO. 21 E-15458
 APOA PROJECT NO. 72 : BEAUFORT SEA ENVIRONMENTAL PROGRAM. REPORT, NO. 22 C-6408
 APOA PROJECT NO. 72 : BEAUFORT SEA ENVIRONMENTAL PROGRAM. REPORT, NO. 24 A-30031
 APOA PROJECT NO. 72 : BEAUFORT SEA ENVIRONMENTAL PROGRAM. REPORT, NO. 25A D-15466
 APOA PROJECT NO. 72 : BEAUFORT SEA ENVIRONMENTAL PROGRAM. REPORT, NO. 25B D-15474
 APOA PROJECT NO. 72 : BEAUFORT SEA ENVIRONMENTAL PROGRAM. REPORT, NO. 26 G-15482
 APOA PROJECT NO. 72 : BEAUFORT SEA ENVIRONMENTAL PROGRAM. REPORT, NO. 27 Q-16241
 APOA PROJECT NO. 72 : BEAUFORT SEA ENVIRONMENTAL PROGRAM. REPORT, NO. 28 Q-15490
 APOA PROJECT NO. 72 : BEAUFORT SEA ENVIRONMENTAL PROGRAM. REPORT, NO. 29 Q-15504
 APOA PROJECT NO. 72 : BEAUFORT SEA ENVIRONMENTAL PROGRAM. REPORT, NO. 30 G-30040
 APOA PROJECT NO. 72 : BEAUFORT SEA ENVIRONMENTAL PROGRAM. REPORT, NO. 31A, 31B Q-30058
 APOA PROJECT NO. 72 : BEAUFORT SEA ENVIRONMENTAL PROGRAM. REPORT, NO. 32 T-15512
 APOA PROJECT NO. 72 : BEAUFORT SEA ENVIRONMENTAL PROGRAM. REPORT, NO. 33 Q-15520
 APOA PROJECT NO. 72 : BEAUFORT SEA ENVIRONMENTAL PROGRAM. REPORT, NO. 34 G-15539
 APOA PROJECT NO. 72 : BEAUFORT SEA ENVIRONMENTAL PROGRAM. REPORT, NO. 35 Q-15547
 APOA PROJECT NO. 72 : BEAUFORT SEA ENVIRONMENTAL PROGRAM. REPORT, NO. 36 G-3530
 APOA PROJECT NO. 72 : BEAUFORT SEA ENVIRONMENTAL PROGRAM. REPORT, NO. 37 Q-11649
 APOA PROJECT NO. 72 : BEAUFORT SEA ENVIRONMENTAL PROGRAM. REPORT, NO. 38 Q-15555
 APOA PROJECT NO. 76 : SUMMER ENVIRONMENTAL STUDIES - EAST MACKENZIE BAY - MACKENZIE DELTA. REPORT
 Q-26700
 APOA PROJECT NO. 77 : MODELLING OF SMALL CONE PROTOTYPE TESTS. REPORT G-26719
 APOA PROJECT NO. 78 : ENVIRONMENTAL DATA GATHERING PROGRAM - BAFFIN BAY, DAVIS STRAIT AND ARCTIC ISLANDS. REPORT G-26727
 APOA PROJECT NO. 89 : STUDY OF THE THICKNESS OF MULTI-YEAR PRESSURE RIDGES. REPORT G-29190
 APOA PROJECT NO. 97 : TESTS OF THE ARCTIC BOAT CONFIGURATION OF THE LOCKHEED CLEAN SWEEP SYSTEM IN A BROKEN ICE FIELD. REPORT Q-26743
 APOA PROJECT NO. 98 : ARCTIC SCIENCE AND TECHNOLOGY INFORMATION SYSTEM X-7773
 APOA PROJECT NO. 98 : ARCTIC SCIENCE AND TECHNOLOGY INFORMATION SYSTEM. REPORT Y-29866
 APOA PROJECT NO. 99 : ICE ISLAND COUNT - SOUTHERN BEAUFORT SEA 1974, 1975 AND 1976. REPORT, NO. 1, 2, 3
 G-26751
 APOA PROJECT NO. 100 : EVALUATION OF THE BENNETT CANAL OIL CONTAINMENT BOCM. REPORT, NO. 1
 Q-26760
 APOA PROJECT NO. 100 : EVALUATION OF THE BENNETT CANAL OIL CONTAINMENT BOCM. REPORT, NO. 2
 Q-26778
 APOA PROJECT NO. 107 : SOME ASPECTS OF WEATHERING AND BURNING OF CRUDE OIL IN WATER AND ICE ENVIRONMENT.
 REPORT Q-26450
 APOA PROJECT NO. 108 : IN-SITU BURNING OF THE PRODUCTS OF A SUBSEA BLOWOUT. REPORT Q-26468
 APOA PROJECT NO. 111 : EVALUATION OF ICE DEFENCE SYSTEMS FOR ARTIFICIAL ISLANDS. REPORT G-26476
 APOA PROJECT NO. 113 : PASSAGE INTO BEAUFORT SEA VIA POINT BARROW. REPORT L-27545
 APOA PROJECT NO. 114 : PRELIMINARY TESTS OF FIRD SCARE DEVICES ON THE BEAUFORT SEA COAST. REPORT
 Q-26484
 APOA PROJECT NO. 126 : BIOLOGICAL LITERATURE REVIEW OF DAVIS STRAIT. REPORT I-26425, J-25224
 APOA PROJECT NO. 127 : WINTER ENVIRONMENTAL INVESTIGATIONS IN DAVIS STRAIT - 1977. REPORT, NO. 1
 I-25232
 APOA PROJECT NO. 127 : WINTER ENVIRONMENTAL INVESTIGATIONS IN DAVIS STRAIT - 1977. REPORT, NO. 2
 J-25240

- BEAUFORT SEA SCOUR RECORDS - PHASE II G-24473
 BEAUFORT SEA SHORELINE STUDY, KOMAKUK BEACH TO BAILLIE ISLANDS Q-29912
 BEAUFORT SEA SUMMER ICE STUDY G-24457
 BEAUFORT SEA SUMMER ICE TESTING PROJECT G-25780
 BIODEGRADATION OF CRUDE PETROLEUM BY THE INDIGENOUS MICROBIAL FLOEA OF THE BEAUFORT SEA Q-11657
 BIOLOGICAL CONSIDERATIONS FOR CONSTRUCTION IN THE CANADIAN PERMAFROST REGION [1] Q-30210
 BIOLOGICAL FLORA OF THE BRITISH ISLES H-30260
 BIOLOGICAL IMPLICATIONS OF NATURAL DISPOSAL OF OIL IN THE MARINE ENVIRONMENT Q-30066
 BIOLOGICAL LITERATURE OF THE DAVIS STRAIT REGION I-26425
 BIOLOGICAL LITERATURE REVIEW OF THE DAVIS STRAIT REGION J-25224
 BIOLOGICAL PRODUCTIVITY OF THE SOUTHERN BEAUFORT SEA : PHYTOPLANKTON AND SEAWEED STUDIES H-11622
 BIOLOGICAL PRODUCTIVITY OF THE SOUTHERN BEAUFORT SEA : THE PHYSICAL-CHEMICAL ENVIRONMENT AND THE PLANKTON J-11606
 BIOLOGICAL PRODUCTIVITY OF THE SOUTHERN BEAUFORT SEA : ZOOBENTHIC STUDIES I-11614
 BIOLOGICAL STUDIES IN THE VICINITY OF HUDSON STRAIT, DAVIS STRAIT AND LABRADOR SEA AREA - 1976 D-26514, J-26506, J-26522
 BIOLOGIST EXPLAINS WHY WE MUST PLAN NOW TO PROTECT THE ARCTIC Q-30252
 BIOLOGIST LOOKS AT OIL IN THE SEA Q-19801
 BIRD MIGRATION ALONG THE BEAUFORT SEA COAST : RADAR AND VISUAL OBSERVATIONS IN 1975 I-29971
 BOWHEAD AND WHITE WHALES IN THE SOUTHERN BEAUFORT SEA I-9784
 CANADIAN GEOTECHNICAL JOURNAL, V. 11, NO. 3, AUG. 1974, P. 374-379, ILL. H-30198
 CANADIAN JOURNAL OF BOTANY, V. 50, NO. 5, MAY 1972, P. 1097-1109, PHOTOS., TABLES Q-30139
 CANADIAN JOURNAL OF BOTANY, V. 51, NO. 12, DEC. 1973, P. 2509-2513, GRAPHS H-30180
 CANADIAN JOURNAL OF BOTANY, V. 52, NO. 1, JAN. 1974, P. 103-116, TABLES H-30147
 CANADIAN JOURNAL OF BOTANY, V. 52, NO. 7, JULY 1974, P. 1731, MAP, TABLES (PART. FOLD.) H-30155
 CANADIAN OIL INDUSTRY'S SCIENTIFIC ACTIVITIES IN THE ARCTIC OFFSHORE Q-13331
 CHANGES IN ARCTIC ERIOPHORUM TUSsock COMMUNITIES FOLLOWING FIRE H-30163
 CHANGES TO THE ACTIVE LAYER CAUSED BY SURFACE DISTURBANCE C-30236
 CHEVRON ACADIA (1978) PROJECT Q-30848
 CIM BULLETIN, V. 64, NO. 712, AUG. 1971, P. 74-76, PHOTOS. J-30112
 COAST AND SHELF OF THE BEAUFORT SEA, PROCEEDINGS I-30317
 COASTAL ENVIRONMENT OF SOUTHERN BAFFIN ISLAND AND NORTHERN LABRADOR-UNGAVA A-25062
 COASTAL SEDIMENTARY PROCESSES AND SEDIMENTS, SOUTHERN BEAUFORT SEA A-30031
 COMPRESSION TESTS ON FRESH WATER ICE G-25496
 COMPRESSION TESTS ON FRESH WATER ICE, 1973 G-25690
 CONTRIBUTION - PARIS. UNIVERSITE. ECOLE DES HAUTES ETUDES EN SCIENCES SOCIALES. CENTRE D'ETUDES ARCTIQUES, NO. 12, V. 2, P. 505- Q-30228
 COTTON GRASS (ERIOPHORUM VAGINATUM) GERMINATION REQUIREMENTS AND COLONIZING POTENTIAL IN THE ARCTIC H-30180
 COUNT OF ICE ISLANDS - BEAUFORT SEA 1972 G-25704
 CROSS-COUNTRY VEHICLE STUDY L-21270
 CRUSHING STRENGTH OF ICE G-25666, G-25674, G-25682, G-25690
 DAVIS STRAIT ICE AND OCEANOGRAPHIC INVESTIGATIONS WINTER 1976-77 G-26492
 DAVIS STRAIT SURFACE DRIFTER BUOYS PROGRAM 1977 D-26620
 DAVIS STRAIT WAVE CLIMATIC STUDY USING THE 1970 THROUGH 1977 METEOROLOGICAL AND OCEANOGRAPHIC CENTRE SYNOPTIC SIGNIFICANT WAVE CHART D-26638
 DESTRUCTION OF ICE ISLANDS BY EXPLOSIVES G-24511
 DISCUSSION OF "A REVIEW OF APOA PROJECT 40 REPORT" G-25593
 DISTRIBUTION AND ABUNDANCE OF POLAR BEARS IN THE EASTERN BEAUFORT SEA I-30333
 DISTRIBUTION AND ABUNDANCE OF SEALS IN THE EASTERN BEAUFORT SEA I-30325
 DISTRIBUTION OF SEA ICE THICKNESS IN THE BEAUFORT SEA G-30040
 DISTRIBUTION OF TAB AND PARTICULATE POLLUTANTS ALONG THE BEAUFORT SEA COAST J-16233
 DISTRIBUTION OF THE ICE THICKNESS IN THE BEAUFORT SEA G-30040
 DOCUMENTATION OF VEHICULAR TRAFFIC ON MACKENZIE DELTA TUNDRA - 1972. FREEZE-UP AND 1973 THAW L-25623, L-25631, L-25640
 EREC REPORT, NO. 680 K-25615
 EREC TECHNICAL MEMORANDUM, NO. 73- 4 K-24554
 DRILLING FLUIDS WASTES CHARACTERISTICS FROM DRILLING OPERATIONS IN THE CANADIAN NORTH Q-12971
 DRILLING VESSEL TYPES Q-19330
 ECOLOGICAL IMPACT OF NORTHERN PETROLEUM DEVELOPMENT Q-30228
 ECOLOGICAL PROBLEMS ASSOCIATED WITH ARCTIC OIL AND GAS DEVELOPMENT Q-30201
 ECOLOGY, V. 54, NO. 4, SUMMER 1973, P. 845-852, PHOTOS., TABLES H-30163
 EFFECT OF A DRILLING WASTE ON THE SURVIVAL AND EMERGENCE OF THE CHIRONOMID - CHIRONOMUS TENTANS (FAERICIUS) Q-13048
 EFFECT OF CONTACT AND INGESTION OF CRUDE OIL ON RINGED SEALS OF THE BEAUFORT SEA Q-11592
 EFFECTS OF CRUDE OILS ON ARCTIC MARINE INVERTEBRATES Q-30279
 EFFECTS OF SUMMER TRAFFIC ON TUNDRA L-29955
 ENERGY BUDGET CHANGES FOLLOWING SURFACE DISTURBANCE TO UPLAND TUNDRA H-30341
 ENGINEERING MEMORANDUM : BEAUFORT SEA SUMMER ICE STUDY G-24457
 ENVIRONMENTAL CONDITIONS IN BAFFIN BAY AND DAVIS STRAIT INCLUDING PRESENTATION OF DATA COLLECTED DURING SUMMER 1972 D-24503
 ENVIRONMENTAL CONDITIONS OFF THE EAST COAST OF CANADA : GODTHAAB, GREENLAND (64 DEG. 10 SEC. N, 51 DEG. 45 SEC. W) E-26549
 ENVIRONMENTAL CONDITIONS OFF THE EAST COAST OF CANADA : SITES 3 (54 DEG. N, 54 DEG. W), 4 (49 DEG. N, 48 DEG. W) AND 5 (47 DEG. N, 4 E-26549
 ENVIRONMENTAL DATA GATHERING PROGRAM - BAFFIN BAY, DAVIS STRAIT AND ARCTIC ISLANDS G-26727
 ENVIRONMENTAL IMPACT ASSESSMENT PROGRAM, MACKENZIE DELTA - PHASE II Q-25798
 ENVIRONMENTAL INVESTIGATIONS AND ANALYSIS IN DAVIS STRAIT - SECOND HALF 1977 A-25062, D-26565, D-26581, D-26590, D-26603, D-26620, D-26638, D-27553, E-26549, G-26557, G-26611, I-25275, I-25283, I-26395, I-26409, I-26425, J-25224, J-25267, J-25810, J-26530, Q-26573, T-26417
 ENVIRONMENTAL STUDIES PANEL WORKSHOP Q-30864
 ENVIRONMENTAL STUDY OF THE BAFFIN BAY-DAVIS STRAIT REGION D-24490, D-24503
 ERIOPHORUM VAGINATUM L. H-30260
 EVALUATION OF DESERT TYPE 6 X 6 OILFIELD TRUCK IN ARCTIC CONDITIONS I-24716
 EVALUATION OF HOVERCRAFT AND ICE RECONNAISSANCE G-25534
 EVALUATION OF ICE DEFENCE SYSTEMS FOR ARTIFICIAL ISLANDS G-26476

APOA PROJECT NO. 128 : DAVIS STRAIT ICE AND OCEANOGRAPHIC INVESTIGATIONS WINTER 1976-77. REPORT
 G-26492
 APOA PROJECT NO. 134 : LATE WINTER AND SPRING INVESTIGATIONS IN DAVIS STRAIT - 1977. REPORT NO. 1, 1A
 J-25259
 APOA PROJECT NO. 135 : BIOLOGICAL STUDIES IN THE VICINITY OF HUDSON STRAIT, DAVIS STRAIT AND LABRADOR SEA
 AREA - 1976. REPORT, NO. D-26514, J-26506, J-26522
 APOA PROJECT NO. 136 : BEAUFORT SEA SHORELINE STUDY, KOMAKUK BEACH TO BAILLIE ISLANDS. REPORT, NO. 2
 Q-29912
 APOA PROJECT NO. 138 : ENVIRONMENTAL INVESTIGATIONS AND ANALYSIS IN DAVIS STRAIT - SECOND HALF 1977.
 REPORT, NO. 1 A-25062
 APOA PROJECT NO. 138 : ENVIRONMENTAL INVESTIGATIONS AND ANALYSIS IN DAVIS STRAIT - SECOND HALF 1977.
 REPORT, NO. 2 J-25810
 APOA PROJECT NO. 138 : ENVIRONMENTAL INVESTIGATIONS AND ANALYSIS IN DAVIS STRAIT - SECOND HALF 1977.
 REPORT, NO. 3, V.1-2 J-26530
 APOA PROJECT NO. 138 : ENVIRONMENTAL INVESTIGATIONS AND ANALYSIS IN DAVIS STRAIT - SECOND HALF 1977.
 REPORT, NO. 4, 4A J-25267
 APOA PROJECT NO. 138 : ENVIRONMENTAL INVESTIGATIONS AND ANALYSIS IN DAVIS STRAIT - SECOND HALF 1977.
 REPORT, NO. 5, 5A I-26395
 APOA PROJECT NO. 138 : ENVIRONMENTAL INVESTIGATIONS AND ANALYSIS IN DAVIS STRAIT - SECOND HALF 1977.
 REPORT, NO. 6 I-26409
 APOA PROJECT NO. 138 : ENVIRONMENTAL INVESTIGATIONS AND ANALYSIS IN DAVIS STRAIT - SECOND HALF 1977.
 REPORT, NO. 7 T-26417
 APOA PROJECT NO. 138 : ENVIRONMENTAL INVESTIGATIONS AND ANALYSIS IN DAVIS STRAIT - SECOND HALF 1977.
 REPORT, NO. 8 I-26425, J-25224
 APOA PROJECT NO. 138 : ENVIRONMENTAL INVESTIGATIONS AND ANALYSIS IN DAVIS STRAIT - SECOND HALF 1977.
 REPORT, NO. 9 I-25275
 APOA PROJECT NO. 138 : ENVIRONMENTAL INVESTIGATIONS AND ANALYSIS IN DAVIS STRAIT - SECOND HALF 1977.
 REPORT, NO. 10 I-25283
 APOA PROJECT NO. 138 : ENVIRONMENTAL INVESTIGATIONS AND ANALYSIS IN DAVIS STRAIT - SECOND HALF 1977.
 REPORT, NO. 11, V.1-2 D-27553
 APOA PROJECT NO. 138 : ENVIRONMENTAL INVESTIGATIONS AND ANALYSIS IN DAVIS STRAIT - SECOND HALF 1977.
 REPORT, NO. 12, 12A E-26549
 APOA PROJECT NO. 138 : ENVIRONMENTAL INVESTIGATIONS AND ANALYSIS IN DAVIS STRAIT - SECOND HALF 1977.
 REPORT, NO. 13 G-26557
 APOA PROJECT NO. 138 : ENVIRONMENTAL INVESTIGATIONS AND ANALYSIS IN DAVIS STRAIT - SECOND HALF 1977.
 REPORT, NO. 14 D-26565
 APOA PROJECT NO. 138 : ENVIRONMENTAL INVESTIGATIONS AND ANALYSIS IN DAVIS STRAIT - SECOND HALF 1977.
 REPORT, NO. 15 Q-26573
 APOA PROJECT NO. 138 : ENVIRONMENTAL INVESTIGATIONS AND ANALYSIS IN DAVIS STRAIT - SECOND HALF 1977.
 REPORT, NO. 16 D-26581
 APOA PROJECT NO. 138 : ENVIRONMENTAL INVESTIGATIONS AND ANALYSIS IN DAVIS STRAIT - SECOND HALF 1977.
 REPORT, NO. 17 E-26590
 APOA PROJECT NO. 138 : ENVIRONMENTAL INVESTIGATIONS AND ANALYSIS IN DAVIS STRAIT - SECOND HALF 1977.
 REPORT, NO. 18 D-26603
 APOA PROJECT NO. 138 : ENVIRONMENTAL INVESTIGATIONS AND ANALYSIS IN DAVIS STRAIT - SECOND HALF 1977.
 REPORT, NO. 19 G-26611
 APOA PROJECT NO. 138 : ENVIRONMENTAL INVESTIGATIONS AND ANALYSIS IN DAVIS STRAIT - SECOND HALF 1977.
 REPORT, NO. 20 D-26620
 APOA PROJECT NO. 138 : ENVIRONMENTAL INVESTIGATIONS AND ANALYSIS IN DAVIS STRAIT - SECOND HALF 1977.
 REPORT, NO. 21 D-26638
 APOA PROJECT REPORT X-19275
 APOA REVIEW Q-29858
 APOA-DIAND TRANSPORTATION STUDY L-29947, L-29955
 ARCTIC CLOTHING STUDY K-24554, K-25550, K-25615
 ARCTIC DRILLING FARGE STUDY Q-24449
 ARCTIC DRILLING OPERATIONS GUIDE Q-21288
 ARCTIC ENVIRONMENTAL OBSERVATIONS - M/V ARCTIC EXPLORER G-26727
 ARCTIC ENVIRONMENTAL RESEARCH 1973 (DEVON ISLAND IBP PROJECT) J-29920
 ARCTIC ENVIRONMENTAL RESEARCH, TUNDRA AND ECOLOGICAL STUDIES ON THE MACKENZIE DELTA AND DEVON ISLAND
 C-30236, H-30147, H-30155, H-30163, H-30180, H-30198, H-30260, H-30341, H-30350, J-30112,
 Q-30120, Q-30139, Q-30171, Q-30201, Q-30210, Q-30228, Q-30252
 X-30317
 ARCTIC INSTITUTE OF NORTH AMERICA BEAUFORT SEA SYMPOSIUM
 ARCTIC ISLANDS UNDERWATER COMPLETIONS Q-19313
 ARCTIC MARINE ENVIRONMENTAL STUDIES Q-30821
 ARCTIC MARINE RESOURCES : HARVEST AND UTILIZATION PANEL I-19356
 ARCTIC OFFSHORE PIPELINE FEASIBILITY STUDY Q-24520
 ARCTIC OFFSHORE PIPELINE FEASIBILITY STUDY IN MACKENZIE RIVER DELTA AREA Q-24520
 ARCTIC OIL AND GAS : PROBLEMS AND POSSIBILITIES Q-30228
 ARCTIC OIL DRILLING OPERATIONS : SOME HUMAN FACTORS ENGINEERING OBSERVATIONS K-25550
 ARCTIC PLANT COMMUNITIES EAST OF THE MACKENZIE DELTA H-30155
 ARCTIC SCIENCE AND TECHNOLOGY INFORMATION SYSTEM Y-29866
 ARCTIC WINTER EVALUATION STUDY OF TRANSPORTATION EQUIPMENT L-24562
 ARCTIC WINTER TEST AND EVALUATION OF KENWORTH TRUCK MODEL 953A I-24716
 ARTIFICIAL ISLANDS IN THE BEAUFORT SEA Q-19321
 ASTIS CURRENT AWARENESS BULLETIN X-7773
 BEAUFORT SEA - ICE MOVEMENT AND CURRENT SURVEY - 1970 G-19283, G-19305, G-21237
 BEAUFORT SEA DRILLING Q-19798
 BEAUFORT SEA ENVIRONMENTAL PROGRAM A-30031, C-6408, D-4766, D-15466, D-15474, D-30007, D-30015,
 D-30023, E-11630, E-15458, F-6793, G-3530, G-11649, G-15482, G-15539, G-30040, H-11622,
 H-11754, I-9784, I-11614, I-29963, I-29971, I-29980, I-30325, I-30333, J-11606,
 J-16233, Q-11592, Q-11657, Q-15490, Q-15504, Q-15520, Q-15547, Q-15555, Q-16241, Q-25904,
 Q-30056, Q-30279, Q-30309, T-15512
 BEAUFORT SEA EXPLORATORY DRILLING SYSTEM Q-25569
 BEAUFORT SEA EXPLORATORY DRILLING SYSTEMS Q-25577
 BEAUFORT SEA ICE SAMPLING PROJECT - 1970 G-19283
 BEAUFORT SEA PRESSURE RIDGE AND ICE ISLAND SCOURING G-25500, G-25518, G-25526, G-25534

EVALUATION OF MECHANICAL PROPERTIES OF MICHEL'S MODEL ICE AND PRELIMINARY ICE-STRUCTURE INTERACTION
EXPERIMENT G-25607

EVALUATION OF MECHANICAL PROPERTIES OF SALINE MODEL ICE G-24538, G-25593

EVALUATION OF THE BENNETT CANNAR OIL CONTAINMENT BOOM Q-26760

EVALUATION OF THE BENNETT-CANNAR OIL CONTAINMENT BOOM Q-26778

EXPERIMENTAL CRUDE OIL SPILLS ON ARCTIC PLANT COMMUNITIES Q-30120

EXTENT AND GROWTH PATTERNS OF LANDFAST ICE IN THE SOUTHERN BEAUFORT SEA - WINTER 1972-73 G-25712

FACTORS AFFECTING USE OF WINTER ROADS DURING SPRING THAW L-25640

FEASIBILITY STUDY EXPLORATORY DRILLING SYSTEMS BEAUFORT SEA Q-23345

FIELD REPORT ON THE OCEANOGRAPHIC CRUISES DURING APRIL, JULY-AUGUST, OCTOBER-NOVEMBER, 1976 D-26590

FINAL REPORT : 1977 OCEAN CURRENT STUDY D-26590

FISHES OF THE CUTER MACKENZIE DELTA I-29998

FISHES OF THE YUKON COAST I-29980

FRONTIER EXPLORATION - HYDROCARBON RESERVE POTENTIAL Q-30813

FUNCTIONAL EFFECTS OF VEGETATION ON THE RADIANT ENERGY BUDGET OF BOREAL FOREST H-30198

GEOLOGICAL ANALYSIS OF OCEAN FLOOR SAMPLES C-21261, D-21253

GEOLOGICAL SAMPLING AND ANALYTICAL PROGRAM - BEAUFORT SEA D-21253

GRAVEL INVENTORY SURVEY, RICHARDS ISLAND AND ADJACENT AREAS B-24546

HYDROCARBON LEVELS IN THE MARINE ENVIRONMENT OF THE SOUTHERN BEAUFORT SEA Q-15555

HYDRODYNAMICS OF AN OILWELL BLOWOUT Q-15520

ICE ADHESION STUDY : FINAL REPORT G-25771

ICE AND CURRENT MEASUREMENTS PROGRAM, BEAUFORT SEA, SPRING 1970 G-19305

ICE CLIMATOLOGY IN THE BEAUFORT SEA G-15482

ICE CRUSHING TESTS - 1974 G-26654

ICE CRUSHING TESTS 1973 G-25682

ICE CRUSHING TESTS 1973-74 G-26662

ICE FORCES ON OFFSHORE MONOPODS AND PILES, SEPTEMBER 1973 G-25674

ICE GEOLOGY OF THE SOUTHERN BEAUFORT SEA G-25712, G-25720, G-25739

ICE ISLAND COUNT - SOUTHERN BEAUFORT SEA G-26751

ICE ISLAND COUNT, SOUTH BEAUFORT SEA, 1972 G-25704

ICE ISLAND COUNT, SOUTHERN BEAUFORT SEA - 1973 G-25720

ICE ISLANDS DESTRUCTION - BEAUFORT SEA G-24511

ICE MOVEMENT IN BEAUFORT SEA 1972-73 G-25658

ICE MOVEMENT IN THE BEAUFORT SEA, 1963/74 G-26670

IMMEDIATE EFFECTS OF WHEELED VEHICLE TRAFFIC ON TUNDRA DURING THE SUMMER L-29947

IN-SITU BURNING OF THE PRODUCTS OF A SUBSEA BLOWOUT Q-26468

INSPECTION OF WINTER ROADS, MACKENZIE DELTA, FOLLOWING SPRING THAW, 1973 L-25623

INTERACTION OF CRUDE OIL WITH ARCTIC SEA ICE Q-16241

INTERIM REPORT - ENVIRONMENT PROTECTION BOARD, NO. 3 H-30350

INTERIM REPORT TO APCA STEERING COMMITTEE, BEAUFORT SEA ENVIRONMENTAL PROGRAM, OF [SIC] THE DESIGN OF A PUBLIC INTERFACE PROJECT Q-30309

INTERPRETATION OF ICE STRENGTH FROM IN-SITU INDENTATION TESTS G-25488

INVESTIGATION OF MULTI-YEAR PRESSURE RIDGES AND SHORE PILE-UPS G-29190

INVESTIGATION OF SEA-BED SCOURING IN THE BEAUFORT SEA G-25542

INVESTIGATION OF SEA-BED SCOURING IN THE BEAUFORT SEA (PHASE II) G-24473

INVESTIGATIONS INTO THE FEASIBILITY OF PRODUCING PRESSURE RIDGE/ICE SHEET SYSTEMS WITH SYNTHETIC ICE G-26689

ISLAND DEFENSE SYSTEM TESTS G-26476

JOURNAL OF APPLIED ECOLOGY, V. 10, 1973, P. 671-682, TABLES Q-30120

JOURNAL OF APPLIED ECOLOGY, V. 11, 1974, P. 355-374, ILL., GRAPHS, TABLES H-30341

JOURNAL OF ECOLOGY, V. 61, 1973, P. 601-615, ILL., MAPS H-30260

JOURNAL OF GLACIOLOGY, V. 19, NO. 81, 1977 F-30295

LABORATORY TESTING OF COMMERCIAL ARCTIC CLOTHING SUBMITTED BY THE ARCTIC PETROLEUM OPERATORS' ASSOCIATION K-24554

LABORATORY TESTS ON FRESH WATER ICE, 1974 G-26662

LAND FAST ICE MOVEMENT - BEAUFORT SEA 1971-72 G-25585

LANDFAST ICE MOVEMENT - MACKENZIE DELTA 1972 G-25585

LANDFAST ICE MOVEMENT - MACKENZIE DELTA 1972-73 G-25658

LANDFAST ICE MOVEMENT - MACKENZIE DELTA 1973-74 G-26670

LATE WINTER AND SPRING INVESTIGATIONS IN DAVIS STRAIT - 1977 J-25259

LIBRARY ACCESSIONS LIST - ARCTIC INSTITUTE OF NORTH AMERICA I-7773

LIGHT INTENSITY AND PRIMARY PRODUCTIVITY UNDER SEA ICE CONTAINING OIL Q-15504

LOGISTICS OPERATIONS : APCA BEAUFORT SEA PROJECTS 1970 G-21237

LONG TERM EFFECTS OF SUMMER TRAFFIC BY TRACKED VEHICLES ON TUNDRA L-29955

MACKENZIE DELTA GRAVEL INVENTORY B-24546

MACKENZIE DELTA ORNITHOLOGICAL STUDY I-21300

MACKENZIE DELTA PROJECT : FINAL REPORT I-21300

MACKENZIE RIVER INPUT TO THE BEAUFORT SEA F-6793

MARINE TOXICITY STUDIES ON DRILLING FLUID WASTES Q-13021

MATHEMATICAL MODEL TO DESCRIBE THE BEHAVIOR OF A MOVING ICE FIELD ENCOUNTERING A CONICAL STRUCTURE. VOL. 1. REVISED REPORT G-25755

MATHEMATICAL MODEL TO DESCRIBE THE BEHAVIOR OF A MOVING ICE FIELD ENCOUNTERING A CONICAL STRUCTURE. VOL. 2. MODEL TESTS TO ASSESS AD G-25763

MICROPALAEONTOLOGIC - MINERALOGIC ANALYSIS OF RECENT MUD SAMPLES FROM ICE-SCOURED SURFACE OF BEAUFORT SHELF G-25526

MODEL EXPERIMENTS TO DETERMINE THE FORCES EXERTED ON STRUCTURES BY MOVING ICE FIELDS (COMPARISON WITH SMALL PROTOTYPE TEST RESULTS) G-26719

MODEL EXPERIMENTS TO DETERMINE THE FORCES EXERTED ON STRUCTURES BY MOVING ICE FIELDS : FINAL REPORT G-24465

MODEL TESTS TO ASSESS ADFREEZE EFFECTS G-25763

MODEL TESTS TO SIMULATE THE ACTION OF ICE ON FIXED STRUCTURES G-24465

MODELLING OF SMALL COKE PROTOTYPE TESTS G-26719

MONITORING OF TWO EXPLORATORY DRILLING SITES IN THE SHALLOW REGIONS OF MACKENZIE BAY Q-12963

MOVEMENT AND DEFORMATION OF THE LANDFAST ICE OF THE SOUTHERN BEAUFORT SEA G-11649

MOVEMENT OF OIL UNDER SEA ICE Q-15490

NATURAL AREAS OF CANADIAN SIGNIFICANCE S-30830

91

- NEAR BOTTOM CURRENTS AND OFFSHORE TIDES D-30007
 NITROGEN FIXATION IN ARCTIC MARINE SEDIMENTS H-11754
 NORMAL AND EXTREME WINDS AND WAVES IN THE CANADIAN SOUTHERN BEAUFORT SEA D-25801
 NORTH OF 60 L-29947
 NORTHERN DEVELOPMENT AND THE NATIVE PEOPLE, A LITERATURE REVIEW OF CURRENT OPINIONS AND ISSUES Q-29904
 NORTHERN ECOSYSTEM AND NORTHERN DEVELOPMENT J-30112
 NORTHERN OIL AND GAS PRODUCTION RELATED EMPLOYMENT OPPORTUNITIES : THE IMPACT OF MACKENZIE DELTA PRODUCTION Q-24481
 NORTHERN RESOURCES RESEARCH PROJECT Q-24481
 NUTCRACKER ICE STRENGTH TESTER AND ITS OPERATION IN THE BEAUFORT SEA G-29939
 NUTCRACKER ICE STRENGTH TESTS, 1969-70 G-19291, G-29939
 NUTCRACKER ICE STRENGTH TESTS, 1970-71 G-21296
 NUTRIENT LIMITATIONS TO PLANT PRODUCTION IN TWO TUNDRA COMMUNITIES H-30147
 OCCURRENCE OF PERMAFROST AND FROZEN SUB-SEABOTTOM MATERIALS IN THE SOUTHERN BEAUFORT SEA C-6408
 OCEAN FLOOR SAMPLING BEAUFORT SEA 1970 D-21245, G-21237
 OFFSHORE DEEP WELL EXPLORATION EXPERIENCE : THE CHEVRON ACADIA (1978) PROJECT Q-30848
 OFFSHORE ENVIRONMENTAL STUDIES PANEL Q-19348
 OFFSHORE PERMAFROST, SOUTHERN BEAUFORT SEA C-21261
 OIL AND THE ECOLOGY OF THE ARCTIC Q-25291
 OIL SPILL COUNTERMEASURES FOR THE SOUTHERN BEAUFORT SEA Q-30058
 OIL SPILL WORKSHOP : SHORELINE PROTECTION AND CLEANUP Q-30856
 OIL, ICE AND CLIMATE IN THE BEAUFORT SEA Q-15547
 OILSPILL WORKSHOP Q-19364
 OILWEEK, V. 21, NO. 46, JAN. 4, 1971, P. 13-14 Q-30171
 OPEN WATER SURFACE CURRENTS IN THE SOUTHERN BEAUFORT SEA D-4766
 PAPERS - SYMPOSIUM ON THE TUNDRA ENVIRONMENT, WINNIPEG, 3 JUNE, 1970. PROCEEDINGS AND TRANSACTIONS. SERIES 4 - ROYAL SOCIETY OF CANA Q-25291
 PASSAGE INTO BEAUFORT SEA VIA POINT BARROW L-27545
 PERMAFROST : NORTH AMERICAN CONTRIBUTION / INTERNATIONAL CONFERENCE ON PERMAFROST, 2D, YAKUTSK, U.S.S.R., JULY 13-26, 1973. WASHINGTON Q-30210
 PETROLE ET LE GAZ ARCTIQUES : PROBLEMES ET PERSPECTIVES - ARCTIC OIL AND GAS : PROBLEMS AND POSSIBILITIES, RAPPORTS SCIENTIFIQUES / Q-30228
 PHYSICAL ASPECTS OF THE BEAUFORT SEA COAST A-30031
 PHYSICAL ENVIRONMENT OF THE BEAUFORT SEA RELATED TO OIL, ICE AND WATER INTERACTIONS Q-30082
 PHYSICAL OCEANOGRAPHY OF THE SOUTH-EASTERN BEAUFORT SEA D-30015
 PHYSICAL-CHEMICAL ENVIRONMENT AND THE PLANKTON J-11606
 PHYTOPLANKTON AND SEAWEEED STUDIES H-11622
 PLANT COMMUNITY RESPONSES TO DISTURBANCES IN THE WESTERN CANADIAN ARCTIC Q-30139
 PRELIMINARY ARCTIC ENGINEERING STUDY OF SURFACE TRANSPORT VEHICLES L-21270
 PRELIMINARY ASSESSMENT OF WATER POLLUTION FROM ABANDONED OIL AND GAS DRILLING SUMPS IN THE NORTHWEST TERRITORIES Q-13528
 PRELIMINARY STUDY OF THE EFFECTS OF OIL WELL DRILLING SUMP FLUIDS ON SOME AQUATIC ORGANISMS OF THE MACKENZIE DELTA Q-13030
 PRELIMINARY STUDY OF THE FATE OF OIL FROM A SUBSEA BLOWOUT ON THE EAST COAST Q-26573
 PRELIMINARY TESTS OF BIRD-SCARE DEVICES ON THE BEAUFORT SEA COAST Q-26484
 PREPARATION OF SPECIFICATIONS FOR LARGE ARCTIC TRUCK L-25747
 PROCEEDINGS - ARCTIC ENVIRONMENTAL WORKSHOP, 6TH, FAIRMONT HOT SPRINGS, B.C., APRIL 17-20, 1977 Q-29890
 PROCEEDINGS - ARCTIC ENVIRONMENTAL WORKSHOP, 6TH, FAIRMONT HOT SPRINGS, B.C., APRIL 17-20, 1977 / EDITED BY J.G. GAINER, W.J. LUGAN Q-30086, Q-30074, Q-30082, Q-30090, Q-30104
 PROCEEDINGS - ARCTIC ENVIRONMENTAL WORKSHOP, 7TH, FAIRMONT HOT SPRINGS, B.C., APRIL 12-15, 1978 Q-18155
 PROCEEDINGS - ARCTIC ENVIRONMENTAL WORKSHOP, 7TH, FAIRMONT HOT SPRINGS, B.C., APRIL 12-15, 1978 / EDITED BY S. JAMES [AND] D. MACKAY I-19356, Q-19313, Q-19321, Q-19330, Q-19348, Q-19364, Q-19372, Q-19798, Q-19801
 PROCEEDINGS - ARCTIC ENVIRONMENTAL WORKSHOP, 8TH, FAIRMONT HOT SPRINGS, B.C., MAY 7-9, 1979 Q-30805
 PROCEEDINGS - ARCTIC ENVIRONMENTAL WORKSHOP, 8TH, FAIRMONT HOT SPRINGS, B.C., MAY 7-9, 1979. CALGARY : ARCTIC INSTITUTE OF NORTH AM Q-30813, Q-30821, Q-30848, Q-30856, Q-30864, Q-30872, S-30830
 PROCEEDINGS - CANADIAN NORTHERN PIPELINE RESEARCH CONFERENCE, OTTAWA, 2-4 FEB., 1972 / EDITED BY R.F. LEGGET AND I.C. MACFARLANE. OT Q-30201
 PROCEEDINGS - CONFERENCE ON THE ENVIRONMENTAL EFFECTS OF OIL AND SALT WATER SPILLS ON LAND, BANFF, NOV. 6-7, 1975 Q-30287
 PROCEEDINGS - IAHR SYMPOSIUM : ICE AND ITS ACTION ON HYDRAULIC STRUCTURES, 1ST, REYKJAVIK, ICELAND, 7-10 SEPT., 1970. [DELFT? : S.N. G-29939
 PROCEEDINGS - SEMINAR ON THE PERMAFROST ACTIVE LAYER, VANCOUVER, 4-5 MAY, 1971 / PREPARED BY R.J.E. BROWN. OTTAWA : NATIONAL RESEARCH C-30236
 PROCEEDINGS - SYMPOSIUM ON APPLIED GLACIOLOGY, CAMBRIDGE, 13-17 SEPTEMBER 1976 P-30295
 PROCEEDINGS AND TRANSACTIONS. SERIES 4 - ROYAL SOCIETY OF CANADA, V. 7 [I.E. 8], 1970, P. 1-12, FIGURES Q-25291
 PROGRESS REPORT - ARCTEC, INC., NO. 00571- 5 G-24465
 PROPERTIES OF WAX MODEL ICE RIDGES G-26689
 PROPOSAL TO EVALUATE AN OIL CONTAINMENT BOOM FOR USE IN ICE-INFESTED WATERS Q-26760
 PUBLICATION - TORONTO. UNIVERSITY. INSTITUTE FOR ENVIRONMENTAL STUDIES, EE 6 Q-29890
 PUBLICATION - TORONTO. UNIVERSITY. INSTITUTE FOR ENVIRONMENTAL STUDIES, EE 6, P. 11-26, ILL. Q-30066
 PUBLICATION - TORONTO. UNIVERSITY. INSTITUTE FOR ENVIRONMENTAL STUDIES, EE 6, P. 27-42, ILL. Q-30074
 PUBLICATION - TORONTO. UNIVERSITY. INSTITUTE FOR ENVIRONMENTAL STUDIES, EE 6, P. 43-53, MAPS Q-30082
 PUBLICATION - TORONTO. UNIVERSITY. INSTITUTE FOR ENVIRONMENTAL STUDIES, EE 6, P. 65-78 Q-30090
 PUBLICATION - TORONTO. UNIVERSITY. INSTITUTE FOR ENVIRONMENTAL STUDIES, EE 6, P. 79-112, ILL. Q-30104
 PUBLICATION - TORONTO. UNIVERSITY. INSTITUTE FOR ENVIRONMENTAL STUDIES, EE 8 Q-18155
 PUBLICATION - TORONTO. UNIVERSITY. INSTITUTE FOR ENVIRONMENTAL STUDIES, EE 8, P. 19-24, ILL., FIGURES Q-19313

PUBLICATION - TORONTO. UNIVERSITY. INSTITUTE FOR ENVIRONMENTAL STUDIES, EE 8, P. 25-38, ILL.
Q-19321

PUBLICATION - TORONTO. UNIVERSITY. INSTITUTE FOR ENVIRONMENTAL STUDIES, EE 8, P. 39-46, ILL.
Q-19330

PUBLICATION - TORONTO. UNIVERSITY. INSTITUTE FOR ENVIRONMENTAL STUDIES, EE 8, P. 47-66 Q-19798

PUBLICATION - TORONTO. UNIVERSITY. INSTITUTE FOR ENVIRONMENTAL STUDIES, EE 8, P. 67-73 Q-19801

PUBLICATION - TORONTO. UNIVERSITY. INSTITUTE FOR ENVIRONMENTAL STUDIES, EE 8, P. 74-85 Q-19348

PUBLICATION - TORONTO. UNIVERSITY. INSTITUTE FOR ENVIRONMENTAL STUDIES, EE 8, P. 86-102

I-19356

PUBLICATION - TORONTO. UNIVERSITY. INSTITUTE FOR ENVIRONMENTAL STUDIES, EE 8, P. 103-117
Q-19364

PUBLICATION - TORONTO. UNIVERSITY. INSTITUTE FOR ENVIRONMENTAL STUDIES, EE 8, P. 118-132
Q-19372

REAL-TIME ENVIRONMENTAL PREDICTION SYSTEM E-11630

REPORT - CANADA. ARCTIC LAND USE RESEARCH PROGRAM, ALUR 72-73- 12 L-29947

REPORT - CANADA. ARCTIC LAND USE RESEARCH PROGRAM, ALUR 72-73- 13 L-29955

REPORT - CANADA. DEFENCE RESEARCH ESTABLISHMENT OTTAWA K-25550

REPORT - CANADA. TASK FORCE ON NORTHERN OIL DEVELOPMENT, NO. 73- 22 L-29955

REPORT - INDUSTRY/GOVERNMENT WORKING GROUP IN DISPOSAL WASTE FLUIDS FROM PETROLEUM EXPLORATORY DRILLING
IN THE CANADIAN NORTH Q-12939

REPORT - INDUSTRY/GOVERNMENT WORKING GROUP IN DISPOSAL WASTE FLUIDS FROM PETROLEUM EXPLORATORY DRILLING
IN THE CANADIAN NORTH, V. 1 Q-12947

REPORT - INDUSTRY/GOVERNMENT WORKING GROUP IN DISPOSAL WASTE FLUIDS FROM PETROLEUM EXPLORATORY DRILLING
IN THE CANADIAN NORTH, V. 2 Q-13528

REPORT - INDUSTRY/GOVERNMENT WORKING GROUP IN DISPOSAL WASTE FLUIDS FROM PETROLEUM EXPLORATORY DRILLING
IN THE CANADIAN NORTH, V. 3 Q-12955

REPORT - INDUSTRY/GOVERNMENT WORKING GROUP IN DISPOSAL WASTE FLUIDS FROM PETROLEUM EXPLORATORY DRILLING
IN THE CANADIAN NORTH, V. 4 Q-12963

REPORT - INDUSTRY/GOVERNMENT WORKING GROUP IN DISPOSAL WASTE FLUIDS FROM PETROLEUM EXPLORATORY DRILLING
IN THE CANADIAN NORTH, V. 5 Q-12971

REPORT - INDUSTRY/GOVERNMENT WORKING GROUP IN DISPOSAL WASTE FLUIDS FROM PETROLEUM EXPLORATORY DRILLING
IN THE CANADIAN NORTH, V. 6 Q-12980

REPORT - INDUSTRY/GOVERNMENT WORKING GROUP IN DISPOSAL WASTE FLUIDS FROM PETROLEUM EXPLORATORY DRILLING
IN THE CANADIAN NORTH, V. 7 Q-12998

REPORT - INDUSTRY/GOVERNMENT WORKING GROUP IN DISPOSAL WASTE FLUIDS FROM PETROLEUM EXPLORATORY DRILLING
IN THE CANADIAN NORTH, V. 8 Q-13005

REPORT - INDUSTRY/GOVERNMENT WORKING GROUP IN DISPOSAL WASTE FLUIDS FROM PETROLEUM EXPLORATORY DRILLING
IN THE CANADIAN NORTH, V. 9 Q-13013

REPORT - INDUSTRY/GOVERNMENT WORKING GROUP IN DISPOSAL WASTE FLUIDS FROM PETROLEUM EXPLORATORY DRILLING
IN THE CANADIAN NORTH, V. 10 Q-13021

REPORT - INDUSTRY/GOVERNMENT WORKING GROUP IN DISPOSAL WASTE FLUIDS FROM PETROLEUM EXPLORATORY DRILLING
IN THE CANADIAN NORTH, V. 11 Q-13030

REPORT - INDUSTRY/GOVERNMENT WORKING GROUP IN DISPOSAL WASTE FLUIDS FROM PETROLEUM EXPLORATORY DRILLING
IN THE CANADIAN NORTH, V. 12 Q-13048

REPORT ON AERIAL SURVEYS 77-2, 77-3, 77-4 : STUDIES OF SEABIRDS AND MARINE MAMMALS IN DAVIS STRAIT,
HUDSON STRAIT AND UNGAVA BAY I-26395

REPORT ON BIOLOGICAL CRUISES, OFFSHORE CRUISES 77-2 AND 77-3, APRIL-JUNE, 1977 IN THE DAVIS STRAIT
J-25259

REPORT ON BIOLOGICAL LITERATURE REVIEW OF THE LABRADOR SEA REGION J-25810

REPORT ON BIOLOGICAL LITERATURE REVIEW OF UNGAVA BAY AND HUDSON STRAIT I-25275

REPORT ON BIOLOGICAL STUDIES, OFFSHORE CRUISE 77-4 THROUGH 77-7, JULY-DECEMBER, 1977 IN THE DAVIS STRAIT
J-25267

REPORT ON CRUISE II, JULY, 1976. ENVIRONMENTAL ASPECTS OF IMPERIAL OIL CRUISE TO FLEMISH PASS AND DAVIS
STRAIT J-26506

REPORT ON CRUISE III, OCTOBER-NOVEMBER, 1976 AND CRUISE IV, NOVEMBER-DECEMBER, 1976. ENVIRONMENTAL
ASPECTS OF THE IMPERIAL OIL CRUISE J-26522

REPORT ON CRUISE 77-1, FEBRUARY, 1977 : ENVIRONMENTAL ASPECTS OF THE CRUISE TO DAVIS STRAIT AND THE
LABRADOR COAST J-25240

REPORT ON ICE AND METEOROLOGICAL OBSERVATIONS IN THE DAVIS STRAIT DURING APRIL, MAY AND JUNE 1977
G-26557

REPORT ON INUIT NATURAL RESOURCE USE IN SOUTH-EAST BAFFIN REGION T-26417

REPORT ON LABRATORY TESTING OF SEA-BED SAMPLES FROM DAVIS STRAIT D-26603

REPORT ON MARINE BENTHIC INVERTEBRATES OF THE SOUTHERN DAVIS STRAIT AND UNGAVA BAY I-25283

REPORT ON PHASE I OF PRESSURE RIDGE AND ICE ISLAND STUDY : EVALUATION OF HOVERCRAFT AND ICE
RECONNAISSANCE G-25534

REPORT ON PRELIMINARY NEARSHORE ENVIRONMENTAL STUDIES ON SOUTHEAST BAFFIN ISLAND I-26409

REPORT ON PRIMARY DATA COLLECTED FOR THE 1977 DAVIS STRAIT BIOLOGICAL PROGRAMME AND ANALYZED PRIOR TO
DECEMBER, 1977 J-26530

REPORT ON SEDIMENT ANALYSIS OF CORES FROM DAVIS STRAIT AND FLEMISH PASS D-26565

REPORT ON STRENGTH AND DEFORMATION CHARACTERISTICS OF SEA-BED SAMPLES FROM DAVIS STRAIT D-26581

REPORT ON THE DAVIS STRAIT AERIAL SURVEY 77-1 I-25232

RESOURCES AND PLANNING OF THE FEDERAL GOVERNMENT FOR OIL SPILL COUNTERMEASURES IN THE BEAUFORT SEA
Q-30074

RESULTS OF MODEL ICE SHEET PROPERTIES RESEARCH G-24538

REVEGETATION STUDIES - NORMAN WELLS, INUVIK AND TUKTOYAKTUK, N.W.T. AND PRUDHOE BAY, ALASKA : APPLICATION
TO THE PROPOSED PIPELINE R H-30350

REVIEW OF APOA PROJECT 40 REPORT G-25593

REVIEW OF RESEARCH ON POLLUTION ASPECTS OF DRILLING AND SUMP FLUIDS Q-12947

REVIEW OF THE OFFSHORE ENVIRONMENTAL LEGISLATION AND REGULATORY PROCESSES Q-19372

REVISED BIOLOGICAL LITERATURE OF THE DAVIS STRAIT REGION I-26425, J-25224

SATELLITE OBSERVATIONS OF THE BEAUFORT SEA ICE COVER G-15539

SCIENCE FORUM 15, V. 3, NO. 3, JUNE 1970, P. 3-8, PHOTOS. Q-30252

SEA ICE MORPHOLOGY IN THE BEAUFORT SEA G-3530

SEA ICE PRESSURE RIDGES AND ICE ISLANDS G-25500

SEA ICE TESTS G-25518

SEA ICE TOPOGRAPHY IN THE BEAUFORT SEA AND ITS EFFECT ON OIL CONTAINMENT G-3530

SEABIRDS OF THE SOUTHEASTERN BEAUFORT SEA I-29963
 SECCND INTERIM REPORT TO APOA STEERING COMMITTEE, BEAUFORT SEA ENVIRONMENTAL PROGRAM, ON PUBLIC INTERFACE
 PROJECT, JULY 1, 1974 TO J Q-29904
 SEDIMENT DISPERSAL IN THE SOUTHERN BEAUFORT SEA D-15466
 SEQUENCE OF EVENTS CONCERNING EXPLORATORY DRILLING IN THE BEAUFORT SEA AND DAVIS STRAIT REGIONS
 Q-30872
 SHORELINE OIL SPILL PROTECTION AND CLEANUP STRATEGIES : SOUTHERN BEAUFORT SEA Q-29912
 SHORELINE PROTECTION AND CLEANUP Q-30856
 SMALL PROTOTYPE CONE TEST G-26646
 SMALL PROTOTYPE CONE TESTS, WINTER 1973-74 G-26646
 SMALL SCALE, IN-SITU ICE STRENGTH TESTS, MARCH 1973 G-25666
 SOCIO-ECONOMIC IMPORTANCE OF WILDLIFE RESOURCE UTILIZATION IN THE SOUTHERN BEAUFORT SEA T-15512
 SOCIO-ECONOMIC/ENVIRONMENTAL IMPACT ASSESSMENT PANEL Q-30872
 SOME ASPECTS OF WEATHERING AND BURNING OF CRUDE OIL IN A WATER-AND-ICE ENVIRONMENT Q-26450
 SOME SEA ICE COVER STATISTICS FOR THE CANADIAN EAST COAST G-26611
 SPECIAL PUBLICATION - ARCTIC INSTITUTE OF NORTH AMERICA Q-30805, Q-30813, Q-30821, Q-30848,
 Q-30856, Q-30864, Q-30872, S-30830
 STATISTICAL ANALYSIS OF ICE PRESSURE RIDGE DISTRIBUTION IN THE SOUTHERN BEAUFORT SEA G-25739
 STATISTICAL STUDY OF PASSAGE INTO THE BEAUFORT SEA VIA POINT BARROW I-27545
 STORM SURGES D-30023
 STUDIES OF SEABIRDS AND MARINE MAMMALS IN DAVIS STRAIT I-26395
 STUDY OF ARCTIC CLOTHING FOR OIL OPERATING CREWS K-25615
 STUDY OF ARCTIC TRANSPORTATION EQUIPMENT - MACKENZIE DELTA L-24562
 STUDY OF BEAUFORT SEA EXPLORATORY DRILLING SYSTEMS Q-25577
 STUDY OF SEABIRDS IN THE COASTAL BEAUFORT SEA AREA, 1972 AND 1974 I-29963
 STUDY OF THE CLOTHING PROBLEMS OF THE OIL OPERATING CREWS IN THE ARCTIC K-25550
 STUDY OF THE THICKNESS OF MULTI-YEAR PRESSURE RIDGES G-29190
 STUDY OF WEATHER, WAVES AND ICING IN THE BEAUFORT SEA E-15458
 SUMMARY REPORT OF INDUSTRY/GOVERNMENT RESEARCH ON POLLUTION FROM DRILLING WASTES Q-12947
 SUMMER ENVIRONMENTAL PROGRAM - MACKENZIE RIVER ESTUARY Q-26700
 SUMMER ENVIRONMENTAL STUDIES - EAST MACKENZIE BAY - MACKENZIE DELTA Q-26700
 SUSPENDED MATTER IN THE SOUTHERN BEAUFORT SEA D-15474
 TECHNICAL MEMORANDUM - CANADA. NATIONAL RESEARCH COUNCIL. ASSOCIATE COMMITTEE ON GEOTECHNICAL RESEARCH,
 NO. 103, P. 37-47 C-30236
 TECHNICAL MEMORANDUM - CANADA. NATIONAL RESEARCH COUNCIL. ASSOCIATE COMMITTEE ON GEOTECHNICAL RESEARCH,
 NO. 104, P. 65-77 Q-30201
 TECHNICAL NOTE - CREARE, INC., NO. 122 G-25500
 TECHNICAL REPORT - CANADA. BEAUFORT SEA PROJECT, NO. 1 I-30325
 TECHNICAL REPORT - CANADA. BEAUFORT SEA PROJECT, NO. 2 I-30333
 TECHNICAL REPORT - CANADA. BEAUFORT SEA PROJECT, NO. 3A, 3B I-29963
 TECHNICAL REPORT - CANADA. BEAUFORT SEA PROJECT, NO. 3C I-29971
 TECHNICAL REPORT - CANADA. BEAUFORT SEA PROJECT, NO. 4 I-9784
 TECHNICAL REPORT - CANADA. BEAUFORT SEA PROJECT, NO. 5 Q-11592
 TECHNICAL REPORT - CANADA. BEAUFORT SEA PROJECT, NO. 6 I-29980
 TECHNICAL REPORT - CANADA. BEAUFORT SEA PROJECT, NO. 8 I-29598
 TECHNICAL REPORT - CANADA. BEAUFORT SEA PROJECT, NO. 9 H-11754
 TECHNICAL REPORT - CANADA. BEAUFORT SEA PROJECT, NO. 10 Q-11657
 TECHNICAL REPORT - CANADA. BEAUFORT SEA PROJECT, NO. 11 Q-30279
 TECHNICAL REPORT - CANADA. BEAUFORT SEA PROJECT, NO. 12A J-11606
 TECHNICAL REPORT - CANADA. BEAUFORT SEA PROJECT, NO. 12B I-11614
 TECHNICAL REPORT - CANADA. BEAUFORT SEA PROJECT, NO. 12C H-11622
 TECHNICAL REPORT - CANADA. BEAUFORT SEA PROJECT, NO. 13 J-16233
 TECHNICAL REPORT - CANADA. BEAUFORT SEA PROJECT, NO. 15 F-6793
 TECHNICAL REPORT - CANADA. BEAUFORT SEA PROJECT, NO. 16 D-30007
 TECHNICAL REPORT - CANADA. BEAUFORT SEA PROJECT, NO. 17 D-4766
 TECHNICAL REPORT - CANADA. BEAUFORT SEA PROJECT, NO. 18 D-30015
 TECHNICAL REPORT - CANADA. BEAUFORT SEA PROJECT, NO. 19 D-30023
 TECHNICAL REPORT - CANADA. BEAUFORT SEA PROJECT, NO. 20 E-11630
 TECHNICAL REPORT - CANADA. BEAUFORT SEA PROJECT, NO. 21 E-15458
 TECHNICAL REPORT - CANADA. BEAUFORT SEA PROJECT, NO. 22 C-6408
 TECHNICAL REPORT - CANADA. BEAUFORT SEA PROJECT, NO. 24 A-30031
 TECHNICAL REPORT - CANADA. BEAUFORT SEA PROJECT, NO. 25A D-15466
 TECHNICAL REPORT - CANADA. BEAUFORT SEA PROJECT, NO. 25B D-15474
 TECHNICAL REPORT - CANADA. BEAUFORT SEA PROJECT, NO. 26 G-15482
 TECHNICAL REPORT - CANADA. BEAUFORT SEA PROJECT, NO. 27 Q-16241
 TECHNICAL REPORT - CANADA. BEAUFORT SEA PROJECT, NO. 28 Q-15490
 TECHNICAL REPORT - CANADA. BEAUFORT SEA PROJECT, NO. 29 Q-15504
 TECHNICAL REPORT - CANADA. BEAUFORT SEA PROJECT, NO. 30 G-30040
 TECHNICAL REPORT - CANADA. BEAUFORT SEA PROJECT, NO. 31A, 31B Q-30058
 TECHNICAL REPORT - CANADA. BEAUFORT SEA PROJECT, NO. 32 T-15512
 TECHNICAL REPORT - CANADA. BEAUFORT SEA PROJECT, NO. 33 Q-15520
 TECHNICAL REPORT - CANADA. BEAUFORT SEA PROJECT, NO. 34 G-15539
 TECHNICAL REPORT - CANADA. BEAUFORT SEA PROJECT, NO. 35 Q-15547
 TECHNICAL REPORT - CANADA. BEAUFORT SEA PROJECT, NO. 36 G-3530
 TECHNICAL REPORT - CANADA. BEAUFORT SEA PROJECT, NO. 37 G-11649
 TECHNICAL REPORT - CANADA. BEAUFORT SEA PROJECT, NO. 38 Q-15555
 TECHNICAL SPECIFICATIONS OF A LARGE ARCTIC TRUCK FOR IMPERIAL OIL LIMITED, CALGARY, ALBERTA L-25747
 TECHNOLOGY UPDATE - ARTIFICIAL ISLANDS IN THE BEAUFORT SEA Q-19321
 TESTS OF THE ARCTIC BOAT CONFIGURATION OF THE LOCKHEED CLEAN SWEEP OIL RECOVERY SYSTEM IN A BROKEN ICE
 FIELD Q-26703
 THEORETICAL ANALYSIS OF ICE FAILURE G-25488, G-25496
 THROUGH THE LOOKING GLASS : A REVIEW OF AN INDUSTRY/PUBLIC INTERFACE PROGRAM IN CANADA'S NORTH
 Q-15206
 TOWARDS AN ENVIRONMENTAL IMPACT ASSESSMENT OF THE PORTION OF THE MACKENZIE GAS PIPELINE FROM ALASKA TO
 ALBERTA. APPENDIX V: VEGETATION H-30350
 TRUELOVE LOWLAND, DEVON ISLAND, CANADA : A HIGH ARCTIC ECOSYSTEM J-29920

USE OF MODEL ICE TO SIMULATE ICE ACTION ON OFFSHORE STRUCTURES G-25607
WATER POLLUTION CHARACTERISTICS OF DRILLING WASTES FROM LAND BASED EXPLORATORY NORTHERN DRILLING
OPERATIONS Q-12955
WILL OIL SPILLS DAMAGE ARCTIC TUNDRA? Q-30171
WIND/WAVE HINDCAST, CANADIAN BEAUFORT SEA D-25801
WIND, WAVES, WEATHER AND ICEBERGS IN PAFFIN BAY AND DAVIS STRAIT, SUMMER 1972 D-24490
WINTER ENVIRONMENTAL INVESTIGATIONS IN DAVIS STRAIT - 1977 I-25232, J-25240
WINTER ROAD PREPARATION AND COMMENCEMENT OF TRAFFIC IN THE MACKENZIE DELTA L-25631
WORKSHOP ON ARCTIC OFFSHORE ENVIRONMENTAL CONCERNS Q-30090
WORKSHOP ON OIL SPILL TECHNOLOGY Q-30104
ZOOBENTHIC STUDIES I-11614
1970 BOTTOM SAMPLING PROGRAM - SOUTH COAST OF BEAUFORT SEA MACKENZIE BAY TO LIVERPOOL BAY, NORTHWEST
TERRITORIES D-21245
1972-1974 ENVIRONMENTAL PROGRAM MACKENZIE DELTA, N.W.T., CANADA Q-25798

ABDELNOUR, R. G-26689, G-26719
 ACRES CONSULTING SERVICES LIMITED G-25771
 ACRES CONSULTING SERVICES LIMITED. A REVIEW OF APOA PROJECT 40 REPORT G-25593
 ACRES/SANTA FE POWER ARCTIC SERVICES Q-23345
 ADAMS, W.A. Q-15504
 ALBERTA ENVIRONMENT RESEARCH SECRETARIAT Q-30287
 ALBERTA. UNIVERSITY. BOREAL INSTITUTE FOR NORTHERN STUDIES Q-24481
 AMOCO CANADA PETROLEUM COMPANY LTD. G-24457
 ANDRIASHEK, DENNIS I-30333
 APOA F-30295, Q-12939, Q-12947, Q-18155, Q-21288, Q-29858, Q-29890, Q-30244, Q-30287, Q-30805,
 X-19275
 APOA. APOA PROJECT NO. 1 : NUTCRACKER ICE STRENGTH TESTS, 1969-70. REPORT, NO. 1 G-19291
 APOA. APOA PROJECT NO. 1 : NUTCRACKER ICE STRENGTH TESTS, 1969-70. REPORT, NO. 2 G-29939
 APOA. APOA PROJECT NO. 2 : BEAUFORT SEA - ICE MOVEMENT AND CURRENT SURVEY - 1970. REPORT, NO. 2
 G-19305
 APOA. APOA PROJECT NO. 2 : BEAUFORT SEA - ICE MOVEMENT AND CURRENT SURVEY - 1970. REPORT, NO. 1
 G-19283
 APOA. APOA PROJECT NO. 2 : BEAUFORT SEA - ICE MOVEMENT AND CURRENT SURVEY - 1970. REPORT, NO. 3
 G-21237
 APOA. APOA PROJECT NO. 3 : OCEAN FLOOR SAMPLING BEAUFORT SEA 1970. REPORT, NO. 1 D-21245
 APOA. APOA PROJECT NO. 3 : OCEAN FLOOR SAMPLING BEAUFORT SEA 1970. REPORT, NO. 2 G-21237
 APOA. APOA PROJECT NO. 4 : GEOLOGICAL ANALYSIS OF OCEAN FLOOR SAMPLES. REPORT, NO. 1 D-21253
 APOA. APOA PROJECT NO. 4 : GEOLOGICAL ANALYSIS OF OCEAN FLOOR SAMPLES. REPORT, NO. 2 C-21261
 APOA. APOA PROJECT NO. 7 : CROSS-COUNTRY VEHICLE STUDY. REPORT L-21270
 APOA. APOA PROJECT NO. 8 : APOA DRILLING COMMITTEE. [REPORT] Q-21288
 APOA. APOA PROJECT NO. 9 : NUTCRACKER ICE STRENGTH TESTS 1970-71. REPORT G-21296
 APOA. APOA PROJECT NO. 11 : MACKENZIE DELTA ORNITHOLOGICAL STUDY. REPORT I-21300
 APOA. APOA PROJECT NO. 12 : FEASIBILITY STUDY OF EXPLORATORY DRILLING IN THE BEAUFORT SEA. REPORT
 Q-23345
 APOA. APOA PROJECT NO. 13 : ARCTIC DRILLING LARGE STUDY. REPORT, NO. 1 Q-24449
 APOA. APOA PROJECT NO. 14 : BEAUFORT SEA SUMMER ICE STUDY. REPORT G-24457
 APOA. APOA PROJECT NO. 16 : THEORETICAL ANALYSIS OF ICE FAILURE. REPORT, NO. 1 G-25488
 APOA. APOA PROJECT NO. 16 : THEORETICAL ANALYSIS OF ICE FAILURE. REPORT, NO. 2 G-25496
 APOA. APOA PROJECT NO. 17 : BEAUFORT SEA PRESSURE RIDGE AND ICE ISLAND SCOURING. REPORT, NO. 1
 G-25500
 APOA. APOA PROJECT NO. 17 : BEAUFORT SEA PRESSURE RIDGE AND ICE ISLAND SCOURING. REPORT, NO. 2
 G-25518
 APOA. APOA PROJECT NO. 17 : BEAUFORT SEA PRESSURE RIDGE AND ICE ISLAND SCOURING. REPORT, NO. 3
 G-25526
 APOA. APOA PROJECT NO. 17 : BEAUFORT SEA PRESSURE RIDGE AND ICE ISLAND SCOURING. REPORT, NO. 4
 G-25534
 APOA. APOA PROJECT NO. 19 : ANALYSIS OF SEA BOTTOM ICEBERG SCOURING RECORDS. REPORT G-25542
 APOA. APOA PROJECT NO. 21 : EVALUATION OF DESERT TYPE 6 X 6 OILFIELD TRUCK IN ARCTIC CONDITIONS. REPORT,
 NO. 1-3 L-24716
 APOA. APOA PROJECT NO. 24 : ARCTIC CLOTHING STUDY. REPORT K-25550
 APOA. APOA PROJECT NO. 25 : MODEL TESTS TO SIMULATE THE ACTION OF ICE ON FIXED STRUCTURES. REPORT
 G-24465
 APOA. APOA PROJECT NO. 30 : BEAUFORT SEA EXPLORATORY DRILLING SYSTEMS. REPORT, NO. 1 Q-25569
 APOA. APOA PROJECT NO. 30 : BEAUFORT SEA EXPLORATORY DRILLING SYSTEMS. REPORT, NO. 2 Q-25577
 APOA. APOA PROJECT NO. 32 : BEAUFORT SEA SCOUR RECORDS - PHASE II. REPORT G-24473
 APOA. APOA PROJECT NO. 33 : LAND FAST ICE MOVEMENT - BEAUFORT SEA 1971-72. REPORT G-25585
 APOA. APOA PROJECT NO. 34 : NORTHERN RESOURCES RESEARCH PROJECT. REPORT Q-24481
 APOA. APOA PROJECT NO. 35 : ENVIRONMENTAL STUDY OF THE BAFFIN BAY-DAVIS STRAIT REGION. REPORT, NO. 1
 D-24490
 APOA. APOA PROJECT NO. 35 : ENVIRONMENTAL STUDY OF THE BAFFIN BAY-DAVIS STRAIT REGION. REPORT, NO. 2
 D-24503
 APOA. APOA PROJECT NO. 36 : ICE ISLANDS DESTRUCTION - BEAUFORT SEA. REPORT G-24511
 APOA. APOA PROJECT NO. 37 : ARCTIC ENVIRONMENTAL RESEARCH, TUNDRA AND ECOLOGICAL STUDIES ON THE
 MACKENZIE DELTA AND DEVON ISLAND. R C-30236, H-30147, H-30155, H-30163, H-30180, H-30198,
 H-30260, H-30341, H-30350, J-30112, Q-25291, Q-30120, Q-30139, Q-30171, Q-30201, Q-30210,
 Q-30226, Q-30252
 APOA. APOA PROJECT NO. 38 : APOA-DIAND TRANSPORTATION STUDY. REPORT, NO. 1 L-29947
 APOA. APOA PROJECT NO. 38 : APOA-DIAND TRANSPORTATION STUDY. REPORT, NO. 2 L-29955
 APOA. APOA PROJECT NO. 39 : ARCTIC OFFSHORE PIPELINE FEASIBILITY STUDY. REPORT Q-24520
 APOA. APOA PROJECT NO. 40 : EVALUATION OF MECHANICAL PROPERTIES OF SALINE MODEL ICE. REPORT, NO. 1,2
 G-24538
 APOA. APOA PROJECT NO. 40 : EVALUATION OF MECHANICAL PROPERTIES OF SALINE MODEL ICE. REPORT, NO. 3
 G-25593
 APOA. APOA PROJECT NO. 41 : EVALUATION OF THE MECHANICAL PROPERTIES OF MICHEL'S MODEL ICE AND
 PRELIMINARY ICE-STRUCTURE INTERACTION G-25607
 APOA. APOA PROJECT NO. 42 : MACKENZIE DELTA GRAVEL INVENTORY. REPORT B-24546
 APOA. APOA PROJECT NO. 45 : ARCTIC CLOTHING STUDY. REPORT, NO. 1 K-25615
 APOA. APOA PROJECT NO. 45 : ARCTIC CLOTHING STUDY. REPORT, NO. 2,3 K-24554
 APOA. APOA PROJECT NO. 48 : DOCUMENTATION OF VEHICULAR TRAFFIC ON MACKENZIE DELTA TUNDRA - 1972.
 FREEZE-UP AND 1973 THAW. REPORT, N L-25623, L-25631, L-25640
 APOA. APOA PROJECT NO. 49 : STUDY OF ARCTIC TRANSPORTATION EQUIPMENT - MACKENZIE DELTA. REPORT
 L-24562
 APOA. APOA PROJECT NO. 51 : ICE MOVEMENT IN BEAUFORT SEA 1972-73. REPORT G-25658
 APOA. APOA PROJECT NO. 52 : CRUSHING STRENGTH OF ICE. REPORT, NO. 1 G-25666
 APOA. APOA PROJECT NO. 52 : CRUSHING STRENGTH OF ICE. REPORT, NO. 2 G-25674
 APOA. APOA PROJECT NO. 52 : CRUSHING STRENGTH OF ICE. REPORT, NO. 3 G-25682
 APOA. APOA PROJECT NO. 52 : CRUSHING STRENGTH OF ICE. REPORT, NO. 4 G-25690
 APOA. APOA PROJECT NO. 53 : COUNT OF ICE ISLANDS - BEAUFORT SEA 1972. REPORT G-25704
 APOA. APOA PROJECT NO. 54 : ICE GEOLOGY OF THE SOUTHERN BEAUFORT SEA. REPORT, NO. 1 G-25712
 APOA. APOA PROJECT NO. 54 : ICE GEOLOGY OF THE SOUTHERN BEAUFORT SEA. REPORT, NO. 2 G-25720
 APOA. APOA PROJECT NO. 54 : ICE GEOLOGY OF THE SOUTHERN BEAUFORT SEA. REPORT, NO. 3 G-25739

APOA. APOA PROJECT NO. 55 : ARCTIC ENVIRONMENTAL RESEARCH 1973 (DEVON ISLAND IBP PROJECT). REPORT
 J-29920
 APOA. APOA PROJECT NO. 56 : PREPARATION OF SPECIFICATIONS FOR LARGE ARCTIC TRUCK. REPORT L-25747
 APOA. APOA PROJECT NO. 57 : ADFREEZE STUDY. REPORT, NO. 1, V. 1 G-25755
 APOA. APOA PROJECT NO. 57 : ADFREEZE STUDY. REPORT, NO. 1, V. 2 G-25763
 APOA. APOA PROJECT NO. 57 : ADFREEZE STUDY. REPORT, NO. 2 G-25771
 APOA. APOA PROJECT NO. 60 : BEAUFORT SEA SUMMER ICE TESTING PROJECT. REPORT G-25780
 APOA. APOA PROJECT NO. 61 : ENVIRONMENTAL IMPACT ASSESSMENT PROGRAM, MACKENZIE DELTA - PHASE II. REPORT
 Q-25798
 APOA. APOA PROJECT NO. 63 : ARCTIC INSTITUTE OF NORTH AMERICA BEAUFORT SEA SYMPOSIUM. REPORT
 X-30317
 APOA. APOA PROJECT NO. 65 : SMALL PROTOTYPE CONE TEST. REPORT G-26646
 APOA. APOA PROJECT NO. 66 : ICE CRUSHING TESTS 1973-74. REPORT, NO. 1 G-26654
 APOA. APOA PROJECT NO. 66 : ICE CRUSHING TESTS 1973-74. REPORT, NO. 2 G-26662
 APOA. APOA PROJECT NO. 67 : ICE MOVEMENT IN THE BEAUFORT SEA, 1963/74. REPORT G-26670
 APOA. APOA PROJECT NO. 68 : PROPERTIES OF WAX MODEL ICE RIDGES. REPORT G-26689
 APOA. APOA PROJECT NO. 69 : AN ANALYTICAL STUDY OF ICE SCOUR. REPORT G-26697
 APOA. APOA PROJECT NO. 70 : WIND/WAVE HINDCAST, CANADIAN BEAUFORT SEA. REPORT D-25801
 APOA. APOA PROJECT NO. 72 : BEAUFORT SEA ENVIRONMENTAL PROGRAM Q-29904, Q-30309
 APOA. APOA PROJECT NO. 72 : BEAUFORT SEA ENVIRONMENTAL PROGRAM. REPORT, NO. 1 I-30325
 APOA. APOA PROJECT NO. 72 : BEAUFORT SEA ENVIRONMENTAL PROGRAM. REPORT, NO. 2 I-30333
 APOA. APOA PROJECT NO. 72 : BEAUFORT SEA ENVIRONMENTAL PROGRAM. REPORT, NO. 3A, 3B I-29963
 APOA. APOA PROJECT NO. 72 : BEAUFORT SEA ENVIRONMENTAL PROGRAM. REPORT, NO. 3C I-29971
 APOA. APOA PROJECT NO. 72 : BEAUFORT SEA ENVIRONMENTAL PROGRAM. REPORT, NO. 4 I-9784
 APOA. APOA PROJECT NO. 72 : BEAUFORT SEA ENVIRONMENTAL PROGRAM. REPORT, NO. 5 Q-11592
 APOA. APOA PROJECT NO. 72 : BEAUFORT SEA ENVIRONMENTAL PROGRAM. REPORT, NO. 6 I-29580
 APOA. APOA PROJECT NO. 72 : BEAUFORT SEA ENVIRONMENTAL PROGRAM. REPORT, NO. 8 I-29998
 APOA. APOA PROJECT NO. 72 : BEAUFORT SEA ENVIRONMENTAL PROGRAM. REPORT, NO. 9 H-11754
 APOA. APOA PROJECT NO. 72 : BEAUFORT SEA ENVIRONMENTAL PROGRAM. REPORT, NO. 10 Q-11657
 APOA. APOA PROJECT NO. 72 : BEAUFORT SEA ENVIRONMENTAL PROGRAM. REPORT, NO. 11 Q-30279
 APOA. APOA PROJECT NO. 72 : BEAUFORT SEA ENVIRONMENTAL PROGRAM. REPORT, NO. 12A J-11606
 APOA. APOA PROJECT NO. 72 : BEAUFORT SEA ENVIRONMENTAL PROGRAM. REPORT, NO. 12B I-11614
 APOA. APOA PROJECT NO. 72 : BEAUFORT SEA ENVIRONMENTAL PROGRAM. REPORT, NO. 12C H-11622
 APOA. APOA PROJECT NO. 72 : BEAUFORT SEA ENVIRONMENTAL PROGRAM. REPORT, NO. 13 J-16233
 APOA. APOA PROJECT NO. 72 : BEAUFORT SEA ENVIRONMENTAL PROGRAM. REPORT, NO. 15 F-6793
 APOA. APOA PROJECT NO. 72 : BEAUFORT SEA ENVIRONMENTAL PROGRAM. REPORT, NO. 16 D-30007
 APOA. APOA PROJECT NO. 72 : BEAUFORT SEA ENVIRONMENTAL PROGRAM. REPORT, NO. 17 D-4766
 APOA. APOA PROJECT NO. 72 : BEAUFORT SEA ENVIRONMENTAL PROGRAM. REPORT, NO. 18 D-30015
 APOA. APOA PROJECT NO. 72 : BEAUFORT SEA ENVIRONMENTAL PROGRAM. REPORT, NO. 19 D-30023
 APOA. APOA PROJECT NO. 72 : BEAUFORT SEA ENVIRONMENTAL PROGRAM. REPORT, NO. 20 E-11630
 APOA. APOA PROJECT NO. 72 : BEAUFORT SEA ENVIRONMENTAL PROGRAM. REPORT, NO. 21 E-15458
 APOA. APOA PROJECT NO. 72 : BEAUFORT SEA ENVIRONMENTAL PROGRAM. REPORT, NO. 22 C-6408
 APOA. APOA PROJECT NO. 72 : BEAUFORT SEA ENVIRONMENTAL PROGRAM. REPORT, NO. 24 A-30031
 APOA. APOA PROJECT NO. 72 : BEAUFORT SEA ENVIRONMENTAL PROGRAM. REPORT, NO. 25A D-15466
 APOA. APOA PROJECT NO. 72 : BEAUFORT SEA ENVIRONMENTAL PROGRAM. REPORT, NO. 25B D-15474
 APOA. APOA PROJECT NO. 72 : BEAUFORT SEA ENVIRONMENTAL PROGRAM. REPORT, NO. 26 G-15482
 APOA. APOA PROJECT NO. 72 : BEAUFORT SEA ENVIRONMENTAL PROGRAM. REPORT, NO. 27 Q-16241
 APOA. APOA PROJECT NO. 72 : BEAUFORT SEA ENVIRONMENTAL PROGRAM. REPORT, NO. 28 Q-15490
 APOA. APOA PROJECT NO. 72 : BEAUFORT SEA ENVIRONMENTAL PROGRAM. REPORT, NO. 29 Q-15504
 APOA. APOA PROJECT NO. 72 : BEAUFORT SEA ENVIRONMENTAL PROGRAM. REPORT, NO. 30 G-30040
 APOA. APOA PROJECT NO. 72 : BEAUFORT SEA ENVIRONMENTAL PROGRAM. REPORT, NO. 31A, 31B Q-30058
 APOA. APOA PROJECT NO. 72 : BEAUFORT SEA ENVIRONMENTAL PROGRAM. REPORT, NO. 32 T-15512
 APOA. APOA PROJECT NO. 72 : BEAUFORT SEA ENVIRONMENTAL PROGRAM. REPORT, NO. 33 Q-15520
 APOA. APOA PROJECT NO. 72 : BEAUFORT SEA ENVIRONMENTAL PROGRAM. REPORT, NO. 34 G-15539
 APOA. APOA PROJECT NO. 72 : BEAUFORT SEA ENVIRONMENTAL PROGRAM. REPORT, NO. 35 Q-15547
 APOA. APOA PROJECT NO. 72 : BEAUFORT SEA ENVIRONMENTAL PROGRAM. REPORT, NO. 36 G-3530
 APOA. APOA PROJECT NO. 72 : BEAUFORT SEA ENVIRONMENTAL PROGRAM. REPORT, NO. 37 G-11649
 APOA. APOA PROJECT NO. 72 : BEAUFORT SEA ENVIRONMENTAL PROGRAM. REPORT, NO. 38 Q-15555
 APOA. APOA PROJECT NO. 76 : SUMMER ENVIRONMENTAL STUDIES - EAST MACKENZIE BAY - MACKENZIE DELTA. REPORT
 Q-26700
 APOA. APOA PROJECT NO. 77 : MODELLING OF SMALL CONE PROTOTYPE TESTS. REPORT G-26719
 APOA. APOA PROJECT NO. 78 : ENVIRONMENTAL DATA GATHERING PROGRAM - BAFFIN BAY, DAVIS STRAIT AND ARCTIC
 ISLANDS. REPORT G-26727
 APOA. APOA PROJECT NO. 89 : STUDY OF THE THICKNESS OF MULTI-YEAR PRESSURE RIDGES. REPORT G-29190
 APOA. APOA PROJECT NO. 97 : TESTS OF THE ARCTIC BOAT CONFIGURATION OF THE LOCKHEED CLEAN SWEEP SYSTEM IN
 A BROKEN ICE FIELD. REPORT Q-26743
 APOA. APOA PROJECT NO. 98 : ARCTIC SCIENCE AND TECHNOLOGY INFORMATION SYSTEM X-7773
 APOA. APOA PROJECT NO. 98 : ARCTIC SCIENCE AND TECHNOLOGY INFORMATION SYSTEM. REPORT Y-29866
 APOA. APOA PROJECT NO. 99 : ICE ISLAND COUNT - SOUTHERN BEAUFORT SEA 1974, 1975 AND 1976. REPORT, NO.
 1, 2, 3 G-26751
 APOA. APOA PROJECT NO. 100 : EVALUATION OF THE BENNETT CANAR OIL CONTAINMENT BOCM. REPORT, NO. 1
 Q-26760
 APOA. APOA PROJECT NO. 100 : EVALUATION OF THE BENNETT CANAR OIL CONTAINMENT BOCM. REPORT, NO. 2
 Q-26770
 APOA. APOA PROJECT NO. 107 : SOME ASPECTS OF WEATHERING AND BURNING OF CRUDE OIL IN WATER AND ICE
 ENVIRONMENT. REPORT Q-26450
 APOA. APOA PROJECT NO. 108 : IN-SITU BURNING OF THE PRODUCTS OF A SUBSEA BLOWOUT. REPORT Q-26468
 APOA. APOA PROJECT NO. 111 : EVALUATION OF ICE DEFENCE SYSTEMS FOR ARTIFICIAL ISLANDS. REPORT
 G-26476
 APOA. APOA PROJECT NO. 113 : PASSAGE INTO BEAUFORT SEA VIA POINT BARROW. REPORT L-27545
 APOA. APOA PROJECT NO. 114 : PRELIMINARY TESTS OF BIRD SCARE DEVICES ON THE BEAUFORT SEA COAST. REPORT
 Q-26484
 APOA. APOA PROJECT NO. 126 : BIOLOGICAL LITERATURE REVIEW OF DAVIS STRAIT. REPORT I-26425, J-25224
 APOA. APOA PROJECT NO. 127 : WINTER ENVIRONMENTAL INVESTIGATIONS IN DAVIS STRAIT - 1977. REPORT, NO. 1
 I-25232
 APOA. APOA PROJECT NO. 127 : WINTER ENVIRONMENTAL INVESTIGATIONS IN DAVIS STRAIT - 1977. REPORT, NO. 2
 J-25240

APOA. APOA PROJECT NO. 128 : DAVIS STRAIT ICE AND OCEANOGRAPHIC INVESTIGATIONS WINTER 1976-77. REPORT
G-26492

APOA. APOA PROJECT NO. 134 : LATE WINTER AND SPRING INVESTIGATIONS IN DAVIS STRAIT - 1977. REPORT, NO.
1, 1A J-25259

APOA. APOA PROJECT NO. 135 : BIOLOGICAL STUDIES IN THE VICINITY OF HUDSON STRAIT, DAVIS STRAIT AND
LABRADOR SEA AREA - 1976. REPORT, D-26514, J-26506, J-26522

APOA. APOA PROJECT NO. 136 : BEAUFORT SEA SHORELINE STUDY, KCMAKUK PEACH TO BAILLIE ISLAND, REPORT, NO.
2 Q-29912

APOA. APOA PROJECT NO. 138 : ENVIRONMENTAL INVESTIGATIONS AND ANALYSIS IN DAVIS STRAIT - SECOND HALF
1977. REPORT, NO. 1 A-25062

APOA. APOA PROJECT NO. 138 : ENVIRONMENTAL INVESTIGATIONS AND ANALYSIS IN DAVIS STRAIT - SECOND HALF
1977. REPORT, NO. 2 J-25810

APOA. APOA PROJECT NO. 138 : ENVIRONMENTAL INVESTIGATIONS AND ANALYSIS IN DAVIS STRAIT - SECOND HALF
1977. REPORT, NO. 3, V.1-2 J-26530

APOA. APOA PROJECT NO. 138 : ENVIRONMENTAL INVESTIGATIONS AND ANALYSIS IN DAVIS STRAIT - SECOND HALF
1977. REPORT, NO. 4, 4A J-25267

APOA. APOA PROJECT NO. 138 : ENVIRONMENTAL INVESTIGATIONS AND ANALYSIS IN DAVIS STRAIT - SECOND HALF
1977. REPORT, NO. 5, 5A I-26395

APOA. APOA PROJECT NO. 138 : ENVIRONMENTAL INVESTIGATIONS AND ANALYSIS IN DAVIS STRAIT - SECOND HALF
1977. REPORT, NO. 6 I-26409

APOA. APOA PROJECT NO. 138 : ENVIRONMENTAL INVESTIGATIONS AND ANALYSIS IN DAVIS STRAIT - SECOND HALF
1977. REPORT, NO. 7 I-26417

APOA. APOA PROJECT NO. 138 : ENVIRONMENTAL INVESTIGATIONS AND ANALYSIS IN DAVIS STRAIT - SECOND HALF
1977. REPORT, NO. 8 I-26425, J-25224

APOA. APOA PROJECT NO. 138 : ENVIRONMENTAL INVESTIGATIONS AND ANALYSIS IN DAVIS STRAIT - SECOND HALF
1977. REPORT, NO. 9 I-25275

APOA. APOA PROJECT NO. 138 : ENVIRONMENTAL INVESTIGATIONS AND ANALYSIS IN DAVIS STRAIT - SECOND HALF
1977. REPORT, NO. 10 I-25283

APOA. APOA PROJECT NO. 138 : ENVIRONMENTAL INVESTIGATIONS AND ANALYSIS IN DAVIS STRAIT - SECOND HALF
1977. REPORT, NO. 11, V.1-2 D-27553

APOA. APOA PROJECT NO. 138 : ENVIRONMENTAL INVESTIGATIONS AND ANALYSIS IN DAVIS STRAIT - SECOND HALF
1977. REPORT, NO. 12, 12A E-26549

APOA. APOA PROJECT NO. 138 : ENVIRONMENTAL INVESTIGATIONS AND ANALYSIS IN DAVIS STRAIT - SECOND HALF
1977. REPORT, NO. 13 G-26557

APOA. APOA PROJECT NO. 138 : ENVIRONMENTAL INVESTIGATIONS AND ANALYSIS IN DAVIS STRAIT - SECOND HALF
1977. REPORT, NO. 14 D-26565

APOA. APOA PROJECT NO. 138 : ENVIRONMENTAL INVESTIGATIONS AND ANALYSIS IN DAVIS STRAIT - SECOND HALF
1977. REPORT, NO. 15 Q-26573

APOA. APOA PROJECT NO. 138 : ENVIRONMENTAL INVESTIGATIONS AND ANALYSIS IN DAVIS STRAIT - SECOND HALF
1977. REPORT, NO. 16 D-26581

APOA. APOA PROJECT NO. 138 : ENVIRONMENTAL INVESTIGATIONS AND ANALYSIS IN DAVIS STRAIT - SECOND HALF
1977. REPORT, NO. 17 D-26590

APOA. APOA PROJECT NO. 138 : ENVIRONMENTAL INVESTIGATIONS AND ANALYSIS IN DAVIS STRAIT - SECOND HALF
1977. REPORT, NO. 18 D-26603

APOA. APOA PROJECT NO. 138 : ENVIRONMENTAL INVESTIGATIONS AND ANALYSIS IN DAVIS STRAIT - SECOND HALF
1977. REPORT, NO. 19 G-26611

APOA. APOA PROJECT NO. 138 : ENVIRONMENTAL INVESTIGATIONS AND ANALYSIS IN DAVIS STRAIT - SECOND HALF
1977. REPORT, NO. 20 D-26620

APOA. APOA PROJECT NO. 138 : ENVIRONMENTAL INVESTIGATIONS AND ANALYSIS IN DAVIS STRAIT - SECOND HALF
1977. REPORT, NO. 21 D-26638

AQUITAINE COMPANY OF CANADA LIMITED A-25062, I-25232, I-25275, I-25283, I-26395, I-26409, I-26425,
J-25240, J-25259, J-25267, J-25810, J-26530, T-26417

ARCHIBALD, RALPH I-30125

ARCTIC CANADA LIMITED G-25755, G-25763, G-26689, G-26719, Q-26400, Q-26743, Q-26760, Q-26778

ARCTIC, INC. G-24465, G-24538, G-25593

ARCTIC, INC. PROGRESS REPORT, NO. 00571- 5 Q-24465

ARCTIC ENVIRONMENTAL WORKSHOP, 6TH, FAIRMONT HOT SPRINGS, B.C., APRIL 17-20, 1977 Q-29890

ARCTIC ENVIRONMENTAL WORKSHOP, 6TH, FAIRMONT HOT SPRINGS, B.C., APRIL 17-20, 1977. PROCEEDINGS / EDITED
BY J.G. GAINES, W.J. LCGAN [Q-30066, Q-30074, Q-30082, Q-30090, Q-30104

ARCTIC ENVIRONMENTAL WORKSHOP, 7TH, FAIRMONT HOT SPRINGS, B.C., APRIL 12-15, 1978 Q-18155

ARCTIC ENVIRONMENTAL WORKSHOP, 7TH, FAIRMONT HOT SPRINGS, B.C., APRIL 12-15, 1978. PROCEEDINGS / EDITED
BY S. JAMES [AND] D. BACKAY. I-19356, Q-19313, Q-19321, Q-19330, Q-19348, Q-19364, Q-19372,
Q-19798, Q-19801

ARCTIC ENVIRONMENTAL WORKSHOP, 8TH, FAIRMONT HOT SPRINGS, B.C., MAY 7-9, 1979 Q-30805

ARCTIC ENVIRONMENTAL WORKSHOP, 8TH, FAIRMONT HOT SPRINGS, B.C., MAY 7-9, 1979. PROCEEDINGS. CALGARY :
ARCTIC INSTITUTE OF NORTH AMER Q-30813, Q-30821, Q-30848, Q-30856, Q-30864, Q-30872, S-30830

ARCTIC INSTITUTE OF NORTH AMERICA X-30317

ARCTIC INSTITUTE OF NORTH AMERICA. LIBRARY ACCESSIONS LIST X-7773

ARCTIC INSTITUTE OF NORTH AMERICA. SPECIAL PUBLICATION Q-30805, Q-30813, Q-30821, Q-30848, Q-30856,
Q-30864, Q-30872, S-30830

ARCTIC SCIENCE AND TECHNOLOGY INFORMATION SYSTEM X-7773

ARSINAUT, LYN D. G-30040

ATMOSPHERIC DYNAMICS CORPORATION E-26549

ATMOSPHERIC DYNAMICS CORPORATION. ENVIRONMENTAL CONDITIONS OFF THE EAST COAST OF CANADA : GODTHAAB,
GREENLAND (64 DEG. 10 SEC. N, 51 E-26549

AZIL, K. Q-26468

BABBY, E.G. A-25062

BABRY, THOMAS W. I-29963

BARTON, E. G-25704

BEAUFORT SEA SYMPOSIUM, UNIVERSITY OF CALGARY, JANUARY 1976 Q-15806

BECKATT, A. Q-13005, Q-13013

BEILCEK, J. Q-26450

BERAY, M.C. E-15458

BLISS, LAWRENCE C. C-30236, H-30163, H-30198, H-30341, J-29920, J-30112, Q-25291, Q-30120, Q-30139,
Q-30201, Q-30210, Q-30228, C-30252

BORNHOLD, BRIAN D. D-15474

EAKEL, WILLIAM D. T-15512
 BRITISH COLUMBIA RESEARCH. DIVISION OF APPLIED BIOLOGY Q-13021
 BROWN (E.J.) AND ASSOCIATES Q-24520
 BAUST, WALTER D. NORTHERN DEVELOPMENT AND THE NATIVE PEOPLE, A LITERATURE REVIEW OF CURRENT OPINIONS AND ISSUES Q-29904
 BRYANT, W.J. Q-12955
 BSZUSTOWSKI, T.A. Q-26468
 BUNCH, J.N. Q-11657
 CALGARY. UNIVERSITY. GRANTS OFFICE Q-30287
 CALVEIT, WENDY I-30333
 CANADA CITIES SERVICES LIMITED A-25062, I-25232, I-25275, I-25283, I-26395, I-26409, I-26425, J-25240, J-25259, J-25267, J-25810, J-26530, T-26417
 CANADA. ARCTIC LAND USE RESEARCH PROGRAM. [REPORT], ALUR 72-73- 12 L-29947
 CANADA. ARCTIC LAND USE RESEARCH PROGRAM. [REPORT], ALUR 72-73- 13 L-29955
 CANADA. BEAUFORT SEA PROJECT. TECHNICAL REPORT, NO. 1 I-30325
 CANADA. BEAUFORT SEA PROJECT. TECHNICAL REPORT, NO. 2 I-30333
 CANADA. BEAUFORT SEA PROJECT. TECHNICAL REPORT, NO. 3A, 3B I-29963
 CANADA. BEAUFORT SEA PROJECT. TECHNICAL REPORT, NO. 3C I-29971
 CANADA. BEAUFORT SEA PROJECT. TECHNICAL REPORT, NO. 4 I-9784
 CANADA. BEAUFORT SEA PROJECT. TECHNICAL REPORT, NO. 5 Q-11592
 CANADA. BEAUFORT SEA PROJECT. TECHNICAL REPORT, NO. 6 I-29980
 CANADA. BEAUFORT SEA PROJECT. TECHNICAL REPORT, NO. 8 I-29998
 CANADA. BEAUFORT SEA PROJECT. TECHNICAL REPORT, NO. 9 H-11754
 CANADA. BEAUFORT SEA PROJECT. TECHNICAL REPORT, NO. 10 Q-11657
 CANADA. BEAUFORT SEA PROJECT. TECHNICAL REPORT, NO. 11 Q-30279
 CANADA. BEAUFORT SEA PROJECT. TECHNICAL REPORT, NO. 12A J-11606
 CANADA. BEAUFORT SEA PROJECT. TECHNICAL REPORT, NO. 12B I-11614
 CANADA. BEAUFORT SEA PROJECT. TECHNICAL REPORT, NO. 12C H-11622
 CANADA. BEAUFORT SEA PROJECT. TECHNICAL REPORT, NO. 13 J-16233
 CANADA. BEAUFORT SEA PROJECT. TECHNICAL REPORT, NO. 15 F-6793
 CANADA. BEAUFORT SEA PROJECT. TECHNICAL REPORT, NO. 16 D-30007
 CANADA. BEAUFORT SEA PROJECT. TECHNICAL REPORT, NO. 17 D-4766
 CANADA. BEAUFORT SEA PROJECT. TECHNICAL REPORT, NO. 18 D-30015
 CANADA. BEAUFORT SEA PROJECT. TECHNICAL REPORT, NO. 19 D-30023
 CANADA. BEAUFORT SEA PROJECT. TECHNICAL REPORT, NO. 20 E-11630
 CANADA. BEAUFORT SEA PROJECT. TECHNICAL REPORT, NO. 21 E-15458
 CANADA. BEAUFORT SEA PROJECT. TECHNICAL REPORT, NO. 22 C-6408
 CANADA. BEAUFORT SEA PROJECT. TECHNICAL REPORT, NO. 24 A-30031
 CANADA. BEAUFORT SEA PROJECT. TECHNICAL REPORT, NO. 25A D-15466
 CANADA. BEAUFORT SEA PROJECT. TECHNICAL REPORT, NO. 25B D-15474
 CANADA. BEAUFORT SEA PROJECT. TECHNICAL REPORT, NO. 26 G-15482
 CANADA. BEAUFORT SEA PROJECT. TECHNICAL REPORT, NO. 27 Q-16241
 CANADA. BEAUFORT SEA PROJECT. TECHNICAL REPORT, NO. 28 Q-15490
 CANADA. BEAUFORT SEA PROJECT. TECHNICAL REPORT, NO. 29 Q-15504
 CANADA. BEAUFORT SEA PROJECT. TECHNICAL REPORT, NO. 30 G-30040
 CANADA. BEAUFORT SEA PROJECT. TECHNICAL REPORT, NO. 31A, 31B Q-30058
 CANADA. BEAUFORT SEA PROJECT. TECHNICAL REPORT, NO. 32 T-15512
 CANADA. BEAUFORT SEA PROJECT. TECHNICAL REPORT, NO. 33 Q-15520
 CANADA. BEAUFORT SEA PROJECT. TECHNICAL REPORT, NO. 34 G-15539
 CANADA. BEAUFORT SEA PROJECT. TECHNICAL REPORT, NO. 35 Q-15547
 CANADA. BEAUFORT SEA PROJECT. TECHNICAL REPORT, NO. 36 G-3530
 CANADA. BEAUFORT SEA PROJECT. TECHNICAL REPORT, NO. 37 G-11649
 CANADA. BEAUFORT SEA PROJECT. TECHNICAL REPORT, NO. 38 Q-15555
 CANADA. DEFENCE RESEARCH ESTABLISHMENT OTTAWA K-24554, K-25550, K-25615
 CANADA. DEFENCE RESEARCH ESTABLISHMENT OTTAWA. DRDO REPORT, NO. 680 K-25615
 CANADA. DEFENCE RESEARCH ESTABLISHMENT OTTAWA. DRDO TECHNICAL MEMORANDUM, NO. 73- 4 K-24554
 CANADA. DEFENCE RESEARCH ESTABLISHMENT OTTAWA. REPORT K-25550
 CANADA. DEPT. OF THE ENVIRONMENT Q-12947
 CANADA. DIAND. NORTH OF 60 L-29947
 CANADA. GOVERNMENT Q-12939
 CANADA. MACKENZIE VALLEY PIPELINE INQUIRY A-30031
 CANADA. NATIONAL RESEARCH COUNCIL. ASSOCIATE COMMITTEE ON GEOTECHNICAL RESEARCH. TECHNICAL MEMORANDUM, NO. 103, P. 37-47 C-30236
 CANADA. NATIONAL RESEARCH COUNCIL. ASSOCIATE COMMITTEE ON GEOTECHNICAL RESEARCH. TECHNICAL MEMORANDUM, NO. 104, P. 65-77 Q-30201
 CANADA. TASK FORCE ON NORTHERN OIL DEVELOPMENT. REPORT, NO. 73- 22 L-29955
 CANADA. WILDLIFE SERVICE I-29963
 CANADIAN INSTITUTE OF MINING AND METALLURGY. CIM BULLETIN, V. 64, NO. 712, AUG. 1971, P. 74-76, PHOTOS. J-30112
 CANADIAN MARINE DRILLING LIMITED Q-26450, Q-26468, Q-26484, Q-26743, Q-26760, Q-26778
 CANADIAN NORTHERN PIPELINE RESEARCH CONFERENCE, OTTAWA, 2-4 FEB., 1972. PROCEEDINGS / EDITED BY R.F. LEGGET AND I.C. MACFARLANE. OTT Q-30201
 CANADIAN PETROLEUM ASSOCIATION C-18155, Q-29890, Q-30805
 CHEVRON PETROLEUM COMPANY C-30848
 CHRISTENSEN, P. Q-15555
 CHUDOBIAK, WALTER J. G-30040
 CLOLMAN, J. E-11630
 COLLINS, MARY Q-15806, Q-29904, Q-30309
 COLCRAIG. UNIVERSITY. INSTITUTE OF ARCTIC AND ALPINE RESEARCH A-25062
 CONFERENCE ON THE ENVIRONMENTAL EFFECTS OF OIL AND SALT WATER SPILLS ON LAND, BANFF, NOV. 6-7, 1975 Q-30287
 COOPER, P.F. G-11649
 COENS, IAN G.W. H-30155
 CRANE, R.G. A-25062
 CREARE, INC. G-25500
 CREARE, INC. TECHNICAL NOTE, NO. 122 G-25500

CHETNEY, W.J. J-16233, Q-15555
 CHOASDALE, K.R. G-19283, G-19291, G-21296, G-25585, G-25704, G-29939
 CULEY, E.E. Q-30848
 DANARD, MAURICE E-26549
 DAVIES, K.F. F-6793
 DE LANGE BOOM, B.R. D-30015
 DEMASTER, DOUGLAS I-30325
 DEFAPE, DENIS Q-24481
 DICKINS, D. G-29190
 DIDUK, ANDREW Q-13048
 DOUGLAS, A. D-30007
 DUICHAK, P.M. E-15458
 EDWARDS, RODERICK Y. G-24465, G-24538, G-25593, G-25763, G-26689, G-26719, Q-26778
 ENVIRONMENT PROTECTION BOARD. INTERIM REPORT, NO. 3 H-30350
 ENVIRONMENT PROTECTION BOARD. TOWARDS AN ENVIRONMENTAL IMPACT ASSESSMENT OF THE PORTION OF THE MACKENZIE
 GAS PIPELINE FROM ALASKA TO H-30350
 ENVIRONMENTAL RESEARCH ASSOCIATES I-21300
 FENCO CONSULTANTS LIMITED G-25666, G-25674, G-25780, G-26492, G-26697
 FONDATION FRANCAISE D'ETUDES NORDIQUES, CONGRES INTERNATIONAL, 5E, LEHAVRE, 2-5 MAI, 1973. LE PETROLE ET
 LE GAZ ARCTIQUES : PROBLEME Q-30228
 FORBES, D.L. A-30031
 FOUNDATION COMPANY OF CANADA LIMITED Q-24449
 FRANK, MARK A. I-5784
 FRANKLIN, L.J. Q-19313
 FRASER, J.B. G-26611
 GAINES, J.G. C-29890
 GARRATT, D.H. Q-19321
 GARRETT, J.F. D-4766
 GEEACI, JOSEPH R. Q-11592
 GLACWELL, R.W. G-25739
 GLOBAL MARINE INC. Q-25577
 GOLDBER, BRAWNER AND ASSOCIATES LTD. D-21245
 GOOLWIN, C. ROSS Y-29866
 GRANGER, E.H. J-11606
 GRAY, LAWRENCE G-30040
 GRAY, ROBERT E. G-30040
 GULF OIL CANADA LIMITED L-24562, Q-25577
 GUNN, WADE W. X-30317
 HAAQ, RICHARD K. H-30147, H-30198, H-30341
 HALLIN, MICHAEL J. Q-13030
 HARRY (F.M.) AND ASSOCIATES LIMITED D-26581, D-26603
 HARTLAND, R.C. Q-11657
 HEDLEY, E.E. G-26654
 HEGGIE, T. S-30830
 HENRY, R.F. E-30023
 HERLINVEAUX, R.H. D-30015
 HERMISTON, F.V. D-30007
 HERNANDEZ, HELIOS H-30350
 HENRIK, J. G-25534, G-25704
 HODGINS, D.O. D-27553
 HOPE, WYB I-5784
 HRODEY, S.E. Q-12955, Q-12963, G-13020
 HSIAO, STEPHEN I.C. H-11622
 HUQUET, W.E. H-30007
 HUNTER, J.A.M. C-6408
 HUNTING GEOLOGY AND GEOPHYSICS LTD. G-24473, G-25542
 IAH SYMPOSIUM : ICE AND ITS ACTION ON HYDRAULIC STRUCTURES, 1ST, REYKJAVIK, ICELAND, 7-10 SEPT. 1970.
 [PROCEEDINGS]. [DELFT] : S.N. G-29939
 IMPERIAL OIL LIMITED A-25062, D-21245, D-25801, D-26514, D-26565, D-26581, D-26593, D-26603,
 D-27553, E-26549, G-19305, G-25666, G-25682, G-26492, G-26557, G-26662, I-25232, I-25275,
 I-25283, I-26395, I-26409, I-26425, J-25224, J-25240, J-25259, J-25267, J-25810, J-26506,
 J-26522, J-26530, L-25747, T-26417
 INDUSTRY/GOVERNMENT WORKING GROUP IN DISPOSAL WASTE FLUIDS FROM PETROLEUM EXPLORATORY DRILLING IN THE
 CANADIAN NORTH Q-12939, Q-12947
 INDUSTRY/GOVERNMENT WORKING GROUP IN DISPOSAL WASTE FLUIDS FROM PETROLEUM EXPLORATORY DRILLING IN THE
 CANADIAN NORTH. [REPORT], V. Q-12947, Q-12955, Q-12963, Q-12971, Q-12980, Q-12998, Q-13005,
 Q-13013, Q-13528
 INDUSTRY/GOVERNMENT WORKING GROUP IN DISPOSAL WASTE FLUIDS FROM PETROLEUM EXPLORATORY DRILLING IN THE
 CANADIAN NORTH. [REPORT], V. 1 Q-13021, Q-13030, Q-13048
 INNOVATIVE VENTURES LTD. D-26590
 INTERNATIONAL BIOLOGICAL PROGRAMME. CANADIAN COMMITTEE. DEVON ISLAND PROJECT J-29920
 INTERNATIONAL CONFERENCE ON PERMAFROST, 2D, YAKUTSK, U.S.S.R., JULY 13-18, 1973. PERMAFROST : NORTH
 AMERICAN CONTRIBUTION. WASHINGTON C-30210
 INTERNATIONAL GLACIOLOGICAL SOCIETY F-30295
 INTERSEA RESEARCH CORPORATION D-25801
 JOHNSON, STEPHEN R. I-29971
 JOHNSTON, R.A.C. I-29980
 JONES, S.J. Q-30805
 JONES, SHAN Q-18155
 KENZEL, F.E. I-29980
 KIM, J. KWANGSE G-25755
 KNOWLES, R. H-11754
 KOIRAS, THOMAS V. G-24538, G-25755
 KOVACS, AUSTIN G-24511, G-25500, G-29190
 KOZAK, M.D. I-29980
 KUYI, EFNIE I-29963

LAKE, W.H. Q-12980, Q-12998
 LALONDE, M.E. E-15458
 LATOUR, PAUL I-30333
 LEBLOND, P.H. D-27553
 LERAND, M.M. D-21253, G-25526
 LEWIS, C.P. A-30031
 LEWIS, J.W. G-24465
 LEWIS, RONALD E.F. ARCTIC OIL DRILLING OPERATIONS : SOME HUMAN FACTORS ENGINEERING OBSERVATIONS
 K-25550
 LGL LIMITED I-29963, I-29971, Q-26484
 LOBLIGER, U. I-29980
 LOCK, A.E. K-25550, K-25615
 LOCKE, C.W. A-25062
 LOCKE, W.W. A-25062
 LOGAN, W.J. Q-29890, Q-30058
 MACDONALD, D. J-16233
 MACDONALD, R.W. Q-15555
 MACKAY, DONALD Q-18155, Q-29890
 MACKAY, J. ECSS C-21261
 MACLAREN ATLANTIC LIMITED D-26514, D-26565, G-26557, I-25232, I-25275, I-26395, I-26409, I-26425,
 J-25224, J-25240, J-25259, J-25267, J-25810, J-26506, J-26522, J-26530, I-26417
 MACLAREN ATLANTIC LIMITED. REVISED BIOLOGICAL LITERATURE OF THE DAVIS STRAIT REGION J-25224
 MACLAREN MARX INC. I-25283
 MACLEAN, D.A. H-30180
 MACNEILL, M.F. D-4766
 MANN, K.H. Q-19801
 MARINE ENVIRONMENTAL SERVICES LIMITED D-24490, D-24503, G-26727
 MARKHAM, W.E. G-15482
 MAREKO, J.B. G-15539
 MARY COLLINS CONSULTANTS LIMITED Q-15806, Q-29904, Q-30309
 MCCULLOCH, J.A.W. E-15458
 MCKAY, W.W. D-26638
 MCLATCHIE, A.S. G-26654
 MCMULLEN, J.D. Q-12963, Q-13528
 MELLOE, MALCOLM G-24511, G-25500
 MENELEY, R.A. Q-30813
 METGE, M. D-26620, Q-26573
 MICHALCHUK, J. Q-13528
 MICHEL, B. G-25607
 MILLER, G.H. A-25062
 MILLER, T.W. G-26654
 MILNE, ALLEN B. Q-30082, Q-30821
 MOLLARL (J.D.) AND ASSOCIATES LIMITED E-24546
 MOORE, E. Q-13005, Q-13013
 MORGENSTERN, MORRETT R. G-25488, G-25496, G-25690, G-26662
 MORISON, MURRAY J. Q-19372
 MORRELL, MICHAEL R. I-29971
 MORRIS, G.F. G-26654
 MULLER, F.B. E-11630
 MULLIN I.C. Q-30279
 MADREAU, J.P. Q-26778
 NEW BRUNSWICK UNIVERSITY. MUSKEG RESEARCH INSTITUTE L-25623, L-25631, L-25640, L-29947, L-29955
 NOLAN, R.W. K-24554
 NOLTE, K.G. G-24457
 NORCOR ENGINEERING AND RESEARCH LIMITED G-29190, Q-16241, Q-26450
 NORTHERN LIBRARIES COLLEGE, 7TH, PARIS, SEPT. 19-23, 1978 Y-29866
 NUTTALL, J.B. G-25488, G-25496, G-25518, G-25690, G-26662
 OCEANOGRAPHIC SERVICES, INC. G-19305
 ORANGE, R.J. Q-30309
 OSBORN, T.R. D-27553
 OVERALL, J. Q-26450
 FALLISTER RESOURCE MANAGEMENT LTD. Q-15806, Q-29904, Q-30309
 FALLISTER, A.F. Q-13331, Q-29904
 PALMER, HARRY E. Q-19372
 PANG, S.H.H. K-25550, K-25615
 PARIS UNIVERSITE. ECOLE DES HAUTES ETUDES EN SCIENCES SOCIALES. CENTRE D'ETUDES ARCTIQUES. CONTRIBUTION,
 NO. 12, V. 2, P. 505-5 Q-30228
 PELLETIER, B.R. D-15466
 PERCY, J.A. Q-30279
 PERCY, E. I-29598
 PETERSON, EVERETT B. Q-30228
 PLE, C. Q-19330
 POIRER, A. G-25763
 RALFORTH, J.R. L-29947, L-29955
 RAMSEIER, RENE O. G-30040
 REED, JOHN C. X-30317
 REMPEL, G. Q-19348
 RICHARDSON, W. JOHN I-29963, I-29971
 ROGGENSACK, W.D. G-25690
 ROSENEGGER, L.W. Q-15490
 ROSS, S.I. Q-30056, Q-30074
 ROYAL SOCIETY OF CANADA. PROCEEDINGS AND TRANSACTIONS. SERIES 4, V. 7 [I.E. 8], 1970, P. 1-12, FIGURES
 Q-25291
 BYNES (J.E.) ENGINEERING LTD. L-21270, L-24562, L-24716, L-25747
 SAUER, JOHN E. X-30317
 SAVLIE, I. E-15458

SCHULTZ, L.A. Q-26743
 SCOTT, R.E.G. G-24457
 SEACONSULT MARINE RESEARCH LTD. D-27553
 SEASING, GARY F. I-29963
 SEDCO, INC. Q-24449, Q-25569
 SEGO, D. G-26662
 SEMINAR ON THE PERMAFROST ACTIVE LAYER, VANCOUVER, 4-5 MAY, 1971. PROCEEDINGS / PREPARED BY B.J.E. BROWN.
 OTTAWA : NATIONAL RESEARCH C-30236
 SERGEANT, DAVID E. I-9784
 SEAR, P. LYNN Q-26484
 SIFERD, CLARK A. Q-12971
 SLANEY (F.F.) AND COMPANY LIMITED Q-25798, Q-26700
 SMITH, J.G. G-21237, G-25704
 SMITH, THOMAS G. Q-11592
 SNG, M.E. Q-19348
 SPEDDING, L.G. G-25585, G-25658, G-25712, G-25720, G-26670, G-26751
 STANLEY ASSOCIATES ENGINEERING LTD. REVIEW OF RESEARCH ON POLLUTION ASPECTS OF DRILLING AND SUMP FLUIDS
 Q-12947
 STEPHENSON, F. D-30307
 STALLING, IAN I-30325, I-30333
 SYMPOSIUM : ASPECTS OF NORTHERN BOTANY, UNIV. OF ALBERTA, JUNE 20-24, 1971 Q-30139
 SYMPOSIUM ON APPLIED GLACIOLOGY, CAMBRIDGE, 13-17 SEPTEMBER 1976 P-30295
 SYMPOSIUM ON BEAUFORT SEA COAST AND SHELF RESEARCH, SAN FRANCISCO, JANUARY 7-9, 1974 X-30317
 SYMPOSIUM ON RECOVERY POTENTIAL OF OILED MARINE NORTHERN ENVIRONMENTS, HALIFAX, NOVA SCOTIA, OCTOBER
 13-14, 1977 Q-13331
 SYMPOSIUM ON THE TUNDRA ENVIRONMENT, WINNIPEG, 3 JUNE, 1970. PAPERS. ROYAL SOCIETY OF CANADA. PROCEEDINGS
 AND TRANSACTIONS. SERIES 4 Q-25291
 TAYLOR, T.P. G-25682
 TELFORD, A.S. Q-19364, Q-26573
 THACKERAY, B.I. Q-12980, Q-12998
 TECHANTON, D.E. Q-19364, Q-30058
 TODD, M.E. Q-19798
 TORHAM, D.R. Q-15520
 TORONTO. UNIVERSITY. INSTITUTE FOR ENVIRONMENTAL STUDIES. PUBLICATION, EE 6 Q-29890
 TORONTO. UNIVERSITY. INSTITUTE FOR ENVIRONMENTAL STUDIES. PUBLICATION, EE 6, P. 11-26, ILL.
 Q-30066
 TORONTO. UNIVERSITY. INSTITUTE FOR ENVIRONMENTAL STUDIES. PUBLICATION, EE 6, P. 27-42, ILL.
 Q-30074
 TORONTO. UNIVERSITY. INSTITUTE FOR ENVIRONMENTAL STUDIES. PUBLICATION, EE 6, P. 43-53, MAPS
 Q-30082
 TORONTO. UNIVERSITY. INSTITUTE FOR ENVIRONMENTAL STUDIES. PUBLICATION, EE 6, P. 65-78 Q-30090
 TORONTO. UNIVERSITY. INSTITUTE FOR ENVIRONMENTAL STUDIES. PUBLICATION, EE 6, P. 79-112, ILL.
 Q-30104
 TORONTO. UNIVERSITY. INSTITUTE FOR ENVIRONMENTAL STUDIES. PUBLICATION, EE 8 Q-18155
 TORONTO. UNIVERSITY. INSTITUTE FOR ENVIRONMENTAL STUDIES. PUBLICATION, EE 8, P. 15-24, ILL., FIGURES
 Q-19313
 TORONTO. UNIVERSITY. INSTITUTE FOR ENVIRONMENTAL STUDIES. PUBLICATION, EE 8, P. 25-38, ILL.
 Q-19321
 TORONTO. UNIVERSITY. INSTITUTE FOR ENVIRONMENTAL STUDIES. PUBLICATION, EE 8, P. 39-46, ILL.
 Q-19330
 TORONTO. UNIVERSITY. INSTITUTE FOR ENVIRONMENTAL STUDIES. PUBLICATION, EE 8, P. 47-66 Q-19798
 TORONTO. UNIVERSITY. INSTITUTE FOR ENVIRONMENTAL STUDIES. PUBLICATION, EE 8, P. 67-73 Q-19801
 TORONTO. UNIVERSITY. INSTITUTE FOR ENVIRONMENTAL STUDIES. PUBLICATION, EE 8, P. 74-85 Q-19348
 TORONTO. UNIVERSITY. INSTITUTE FOR ENVIRONMENTAL STUDIES. PUBLICATION, EE 8, P. 86-102 I-19356
 TORONTO. UNIVERSITY. INSTITUTE FOR ENVIRONMENTAL STUDIES. PUBLICATION, EE 8, P. 103-117 Q-19364
 TORONTO. UNIVERSITY. INSTITUTE FOR ENVIRONMENTAL STUDIES. PUBLICATION, EE 8, P. 118-132 Q-19372
 TROIMENKOFF, F.N. G-26476
 TUDMAN, H.F. I-19356
 TULOCK, P. G-25763
 VANDEMEULEN, J.H. Q-30066
 VANT, MAICOLIN R. G-30040
 VESITY, P.H. G-26646
 WACASEY, J.F. I-11614
 WADGAMS, JETES G-3530
 WALKER, L.A. Q-15547
 WALLACE, W.G. G-25763, G-26689, G-26719, Q-26778
 WEIN, ROSS W. C-30236, H-30163, H-30180, H-30260, J-30112, G-30120, Q-30139, Q-30171, Q-30201,
 Q-30210
 WELK, R.E. Q-12980, Q-12998, Q-13005, Q-13013
 WEISSENGER, CATHERINE. SEQUENCE OF EVENTS CONCERNING EXPLORATORY DRILLING IN THE BEAUFORT SEA AND DAVIS
 STRAIT REGIONS Q-30872
 WESTBURN INTERNATIONAL INDUSTRIES LTD. Q-24449, Q-25569
 WILSON, S.E.G. I-27545
 WONG, C.S. J-16233, Q-15553
 WOODWARD, M.J. D-30007
 WOBETTS, B.W. Q-29912
 WRIGHT, E. G-29190
 WRIGHT, DENNIS G. Q-13048

AERIAL PHOTOGRAPHY - BAFFIN ISLAND, N.W.T. A-25062
 AERIAL PHOTOGRAPHY - HUDSON STRAIT, N.W.T. A-25062
 AERIAL PHOTOGRAPHY - UNGAVA BAY, QUEBEC A-25062
 AERIAL SURVEYS - BAFFIN BAY-DAVIS STRAIT I-25232, I-26395
 AERIAL SURVEYS - HUDSON STRAIT, N.W.T. I-26395
 AERIAL SURVEYS - UNGAVA BAY, QUEBEC I-26395
 AIR QUALITY - MACKENZIE (DELTA), N.W.T. Q-25798
 AIRCRAFT DISTURBANCE Q-26484
 ALBEDO - BEAUFORT SEA Q-15547
 ALGAE - BEAUFORT SEA H-11622
 ANTARCTIC RESEARCH - PERIODICALS X-7773
 APOA Q-13331, Q-29858, Q-30244
 APOA - PERIODICALS X-19275
 APOA INDUSTRY/PUBLIC INTERFACE PROGRAM. BEAUFORT SEA PROJECT Q-15806, Q-29904, Q-30309
 ARCTIC RESEARCH Q-30244
 ARCTIC RESEARCH - INFORMATION SERVICES X-7773, Y-29866
 ARCTIC RESEARCH - PERIODICALS X-7773, X-19275
 ARCTIC SCIENCE AND TECHNOLOGY INFORMATION SYSTEM Y-29866
 ARTIFICIAL ISLANDS G-24465, G-24538, G-25607, G-25674, G-25755, G-25763, G-26476, G-26646, G-26689,
 G-26719
 ARTIFICIAL ISLANDS - ENVIRONMENTAL ASPECTS - MACKENZIE (ESTUARY), N.W.T. Q-26700
 ARTIFICIAL ISLANDS - BEAUFORT SEA Q-19321, Q-23345, Q-30104
 ARTIFICIAL ISLANDS - CANADIAN ARCTIC ISLANDS WATERS Q-19313
 ARTIFICIAL ISLANDS - CANADIAN ARCTIC WATERS Q-18155
 ATMOSPHERIC TEMPERATURE - BAFFIN BAY-DAVIS STRAIT E-26549
 ATMOSPHERIC TEMPERATURE - BEAUFORT SEA G-19305
 ATMOSPHERIC TEMPERATURE - LABRADOR SEA E-26549
 ATMOSPHERIC TEMPERATURE - MACKENZIE (DELTA), N.W.T. G-25585, G-25658, G-26670, I-25640
 ATMOSPHERIC TEMPERATURE - RICHARDS ISLAND, N.W.T. I-25631
 AVALANCHES F-30295
 BACTERIA, ANAEROBIC - BEAUFORT SEA H-11754
 BACTERIA, ANAEROBIC - ESKIMO LAKES, N.W.T. H-11754
 BACTERIA, HETEROTROPHIC - BEAUFORT SEA Q-11657
 BACTERIA, PSYCHROPHILIC - BEAUFORT SEA Q-11657
 BEACHES - BAFFIN ISLAND, N.W.T. A-25062
 BEACHES - HUDSON STRAIT, N.W.T. A-25062
 BEACHES - UNGAVA BAY, QUEBEC A-25062
 BENTHOS - BAFFIN BAY-DAVIS STRAIT I-25283, I-26425, J-25224, J-25240, J-25810, J-26506, J-26522
 BENTHOS - BAFFIN ISLAND (REGION), N.W.T. I-26409
 BENTHOS - BEAUFORT SEA I-11614
 BENTHOS - FLEMISH PASS, LABRADOR SEA J-26506, J-26522
 BENTHOS - HUDSON STRAIT, N.W.T. I-25275, J-26522
 BENTHOS - LABRADOR SEA J-25240, J-25810, J-26506
 BENTHOS - MACKENZIE (ESTUARY), N.W.T. Q-26700
 BENTHOS - UNGAVA BAY, QUEBEC I-25275, I-25283
 BIOASSAY Q-12980, Q-12998, Q-13005, Q-13013, Q-13021, Q-13030, Q-13048
 BIOLOGICAL PRODUCTIVITY - BEAUFORT SEA H-11622, I-11614, J-11606
 BIRDS - GEOGRAPHICAL DISTRIBUTION - BEAUFORT SEA I-29971
 BIRDS - GEOGRAPHICAL DISTRIBUTION - Y.T., NORTHERN I-29971
 BIRDS - MIGRATION - BEAUFORT SEA I-29971
 BIRDS - MIGRATION - Y.T., NORTHERN I-29971
 BIRDS - PAILLIE ISLANDS, N.W.T. I-21300
 BIRDS - FANKS ISLAND, N.W.T. I-21300
 BIRDS - HERSCHEL ISLAND, N.W.T. I-21300
 BIRDS - MACKENZIE (DELTA), N.W.T. I-21300, Q-25798
 BIRDS - MACKENZIE (ESTUARY), N.W.T. Q-26700
 BOTANY - ECOLOGY - ALASKA H-30163
 BOTANY - ECOLOGY - MACKENZIE (DELTA), N.W.T. H-30163, Q-30139
 BOTANY - ECOLOGY - N.W.T. - E.F. Q-30139
 BOTANY - ECOLOGY - TUKTOYAKTUK, N.W.T. H-30147, H-30341
 BOTANY - MACKENZIE (DELTA), N.W.T. Q-25798
 BOTANY - TRUELOVE LOWLAND, N.W.T. J-29920
 BOTTOM SEDIMENTS - COMPOSITION - BEAUFORT SEA D-21245, D-21253, Q-15555
 BOTTOM SEDIMENTS - PHYSICAL PROPERTIES - BAFFIN BAY-DAVIS STRAIT D-26581, D-26603
 BOTTOM SEDIMENTS - BAFFIN BAY-DAVIS STRAIT D-26565, D-26581, D-26603, I-25283
 BOTTOM SEDIMENTS - BEAUFORT SEA C-6408, D-15466, G-25526, G-26697, H-11754
 BOTTOM SEDIMENTS - ESKIMO LAKES, N.W.T. H-11754
 BOTTOM SEDIMENTS - FLEMISH PASS, LABRADOR SEA D-26565
 BOTTOM SEDIMENTS - UNGAVA BAY, QUEBEC I-25283
 BOWHEAD WHALE - AMUNDSEN GULF, N.W.T. I-9784
 BOWHEAD WHALE - BEAUFORT SEA I-9784
 CANADA. BEAUFORT SEA PROJECT Q-15806, Q-30821
 CANADA. EASTERN ARCTIC MARINE ENVIRONMENTAL STUDIES Q-30090, Q-30821
 CANADA. EPS. ARCTIC MARINE OILSPILL PROGRAM Q-30074
 CANADA. OFFSHORE LABRADOR BIOLOGICAL STUDIES Q-30821
 CANADA. FANKS CANALS S-30830
 CANADIAN MARINE DRILLING LTD. Q-19798
 CHEMICAL OCEANOGRAPHY - BAFFIN BAY-DAVIS STRAIT J-25240, J-25259, J-26506, J-26522, J-26530
 CHEMICAL OCEANOGRAPHY - BEAUFORT SEA I-29980, J-11606, Q-15555
 CHEMICAL OCEANOGRAPHY - FLEMISH PASS, LABRADOR SEA J-26506, J-26522
 CHEMICAL OCEANOGRAPHY - HUDSON STRAIT, N.W.T. J-26522
 CHEMICAL OCEANOGRAPHY - LABRADOR SEA J-25240, J-26506
 CHEMICAL OCEANOGRAPHY - MACKENZIE (ESTUARY), N.W.T. Q-26700
 CLAY - BEAUFORT SEA G-25526
 CLIMATIC CHANGES - BEAUFORT SEA Q-15547
 CLOTHING, COLD WEATHER - CANADIAN ARCTIC K-24554, K-25550

CLOTHING, COLD WEATHER - MACKENZIE (DELTA), N.W.T. R-25615
 COASTS - BAFFIN ISLAND, N.W.T. A-25062
 COASTS - BEAUFORT SEA A-30031, I-30317
 COASTS - HUDSON STRAIT, N.W.T. A-25062
 COASTS - UNGAVA BAY, QUEBEC A-25062
 COASTS - Y.T., NORTHERN A-30031
 CONTINENTAL SHELF - BEAUFORT SEA X-30317
 DEEP-SEA DRILLING SHIPS - BEAUFORT SEA Q-24449, Q-25569, Q-25577
 DEEP-SEA DRILLING SHIPS - LABRADOR SEA Q-19330
 DIPTERA - MACKENZIE (DELTA), N.W.T. Q-13048
 DRILLING MUDS - ANALYSIS - CANADIAN ARCTIC Q-12971
 DRILLING MUDS - ANALYSIS - HUDSON BAY Q-12971
 DRILLING MUDS - ANALYSIS - MACKENZIE (DELTA), N.W.T. Q-12971
 DRILLING MUDS - ANALYSIS - FYN POINT, N.W.T. Q-12971
 DRILLING MUDS - ANALYSIS - SABINE PENINSULA, N.W.T. Q-12971
 DRILLING MUDS - DISPOSAL - CANADIAN ARCTIC Q-12939, Q-12947
 DRILLING MUDS - DISPOSAL - MACKENZIE (DELTA), N.W.T. Q-12955, Q-13528
 DRILLING MUDS - DISPOSAL - MACKENZIE BAY, N.W.T. Q-12963
 DRILLING MUDS - DISPOSAL - N.W.T. - D.F. Q-13528
 DRILLING MUDS - DISPOSAL - SABINE PENINSULA, N.W.T. Q-12955
 DRILLING MUDS - TOXICOLOGY - BEAUFORT SEA Q-12980
 DRILLING MUDS - TOXICOLOGY - CANADIAN ARCTIC Q-12939, Q-12998, Q-13305, Q-13013
 DRILLING MUDS - TOXICOLOGY - HUDSON BAY Q-13005, Q-13021
 DRILLING MUDS - TOXICOLOGY - MACKENZIE (DELTA), N.W.T. Q-13005, Q-13021, Q-13030, Q-13049
 DRILLING MUDS - TOXICOLOGY - MACKENZIE BAY, N.W.T. Q-12980
 DRILLING MUDS - TOXICOLOGY - FYN POINT, N.W.T. Q-13005
 DRILLING MUDS - TOXICOLOGY - SABINE PENINSULA, N.W.T. Q-13005
 ECOLOGICAL RESEARCH - CANADIAN ARCTIC Q-30244
 ECOLOGY - ALASKA Q-25291
 ECOLOGY - CANADIAN ARCTIC J-30112, Q-25291
 ECOSYSTEMS - CANADIAN ARCTIC J-30112, Q-30201, Q-30210, Q-30228, Q-30252
 ECOSYSTEMS - TRUELOVE LOWLAND, N.W.T. J-29920
 ELASTIC PLATES AND SHELLS G-24465, G-24538, G-26689
 EMPLOYMENT FORECASTING - MACKENZIE (DELTA), N.W.T. Q-24481
 ENERGY BUDGET - NORMAN WELLS, N.W.T. H-30198
 ENVIRONMENTAL POLICY - BEAUFORT SEA Q-30074, Q-30090
 ENVIRONMENTAL POLICY - CANADIAN ARCTIC Q-19372, Q-30805
 ENVIRONMENTAL PROTECTION - FERNAPROST REGIONS C-30236
 ENVIRONMENTAL PROTECTION - ALASKA Q-25291
 ENVIRONMENTAL PROTECTION - CANADIAN ARCTIC C-30236, Q-19348, Q-25291, Q-30201, Q-30210, Q-30228, Q-30244, Q-30252, Q-30905
 ENVIRONMENTAL PROTECTION - CANADIAN ARCTIC WATERS Q-18155, Q-29890
 ENVIRONMENTAL PROTECTION - MACKENZIE (DELTA), N.W.T. Q-29912
 ENVIRONMENTAL PROTECTION - Y.T., NORTHERN Q-29912
 FAST ICE - FORMATION - BEAUFORT SEA G-25712
 FAST ICE - MOVEMENT - BEAUFORT SEA G-25658, G-26670
 FAST ICE - MOVEMENT - MACKENZIE (DELTA), N.W.T. G-25565, G-25658, G-26670
 FAST ICE - TEMPERATURE - MACKENZIE (DELTA), N.W.T. G-25585, G-25658
 FERTILIZERS AND MANURES H-30350
 FIRE ECOLOGY - CARIBOU HILLS, N.W.T. H-30163
 FIRE ECOLOGY - ELLICOTT, ALASKA H-30163
 FIRE ECOLOGY - INUVIK, N.W.T. H-30163
 FIRE ECOLOGY - MOSQUITO FORK, ALASKA H-30163
 FIRE ECOLOGY - TUKICYARTUK, N.W.T. H-30341
 FISHERIES - BEAUFORT SEA T-15512
 FISHERIES - N.W.T. - D.F. T-15512
 FISHERIES - N.W.T. - D.M. T-15512
 FISHERIES - Y.T., NORTHERN I-29980
 FISHES - BAFFIN BAY-DAVIS STRAIT I-26425, J-25224, J-25259, J-25267, J-25810, J-26506, J-26522, J-26530
 FISHES - BAFFIN ISLAND (REGION), N.W.T. I-26409, I-26417
 FISHES - BEAUFORT SEA I-29980, I-29998, Q-15555
 FISHES - CANADIAN ARCTIC WATERS I-19356
 FISHES - FLEMISH PASS, LABRADOR SEA J-26506, J-26522
 FISHES - HUDSON STRAIT, N.W.T. I-25275, J-26522
 FISHES - LABRADOR SEA J-25810, J-26506
 FISHES - MACKENZIE (DELTA), N.W.T. I-29998, Q-25798
 FISHES - MACKENZIE (ESTUARY), N.W.T. Q-26700
 FISHES - UNGAVA BAY, QUEBEC I-25275
 FISHES, FRESH-WATER - MACKENZIE (DELTA), N.W.T. I-29998
 FLOW METERS D-26590
 FORESTS AND FORESTRY - NORMAN WELLS, N.W.T. H-30198
 FUR TRADE - N.W.T. - D.F. T-15512
 FUR TRADE - N.W.T. - D.M. T-15512
 GAS PIPELINES - CANADIAN ARCTIC Q-29904
 GAS WELL DRILLING - ENVIRONMENTAL ASPECTS - MACKENZIE (DELTA), N.W.T. Q-13528
 GAS WELL DRILLING - ENVIRONMENTAL ASPECTS - SABINE PENINSULA, N.W.T. Q-13528
 GAS WELL DRILLING, SUBMARINE - ENVIRONMENTAL ASPECTS - BEAUFORT SEA Q-29904
 GEOCHEMISTRY - BEAUFORT SEA D-21253
 GEOGRAPHY - CANADIAN ARCTIC Q-30210
 GEOLOGY - MACKENZIE (DELTA), N.W.T. Q-25798
 GEOLOGY - TRUELOVE LOWLAND, N.W.T. J-29920
 GEOMORPHOLOGY - Y.T., NORTHERN A-30031
 GERMINATION H-30180
 GLACIOLOGY F-30295
 GRASSES - ALASKA H-30260

GRASSES - CANADIAN ARCTIC H-30260
 GRASSES - INUVIK, N.W.T. H-30180
 GRASSES - MACKENZIE (DELTA), N.W.T. H-30180
 GRASSES - TUKTOYAKTUK, N.W.T. H-30180
 GRAVEL - MACKENZIE (DELTA), N.W.T. B-24546
 GRAVEL - RICHARDS ISLAND, N.W.T. B-24546
 GROUND-EFFECT MACHINES G-25500, G-25534, L-25631
 GROUND-EFFECT MACHINES - MACKENZIE (DELTA), N.W.T. L-21270, L-24562
 GROWTH (PLANTS) H-30180
 HEAT BUDGET - BEAUFORT SEA Q-15547
 HYDROCARBONS - BEAUFORT SEA Q-15555
 HYDROGRAPHY - BAFFIN BAY-DAVIS STRAIT J-26506, J-26522
 HYDROGRAPHY - FLEMISH PASS, LABRADOR SEA J-26506, J-26522
 HYDROGRAPHY - HUDSON STRAIT, N.W.T. J-26522
 HYDROGRAPHY - LABRADOR SEA J-26506
 HYDROLOGY - MACKENZIE (DELTA), N.W.T. Q-25798
 HYDROLOGY - MACKENZIE (RIVER AND BASIN), N.W.T. P-6793
 HYDROLOGY - TRUELOVE LOWLAND, N.W.T. J-29920
 ICE F-30295
 ICE - ELASTICITY G-26689
 ICE - MECHANICAL PROPERTIES G-25593, G-25607
 ICE - PHYSICAL PROPERTIES G-25607
 ICE - STRAIN G-25496
 ICE - STRENGTH G-25496, G-25593, G-25607, G-26646, G-26719
 ICE - STRENGTH - MATHEMATICAL MODELS G-25755, G-25763, G-25771
 ICE - THICKNESS G-26689
 ICE CORES - MACKENZIE (DELTA), N.W.T. G-19283
 ICE COVER - BAFFIN BAY-DAVIS STRAIT G-26611
 ICE COVER - BEAUFORT SEA G-30040, G-24449
 ICE COVER - LABRADOR SEA G-26611
 ICE CRYSTALS - ORIENTATION - MACKENZIE BAY, N.W.T. G-25518
 ICE FLOES - BAFFIN BAY-DAVIS STRAIT G-26492, G-26557
 ICE FLOES - BEAUFORT SEA G-15482, G-25780
 ICE FLOES - LABRADOR SEA G-26492, G-26557
 ICE ISLANDS - BEAUFORT SEA G-24511, G-25500, G-25704, G-25720, G-26751, Q-30104
 ICE ISLANDS - MACKENZIE BAY, N.W.T. G-24511, G-25500
 ICE LOADS - MATHEMATICAL MODELS G-25771
 ICE PRESSURE G-19291, G-21296, G-24538, G-25488, G-25607, G-25666, G-25674, G-25682, G-26476, G-26646, G-26654, G-26689, G-26719, G-29939
 ICE PRESSURE - EXPERIMENTS G-24465
 ICE PRESSURE - MATHEMATICAL MODELS G-25755, G-25763, G-25771
 ICE SCOURING - BEAUFORT SEA G-24473, G-25526, G-25542, G-26697, X-30317
 ICE-BREAKING - MACKENZIE BAY, N.W.T. G-24511
 ICEBERGS - BAFFIN BAY-DAVIS STRAIT G-26557
 ICEBERGS - BAFFIN BAY-DAVIS STRAIT, N.W.T. D-24490, D-24503, G-26727
 ICEBERGS - BEAUFORT SEA G-26697
 ICEBERGS - CANADIAN ARCTIC ISLANDS WATERS G-26727
 ICEBERGS - LABRADOR SEA G-26557
 ICEBERGS - SMITH SOUND, GREENLAND/N.W.T. G-26727
 ICING - SHIPS - BEAUFORT SEA E-15458
 INDIANS - ECONOMIC CONDITIONS - N.W.T. - D.F. T-15512
 INDIANS - ECONOMIC CONDITIONS - N.W.T. - D.M. T-15512
 INDIANS - HUNTING, TRAPPING AND FISHING - N.W.T. - D.F. T-15512
 INDIANS - HUNTING, TRAPPING AND FISHING - N.W.T. - D.M. T-15512
 INDIANS - CANADIAN ARCTIC Q-29904
 INDUSTRIAL WASTES - ENVIRONMENTAL ASPECTS - CANADIAN ARCTIC Q-30228
 INFORMATION SERVICES - CANADA X-7773, Y-29866
 INUIT - ECONOMIC CONDITIONS - N.W.T. - D.F. T-15512
 INUIT - ECONOMIC CONDITIONS - N.W.T. - D.M. T-15512
 INUIT - HUNTING, TRAPPING AND FISHING - BAFFIN ISLAND, N.W.T. T-26417
 INUIT - HUNTING, TRAPPING AND FISHING - BROUGHTON ISLAND, N.W.T. T-26417
 INUIT - HUNTING, TRAPPING AND FISHING - FROBISHER BAY, N.W.T. T-26417
 INUIT - HUNTING, TRAPPING AND FISHING - JONES SOUND (REGION), N.W.T. J-29920
 INUIT - HUNTING, TRAPPING AND FISHING - LAKE HARBOUR, N.W.T. T-26417
 INUIT - HUNTING, TRAPPING AND FISHING - N.W.T. - D.F. T-15512
 INUIT - HUNTING, TRAPPING AND FISHING - N.W.T. - D.M. T-15512
 INUIT - HUNTING, TRAPPING AND FISHING - PANGNIRTUNG, N.W.T. T-26417
 INUIT - HUNTING, TRAPPING AND FISHING - PORT BURWELL, N.W.T. T-26417
 INUIT - CANADIAN ARCTIC Q-29904
 INVERTEBRATES - BAFFIN BAY-DAVIS STRAIT I-25283, J-25267
 INVERTEBRATES - CANADIAN ARCTIC WATERS Q-30279
 INVERTEBRATES - TRUELOVE LOWLAND, N.W.T. J-29920
 INVERTEBRATES - UNGAVA BAY, QUEBEC I-25283
 LACUR SUPPLY - MACKENZIE (DELTA), N.W.T. Q-24481
 LAKE ICE - CRYSTAL STRUCTURE - EAGLE LAKE, ALBERTA G-25690, G-26662
 LAKE ICE - DEFORMATION - EAGLE LAKE, ALBERTA G-25666
 LAKE ICE - STRAIN - EAGLE LAKE, ALBERTA G-25682, G-25690, G-26654, G-26662
 LAKE ICE - STRENGTH - EAGLE LAKE, ALBERTA G-21296, G-25666, G-25674, G-25682, G-25690, G-26476, G-26654, G-26662
 LAKE ICE - STRESSES - EAGLE LAKE, ALBERTA G-25666, G-25674, G-25690
 LAKE ICE - TEMPERATURE - EAGLE LAKE, ALBERTA G-25682, G-25690, G-26654, G-26662
 LAKE ICE - THICKNESS - EAGLE LAKE, ALBERTA G-21296
 LANDFORMS - Y.T., NORTHERN A-30031
 LIMNOLOGY - TRUELOVE LOWLAND, N.W.T. J-29920
 LOGISTICS - BEAUFORT SEA G-21237, Q-24449
 LOGISTICS - MACKENZIE (DELTA), N.W.T. L-24562

T 346

95/1

MAMMALS - MACKENZIE (DELTA), N.W.T. Q-25798
 MAMMALS - MACKENZIE (ESTUARY), N.W.T. C-26700
 MARINE BIOLOGY - BAFFIN BAY-DAVIS STRAIT D-26514, J-25224, J-26530
 MARINE BIOLOGY - FLEMISH PASS, LABRADOR SEA D-26514
 MARINE BIOLOGY - LABRADOR SEA D-26514
 MARINE ECOLOGY - BEAUFORT SEA J-11606, X-30317
 MARINE FAUNA - BEAUFORT SEA G-25525, I-11614
 MARINE FAUNA - CANADIAN ARCTIC WATERS Q-30279
 MARINE FAUNA - MACKENZIE (DELTA), N.W.T. Q-25798
 MARINE MAMMALS - BAFFIN BAY-DAVIS STRAIT I-25232, I-26395, I-26425, J-25224, J-25240, J-25259,
 J-25267, J-25310, J-26506, J-26522, J-26530
 MARINE MAMMALS - BAFFIN ISLAND (REGION), N.W.T. I-26409, T-26417
 MARINE MAMMALS - FLEMISH PASS, LABRADOR SEA J-26506, J-26522
 MARINE MAMMALS - HUDSON STRAIT, N.W.T. I-25275, I-26395, J-26522
 MARINE MAMMALS - LABRADOR SEA J-25240, J-25810, J-26506
 MARINE MAMMALS - MACKENZIE (ESTUARY), N.W.T. Q-26700
 MARINE MAMMALS - UNGAVA BAY, QUEBEC I-25275, I-26395
 MARINE MAMMALS, PROTECTION OF - CANADIAN ARCTIC WATERS I-19356
 MARINE POLLUTION - BEAUFORT SEA J-16233, Q-15555, Q-30074
 MARINE POLLUTION - CANADIAN ARCTIC Q-12939, Q-12947
 MARINE POLLUTION - CANADIAN ARCTIC WATERS Q-18155, Q-29850, Q-30279
 MARINE POLLUTION - CANADIAN WATERS Q-30066
 MARINE POLLUTION - MACKENZIE BAY, N.W.T. Q-12963, Q-12980
 MARINE POLLUTION - N.W.T. - D.M. Q-15555
 MARINE RESOURCES - BAFFIN BAY-DAVIS STRAIT J-25810
 MARINE RESOURCES - BEAUFORT SEA T-15512
 MARINE RESOURCES - CANADIAN ARCTIC WATERS I-19356, Q-18155
 MARINE RESOURCES - LABRADOR SEA J-25810
 MARINE RESOURCES - N.W.T. - D.F. T-15512
 MARINE RESOURCES - N.W.T. - D.M. T-15512
 METEOROLOGY - BAFFIN BAY-DAVIS STRAIT E-26549, G-26492, G-26557
 METEOROLOGY - BAFFIN BAY-DAVIS STRAIT, N.W.T. D-24490, D-24503, G-26727
 METEOROLOGY - BEAUFORT SEA D-30023, G-21237, G-24457, Q-25577
 METEOROLOGY - CANADIAN ARCTIC ISLANDS WATERS G-26727
 METEOROLOGY - LABRADOR SEA Z-26549, G-26492, G-26557
 METEOROLOGY - MACKENZIE (DELTA), N.W.T. Q-25798
 METEOROLOGY - RICHARDS ISLAND, N.W.T. I-25631
 METEOROLOGY - SMITH SOUND, GREENLAND/N.W.T. G-26727
 METEOROLOGY - TRUELOVE LOWLAND, N.W.T. J-29920
 METIS - ECONOMIC CONDITIONS - N.W.T. - D.F. T-15512
 METIS - ECONOMIC CONDITIONS - N.W.T. - D.M. T-15512
 METIS - HUNTING, TRAPPING AND FISHING - N.W.T. - D.F. T-15512
 METIS - HUNTING, TRAPPING AND FISHING - N.W.T. - D.M. T-15512
 MICRO-ORGANISMS - TRUELOVE LOWLAND, N.W.T. J-29920
 MINERALOGY - BEAUFORT SEA D-21253
 NATIONAL PARKS AND RESERVES - N.W.T. S-30830
 NATIONAL PARKS AND RESERVES - Y.T. S-30830
 NATURAL GAS - ECONOMIC ASPECTS - MACKENZIE (DELTA), N.W.T. Q-24481
 NATURAL GAS - N.W.T. - D.F. Q-30813
 NATURAL GAS IN SUBMERGED LANDS - BAFFIN BAY-DAVIS STRAIT, N.W.T. Q-30813
 NATURAL GAS IN SUBMERGED LANDS - BEAUFORT SEA Q-30813
 NATURAL GAS IN SUBMERGED LANDS - CANADIAN ARCTIC WATERS Q-30813
 NATURAL GAS IN SUBMERGED LANDS - LABRADOR WATERS Q-30813
 NITROGEN-FIXATION H-11754
 OCEAN BOTTOM - BEAUFORT SEA D-21245, G-21237
 OCEAN CURRENTS - MEASUREMENT - BEAUFORT SEA G-19305
 OCEAN CURRENTS - VELOCITY - BEAUFORT SEA G-19305
 OCEAN CURRENTS - BAFFIN BAY-DAVIS STRAIT D-26514, D-26590, D-26620, D-27553, G-26492
 OCEAN CURRENTS - BAFFIN BAY-DAVIS STRAIT, N.W.T. A-25062, D-24503
 OCEAN CURRENTS - BEAUFORT SEA D-4756, D-15466, D-30007, D-30015, G-21237
 OCEAN CURRENTS - FLEMISH PASS, LABRADOR SEA D-26514
 OCEAN CURRENTS - HUDSON STRAIT, N.W.T. A-25062, D-26620, D-27553
 OCEAN CURRENTS - LABRADOR SEA D-26514, D-27553, G-26492
 OCEAN CURRENTS - UNGAVA BAY, QUEBEC A-25062
 OCEAN TEMPERATURE - BAFFIN BAY-DAVIS STRAIT D-26514, D-26590, D-27553, J-25240, J-25259, J-25267,
 J-26506, J-26522, J-26530
 OCEAN TEMPERATURE - BAFFIN ISLAND (REGION), N.W.T. I-26409
 OCEAN TEMPERATURE - BEAUFORT SEA C-21261, D-30015, I-29980
 OCEAN TEMPERATURE - FLEMISH PASS, LABRADOR SEA D-26514, J-26506, J-26522
 OCEAN TEMPERATURE - HUDSON STRAIT, N.W.T. D-27553, J-26522
 OCEAN TEMPERATURE - LABRADOR SEA D-26514, D-27553, J-25240, J-26506
 OCEAN WAVES - BAFFIN BAY-DAVIS STRAIT D-26514, D-26638
 OCEAN WAVES - BAFFIN BAY-DAVIS STRAIT, N.W.T. D-24490, D-24503, G-26727
 OCEAN WAVES - BEAUFORT SEA D-25801, E-15458
 OCEAN WAVES - CANADIAN ARCTIC ISLANDS WATERS G-26727
 OCEAN WAVES - FLEMISH PASS, LABRADOR SEA D-26514
 OCEAN WAVES - LABRADOR SEA D-26514
 OCEAN WAVES - SMITH SOUND, GREENLAND/N.W.T. G-26727
 OCEAN-ATMOSPHERE INTERACTION - BAFFIN BAY-DAVIS STRAIT D-26638
 OCEANOGRAPHY - BAFFIN BAY-DAVIS STRAIT D-26514
 OCEANOGRAPHY - BAFFIN BAY-DAVIS STRAIT, N.W.T. D-24490, D-24503
 OCEANOGRAPHY - BEAUFORT SEA D-4766, D-30015, J-11606, Q-25577, X-30317
 OCEANOGRAPHY - FLEMISH PASS, LABRADOR SEA D-26514
 OCEANOGRAPHY - LABRADOR SEA D-26514
 OCEANOGRAPHY - MACKENZIE (DELTA), N.W.T. Q-24520
 OCEANOGRAPHY - MACKENZIE (ESTUARY), N.W.T. Q-26700

OIL SPILLS - G-3530
 OIL SPILLS - CCOUNTERMEASURES - Q-26468
 OIL SPILLS - CCOUNTERMEASURES - ARCTIC REGIONS - Q-30856
 OIL SPILLS - CCOUNTERMEASURES - ATKINSON POINT (REGION), N.W.T. - Q-26484
 OIL SPILLS - CCOUNTERMEASURES - BAFFIN BAY-DAVIS STRAIT - Q-26573
 OIL SPILLS - COUNTERMEASURES - BALAENA BAY, N.W.T. - Q-16241
 OIL SPILLS - CCOUNTERMEASURES - BEAUFORT SEA - Q-16241, Q-19798, Q-26484, Q-26760, Q-26778, Q-29912,
 Q-30058, Q-30074, Q-30104
 OIL SPILLS - CCOUNTERMEASURES - CANADIAN ARCTIC - Q-26743
 OIL SPILLS - COUNTERMEASURES - CANADIAN ARCTIC WATERS - Q-19364, Q-29890, Q-30074, Q-30104
 OIL SPILLS - CCOUNTERMEASURES - MACKENZIE (DELTA), N.W.T. - Q-29912
 OIL SPILLS - COUNTERMEASURES - MACKENZIE BAY, N.W.T./Y.T. - Q-16241
 OIL SPILLS - COUNTERMEASURES - PARRY PENINSULA (REGION), N.W.T. - Q-16241
 OIL SPILLS - CCOUNTERMEASURES - Y.T., NORTHERN - Q-29912
 OIL SPILLS - CCOUNTERMEASURES - YELLOWKNIFE, N.W.T. - Q-26450
 OIL SPILLS - ENVIRONMENTAL ASPECTS - ARCTIC REGIONS - Q-30856
 OIL SPILLS - ENVIRONMENTAL ASPECTS - BALAENA BAY, N.W.T. - Q-15504, Q-16241
 OIL SPILLS - ENVIRONMENTAL ASPECTS - BEAUFORT SEA - H-11622, Q-11592, Q-15547, Q-16241
 OIL SPILLS - ENVIRONMENTAL ASPECTS - CANADA - Q-30287
 OIL SPILLS - ENVIRONMENTAL ASPECTS - CANADIAN ARCTIC - Q-30228
 OIL SPILLS - ENVIRONMENTAL ASPECTS - CANADIAN ARCTIC WATERS - Q-18155, Q-19364, Q-19801, Q-29890,
 Q-30279
 OIL SPILLS - ENVIRONMENTAL ASPECTS - CANADIAN WATERS - Q-30066
 OIL SPILLS - ENVIRONMENTAL ASPECTS - MACKENZIE BAY, N.W.T./Y.T. - Q-16241
 OIL SPILLS - ENVIRONMENTAL ASPECTS - PARRY PENINSULA (REGION), N.W.T. - Q-16241
 OIL SPILLS - SAFETY MEASURES - ARCTIC REGIONS - Q-30856
 OIL SPILLS - CANADIAN ARCTIC - Q-30244
 OIL SPILLS - CANADIAN ARCTIC WATERS - Q-13331
 OIL SPILLS AND PLANTS - CANADIAN WATERS - Q-30066
 OIL SPILLS AND PLANTS - INUVIK, N.W.T. - Q-30120, Q-30171
 OIL SPILLS AND PLANTS - MACKENZIE (DELTA), N.W.T. - Q-30120, Q-30171
 OIL SPILLS AND PLANTS - TUKTOYAKTUK, N.W.T. - Q-30120, Q-30171
 OIL SPILLS AND PLANTS - TUNUNUK POINT, N.W.T. - Q-30120, Q-30171
 OIL SPILLS AND SEA ICE - Q-15490, Q-26450
 OIL SPILLS AND SEA ICE - BAFFIN BAY-DAVIS STRAIT - Q-26573
 OIL SPILLS AND SEA ICE - BALAENA BAY, N.W.T. - Q-16241
 OIL SPILLS AND SEA ICE - BEAUFORT SEA - Q-15547, Q-16241, Q-30058, Q-30082
 OIL SPILLS AND SEA ICE - CANADIAN ARCTIC - Q-26743
 OIL SPILLS AND SEA ICE - CANADIAN ARCTIC WATERS - Q-19364, Q-30082
 OIL SPILLS AND SEA ICE - MACKENZIE BAY, N.W.T./Y.T. - Q-16241
 OIL SPILLS AND SEA ICE - PARRY PENINSULA (REGION), N.W.T. - Q-16241
 OIL SPILLS AND SEA WATER - Q-15490, Q-26450, Q-26468
 OIL SPILLS AND SEA WATER - BAFFIN BAY-DAVIS STRAIT - Q-26573
 OIL SPILLS AND SEA WATER - BALAENA BAY, N.W.T. - Q-15504
 OIL SPILLS AND SEA WATER - BEAUFORT SEA - J-16233, Q-15520, Q-15547, Q-15555, Q-30104
 OIL SPILLS AND SEA WATER - CANADIAN ARCTIC WATERS - Q-13331, Q-19801, Q-30104
 OIL SPILLS AND SEA WATER - MACKENZIE (DELTA), N.W.T. - J-16233
 OIL SPILLS AND SEA WATER - MACKENZIE BAY, N.W.T./Y.T. - J-16233
 OIL SPILLS AND SEA WATER - TUKTOYAKTUK PENINSULA (REGION), N.W.T. - J-16233
 OIL SPILLS AND SOILS - MACKENZIE (DELTA), N.W.T. - Q-30120
 OIL WELL BLOWOUTS - Q-26468
 OIL WELL BLOWOUTS - ENVIRONMENTAL ASPECTS - BEAUFORT SEA - Q-30082
 OIL WELL BLOWOUTS - BAFFIN BAY-DAVIS STRAIT - Q-26573
 OIL WELL BLOWOUTS - BEAUFORT SEA - Q-15520, Q-30058, Q-30104
 OIL WELL BLOWOUTS - CANADIAN ARCTIC - Q-21288
 OIL WELL DRILLING - ENVIRONMENTAL ASPECTS - CANADIAN ARCTIC - Q-12939, Q-12947, Q-12998, Q-13005,
 Q-13013
 OIL WELL DRILLING - ENVIRONMENTAL ASPECTS - MACKENZIE (DELTA), N.W.T. - Q-12955, Q-13005, Q-13021,
 Q-13030, Q-13048, Q-13528
 OIL WELL DRILLING - ENVIRONMENTAL ASPECTS - N.W.T. - D.F. - Q-13538
 OIL WELL DRILLING - ENVIRONMENTAL ASPECTS - PYM POINT, N.W.T. - Q-13005
 OIL WELL DRILLING - ENVIRONMENTAL ASPECTS - SABINE PENINSULA, N.W.T. - Q-12955, Q-13005, Q-13528
 OIL WELL DRILLING - CANADIAN ARCTIC - Q-21288
 OIL WELL DRILLING, SUBMARINE - ENVIRONMENTAL ASPECTS - BAFFIN BAY-DAVIS STRAIT - Q-30821
 OIL WELL DRILLING, SUBMARINE - ENVIRONMENTAL ASPECTS - BEAUFORT SEA - Q-12980, Q-15547, Q-15555,
 Q-30090, Q-30821
 OIL WELL DRILLING, SUBMARINE - ENVIRONMENTAL ASPECTS - CANADIAN ARCTIC - Q-12939, Q-12947, Q-19348
 OIL WELL DRILLING, SUBMARINE - ENVIRONMENTAL ASPECTS - CANADIAN ARCTIC WATERS - Q-18155, Q-29890,
 Q-30090, Q-30821, Q-30864
 OIL WELL DRILLING, SUBMARINE - ENVIRONMENTAL ASPECTS - CANADIAN WATERS - Q-30864
 OIL WELL DRILLING, SUBMARINE - ENVIRONMENTAL ASPECTS - HUDSON BAY - Q-13005, Q-13021
 OIL WELL DRILLING, SUBMARINE - ENVIRONMENTAL ASPECTS - LABRADOR WATERS - Q-30821
 OIL WELL DRILLING, SUBMARINE - ENVIRONMENTAL ASPECTS - MACKENZIE (DELTA), N.W.T. - J-29998
 OIL WELL DRILLING, SUBMARINE - ENVIRONMENTAL ASPECTS - MACKENZIE BAY, N.W.T. - Q-12963, Q-12980
 OIL WELL DRILLING, SUBMARINE - EQUIPMENT AND SUPPLIES - CANADIAN ARCTIC - K-25550
 OIL WELL DRILLING, SUBMARINE - LAW AND LEGISLATION - CANADIAN ARCTIC WATERS - Q-19372
 OIL WELL DRILLING, SUBMARINE - LAW AND LEGISLATION - CANADIAN WATERS - Q-30848
 OIL WELL DRILLING, SUBMARINE - ATLANTIC OCEAN, NORTH - Q-30848
 OIL WELL DRILLING, SUBMARINE - BAFFIN BAY-DAVIS STRAIT, N.W.T. - Q-30872
 OIL WELL DRILLING, SUBMARINE - BEAUFORT SEA - E-11630, Q-19798, Q-24449, Q-25565, Q-25577,
 Q-30872
 OIL WELL DRILLING, SUBMARINE - CANADIAN ARCTIC WATERS - Q-18155
 OIL WELL DRILLING RIGS - TRANSPORTATION - MACKENZIE (DELTA), N.W.T. - L-24562
 OILS SPILLS AND SOILS - TUKTOYAKTUK, N.W.T. - H-30341
 PACK ICE - BAFFIN BAY-DAVIS STRAIT, N.W.T. - D-24503
 PALAEOLOGY - QUATERNARY - BEAUFORT SEA - D-21253

PALAEOONTOLOGY - RECENT - BEAUFORT SEA G-25526
 PALYNOLOGY - BEAUFORT SEA D-21253
 PERIODICALS, CANADIAN X-7773, X-19275
 PERMAFROST - TEMPERATURE - NORMAN WELLS, N.W.T. H-30198
 PERMAFROST - THICKNESS - MACKENZIE (DELTA), N.W.T. L-29955
 PERMAFROST - CANADIAN ARCTIC C-30236, C-30228
 PERMAFROST - TRUELOVE LOWLAND, N.W.T. J-29920
 PERMAFROST BENEATH OCEANS - BEAUFORT SEA C-6408, C-21261, D-21245, X-30317
 PERMAFROST BENEATH OCEANS - MACKENZIE (DELTA), N.W.T. Q-24520
 PETROLEUM - BIODegradation - BEAUFORT SEA Q-11657
 PETROLEUM - ECONOMIC ASPECTS - MACKENZIE (DELTA), N.W.T. Q-24481
 PETROLEUM IN SUBMERGED LANDS - BAFFIN BAY-DAVIS STRAIT, N.W.T. Q-30813
 PETROLEUM IN SUBMERGED LANDS - BEAUFORT SEA Q-30813
 PETROLEUM IN SUBMERGED LANDS - CANADIAN ARCTIC WATERS Q-30813
 PETROLEUM IN SUBMERGED LANDS - LABRADOR WATERS Q-30813
 PETROLEUM INDUSTRY - ECONOMIC ASPECTS - MACKENZIE (DELTA), N.W.T. Q-24481
 PETROLEUM INDUSTRY - EMPLOYEES - CANADIAN ARCTIC K-25550
 PETROLEUM INDUSTRY - EMPLOYEES - MACKENZIE (DELTA), N.W.T. K-25615, Q-24481
 PETROLEUM INDUSTRY - ENVIRONMENTAL ASPECTS - ALASKA Q-25291
 PETROLEUM INDUSTRY - ENVIRONMENTAL ASPECTS - AMUNDSEN GULF, N.W.T. I-9784
 PETROLEUM INDUSTRY - ENVIRONMENTAL ASPECTS - BEAUFORT SEA I-9784
 PETROLEUM INDUSTRY - ENVIRONMENTAL ASPECTS - CANADIAN ARCTIC Q-21288, Q-25291, Q-30201, Q-30210,
 Q-30228, Q-30252, Q-30805, C-30872
 PETROLEUM INDUSTRY - ENVIRONMENTAL ASPECTS - CANADIAN ARCTIC WATERS Q-30864
 PETROLEUM INDUSTRY - ENVIRONMENTAL ASPECTS - CANADIAN WATERS Q-30864
 PETROLEUM INDUSTRY - ENVIRONMENTAL ASPECTS - MACKENZIE (DELTA), N.W.T. I-21300, Q-30139
 PETROLEUM INDUSTRY - ENVIRONMENTAL ASPECTS - N.W.T. - D.F. Q-30139
 PETROLEUM INDUSTRY - EQUIPMENT AND SUPPLIES - CANADIAN ARCTIC L-25747, Q-21288
 PETROLEUM INDUSTRY - EQUIPMENT AND SUPPLIES - MACKENZIE (DELTA), N.W.T. K-25615, L-24716
 PETROLEUM INDUSTRY - PERIODICALS - CANADIAN ARCTIC X-19275
 PETROLEUM INDUSTRY - PLANT FACILITIES - MACKENZIE (DELTA), N.W.T. Q-25798
 PETROLEUM INDUSTRY - PUBLIC RELATIONS - BEAUFORT SEA (REGION) Q-15806, Q-29904, Q-30309
 PETROLEUM INDUSTRY - PUBLIC RELATIONS - CANADIAN ARCTIC Q-29904, Q-30309
 PETROLEUM INDUSTRY - PUBLIC RELATIONS - N.W.T. Q-15806
 PETROLEUM INDUSTRY - SOCIAL ASPECTS - BEAUFORT SEA (REGION) Q-15806
 PETROLEUM INDUSTRY - SOCIAL ASPECTS - CANADIAN ARCTIC Q-30872
 PETROLEUM INDUSTRY - SOCIAL ASPECTS - MACKENZIE (DELTA), N.W.T. Q-25798
 PETROLEUM INDUSTRY - SOCIAL ASPECTS - N.W.T. Q-15806
 PETROLEUM INDUSTRY - CANADA Q-25859
 PETROLEUM INDUSTRY - CANADIAN ARCTIC Q-13331, Q-29858, Q-30244
 PETROLEUM LAW AND LEGISLATION - CANADIAN ARCTIC Q-19372
 PETROLEUM PIPELINES - COSTS - MACKENZIE (DELTA), N.W.T. Q-24520
 PETROLEUM PIPELINES - DESIGN AND CONSTRUCTION - BEAUFORT SEA Q-24520
 PETROLEUM PIPELINES - DESIGN AND CONSTRUCTION - MACKENZIE (DELTA), N.W.T. Q-24520
 PETROLEUM PIPELINES - ENVIRONMENTAL ASPECTS - ALASKA Q-25291
 PETROLEUM PIPELINES - ENVIRONMENTAL ASPECTS - CANADIAN ARCTIC Q-25291, Q-30252
 PHYSICAL GEOGRAPHY - MACKENZIE (DELTA), N.W.T. A-30031
 PHYSICAL GEOGRAPHY - Y.T., NORTHERN A-30031
 PHYTOGEOGRAPHY - MACKENZIE (DELTA), N.W.T. H-30155
 PHYTOPLANKTON - BALAENA BAY, N.W.T. Q-15504
 PHYTOPLANKTON - BEAUFORT SEA H-11522
 PLANKTON - BAFFIN BAY-DAVIS STRAIT I-26425, J-25224, J-25240, J-25259, J-25267, J-25810, J-26506,
 J-26522, J-26530
 PLANKTON - BEAUFORT SEA Q-15555
 PLANKTON - FLEMISH PASS, LABRADOR SEA J-26506, J-26522
 PLANKTON - HUDSON STRAIT, N.W.T. I-25275, J-26522
 PLANKTON - LABRADOR SEA J-25240, J-25810, J-26506
 PLANKTON - MACKENZIE (ESTUARY), N.W.T. Q-26700
 PLANKTON - UNGAVA BAY, QUEBEC I-25275
 PLANT-SOIL RELATIONSHIPS - CANADIAN ARCTIC Q-30228
 PLANTS - NUTRITION - TUKTOYAKTUK, N.W.T. H-30147
 PLANTS - MACKENZIE (DELTA), N.W.T. H-30155
 POLAR BEARS - GEOGRAPHICAL DISTRIBUTION - BEAUFORT SEA I-30333
 POLAR BEARS - HABITS AND BEHAVIOUR - BEAUFORT SEA I-30333
 POLAR BEARS - HABITS AND BEHAVIOUR - CANADIAN ARCTIC I-30333
 POLAR BEARS - POPULATION - BEAUFORT SEA I-30333
 PRESSURE RIDGES G-3530
 PRESSURE RIDGES (ICE) G-25755, G-25763, G-25771, G-26689
 PRESSURE RIDGES (ICE) - BEAUFORT SEA G-25500, G-25534, G-25712, G-25739, G-26697, G-29190
 PRESSURE RIDGES (ICE) - MACKENZIE BAY, N.W.T. G-25500, G-29190
 PRIMARY PRODUCTION (BIOLOGY) - BALAENA BAY, N.W.T. Q-15504
 PRIMARY PRODUCTION (BIOLOGY) - BEAUFORT SEA H-11622, J-11606, X-30317
 PRIMARY PRODUCTION (BIOLOGY) - TRUELOVE LOWLAND, N.W.T. J-29920
 PRIMARY PRODUCTION (BIOLOGY) - TUKTOYAKTUK, N.W.T. H-30147
 REMOTE SENSING OF SEA ICE - BEAUFORT SEA G-30040
 RESEARCH - CANADIAN ARCTIC Q-30244
 REVEGETATION - INUVIK, N.W.T. H-30350
 REVEGETATION - MACKENZIE (DELTA), N.W.T. H-30180, Q-30139
 REVEGETATION - N.W.T. - D.F. Q-30139
 REVEGETATION - NORMAN WELLS, N.W.T. H-30350
 REVEGETATION - PRUDHOE BAY (REGION), ALASKA H-30350
 REVEGETATION - TUKTOYAKTUK, N.W.T. H-30350
 RIVER ICE - STRENGTH - HAY (RIVER AND BASIN), N.W.T. G-26476
 ROADS - ENVIRONMENTAL ASPECTS - TUKTOYAKTUK, N.W.T. H-30341
 ROADS - MACKENZIE (DELTA), N.W.T. L-25631, L-25640
 ROADS - RICHARDS ISLAND, N.W.T. L-25623, L-25631

SALINITY - BAFFIN BAY-DAVIS STRAIT D-26514, D-26590, D-27553, J-25240, J-25259, J-25267, J-26506, J-26522, J-26530
 SALINITY - BAFFIN ISLAND (REGION), N.W.T. I-26409
 SALINITY - BEAUFORT SEA D-30015, I-29980
 SALINITY - FLEMISH PASS, LABRADOR SEA D-26514, J-26506, J-26522
 SALINITY - HUDSON STRAIT, N.W.T. D-27553, J-26522
 SALINITY - LABRADOR SEA D-26514, D-27553, J-25240, J-26506
 SALINITY - MACKENZIE (DELTA), N.W.T. G-19283
 SATELLITE SEA ICE PHOTOGRAPHS - BEAUFORT SEA G-15539, G-25712
 SEA BIRDS - GEOGRAPHICAL DISTRIBUTION - BAFFIN BAY-DAVIS STRAIT J-26530
 SEA BIRDS - GEOGRAPHICAL DISTRIBUTION - BEAUFORT SEA I-29963
 SEA BIRDS - GEOGRAPHICAL DISTRIBUTION - CANADIAN ARCTIC I-29963
 SEA BIRDS - GEOGRAPHICAL DISTRIBUTION - Y.T., NORTHERN I-29971
 SEA BIRDS - HABITS AND BEHAVIOUR - ATKINSON POINT (REGION), N.W.T. Q-26484
 SEA BIRDS - HABITS AND BEHAVIOUR - BEAUFORT SEA Q-26484
 SEA BIRDS - MIGRATION - BEAUFORT SEA I-29963, I-29971
 SEA BIRDS - MIGRATION - CANADIAN ARCTIC I-29963
 SEA BIRDS - BAFFIN BAY-DAVIS STRAIT I-25232, I-26395, I-26425, J-25224, J-25240, J-25259, J-25267, J-25810, J-26506, J-26522
 SEA BIRDS - BAFFIN ISLAND (REGION), N.W.T. I-26409, T-26417
 SEA BIRDS - CANADIAN ARCTIC WATERS I-19356
 SEA BIRDS - FLEMISH PASS, LABRADOR SEA J-26506, J-26522
 SEA BIRDS - HUDSON STRAIT, N.W.T. I-25275, I-26395, J-26522
 SEA BIRDS - LABRADOR SEA J-25240, J-25810, J-26506
 SEA BIRDS - UNGAVA BAY, QUEBEC I-25275, I-26395
 SEA ICE - BREAK-UP - BAFFIN BAY-DAVIS STRAIT G-26611
 SEA ICE - BREAK-UP - BEAUFORT SEA G-15482
 SEA ICE - BREAK-UP - LABRADOR SEA G-26611
 SEA ICE - CRYSTAL STRUCTURE - MACKENZIE (DELTA), N.W.T. G-19283
 SEA ICE - CRYSTAL STRUCTURE - TUKTOYAKTUK HARBOUR, N.W.T. G-19291
 SEA ICE - DEFORMATION - BEAUFORT SEA G-11649
 SEA ICE - DEFORMATION - KUGMALLIT BAY, N.W.T. G-11649
 SEA ICE - DEFORMATION - PTARMIGAN BAY, N.W.T. G-11649
 SEA ICE - DENSITY - BEAUFORT SEA G-25780
 SEA ICE - DIELECTRIC PROPERTIES - BEAUFORT SEA G-30040
 SEA ICE - FORECASTING - BEAUFORT SEA E-11630
 SEA ICE - FORMATION - BAFFIN BAY-DAVIS STRAIT G-26611
 SEA ICE - FORMATION - BEAUFORT SEA G-15482
 SEA ICE - FORMATION - LABRADOR SEA G-26611
 SEA ICE - LIGHT TRANSMISSION - BALAENA BAY, N.W.T. Q-15504
 SEA ICE - MAPS - BEAUFORT SEA G-30040
 SEA ICE - MEASUREMENT - BEAUFORT SEA G-3530, G-11649, G-19305
 SEA ICE - MEASUREMENT - KUGMALLIT BAY, N.W.T. G-11649
 SEA ICE - MEASUREMENT - PTARMIGAN BAY, N.W.T. G-11649
 SEA ICE - MECHANICAL PROPERTIES G-24538
 SEA ICE - MECHANICAL PROPERTIES - MACKENZIE (DELTA), N.W.T. G-25488
 SEA ICE - MOVEMENT - BAFFIN BAY-DAVIS STRAIT G-26492
 SEA ICE - MOVEMENT - BEAUFORT SEA G-11649, G-15539, G-19305
 SEA ICE - MOVEMENT - KUGMALLIT BAY, N.W.T. G-11649
 SEA ICE - MOVEMENT - LABRADOR SEA G-26492
 SEA ICE - MOVEMENT - PTARMIGAN BAY, N.W.T. G-11649
 SEA ICE - PHOTOGRAPHIC ANALYSIS - BEAUFORT SEA G-24457
 SEA ICE - PHYSICAL PROPERTIES - BEAUFORT SEA G-25780
 SEA ICE - SALT CONTENT G-24538
 SEA ICE - SALT CONTENT - BAFFIN BAY-DAVIS STRAIT G-26492
 SEA ICE - SALT CONTENT - BEAUFORT SEA G-24457, G-25500, G-25780
 SEA ICE - SALT CONTENT - LABRADOR SEA G-26492
 SEA ICE - SALT CONTENT - MACKENZIE (DELTA), N.W.T. G-19283
 SEA ICE - SALT CONTENT - MACKENZIE BAY, N.W.T. G-25500, G-25518
 SEA ICE - SALT CONTENT - TUKTOYAKTUK HARBOUR, N.W.T. G-19291
 SEA ICE - STRENGTH G-24465, G-24538, G-25607, G-26646, G-26689, G-26719, G-29939
 SEA ICE - STRENGTH - BAFFIN BAY-DAVIS STRAIT G-26492
 SEA ICE - STRENGTH - BEAUFORT SEA G-19283, G-24457, G-25500, G-25780
 SEA ICE - STRENGTH - LABRADOR SEA G-26492
 SEA ICE - STRENGTH - MACKENZIE (DELTA), N.W.T. G-19283, G-19291, G-25488
 SEA ICE - STRENGTH - MACKENZIE BAY, N.W.T. G-25500, G-25518
 SEA ICE - STRENGTH - TUKTOYAKTUK HARBOUR, N.W.T. G-19291, G-21296
 SEA ICE - STRESSES - MACKENZIE (DELTA), N.W.T. G-25488
 SEA ICE - STRESSES - TUKTOYAKTUK HARBOUR, N.W.T. G-19291
 SEA ICE - SURFACE PROPERTIES - BEAUFORT SEA G-25739
 SEA ICE - TEMPERATURE G-24538
 SEA ICE - TEMPERATURE - BAFFIN BAY-DAVIS STRAIT G-26452
 SEA ICE - TEMPERATURE - BEAUFORT SEA G-25500, G-25780
 SEA ICE - TEMPERATURE - LABRADOR SEA G-26452
 SEA ICE - TEMPERATURE - MACKENZIE (DELTA), N.W.T. G-19283
 SEA ICE - TEMPERATURE - MACKENZIE BAY, N.W.T. G-25500
 SEA ICE - TEMPERATURE - TUKTOYAKTUK HARBOUR, N.W.T. G-19291
 SEA ICE - TERMINOLOGY G-26557
 SEA ICE - THICKNESS G-24538
 SEA ICE - THICKNESS - BAFFIN BAY-DAVIS STRAIT G-26492
 SEA ICE - THICKNESS - BEAUFORT SEA G-15482, G-25739, G-30040
 SEA ICE - THICKNESS - LABRADOR SEA G-26492
 SEA ICE - THICKNESS - MACKENZIE (DELTA), N.W.T. G-19283
 SEA ICE - THICKNESS - MACKENZIE BAY, N.W.T. G-29190
 SEA ICE - THICKNESS - TUKTOYAKTUK HARBOUR, N.W.T. G-19291, G-21296
 SEA ICE - VELOCITY - BEAUFORT SEA G-19305

SEA ICE - BAFFIN BAY-DAVIS STRAIT D-26514, D-26638, G-26557
SEA ICE - BAFFIN BAY-DAVIS STRAIT, N.W.T. A-25062, G-26727
SEA ICE - BEAUFORT SEA D-4766, D-25801, D-30015, G-15482, G-21237, G-24457, G-25534, G-26697,
L-27545, Q-23345, Q-24449, Q-25577, X-30317
SEA ICE - CANADIAN ARCTIC ISLANDS WATERS G-26727
SEA ICE - CANADIAN ARCTIC WATERS Q-30244
SEA ICE - FLEMISH PASS, LABRADOR SEA D-26514
SEA ICE - HUDSON STRAIT, N.W.T. A-25062
SEA ICE - LABRADOR SEA D-26514, G-26557
SEA ICE - MACKENZIE (DELTA), N.W.T. Q-24520
SEA ICE - SMITH SOUND, GREENLAND/N.W.T. G-26727
SEA ICE - UNGAVA BAY, QUEBEC A-25062
SEA ICE AND CLIMATE - BEAUFORT SEA Q-15547
SEA WATER - SUSPENSIONS - BEAUFORT SEA D-15474
SEALING - BEAUFORT SEA T-15512
SEALING - N.W.T. - D.F. T-15512
SEALING - N.W.T. - L.M. T-15512
SEALS (ANIMALS) - GEOGRAPHICAL DISTRIBUTION - BEAUFORT SEA I-30325
SEALS (ANIMALS) - HABITS AND BEHAVIOUR - BEAUFORT SEA I-30325
SEALS (ANIMALS) - HABITS AND BEHAVIOUR - CANADIAN ARCTIC WATERS I-30325
SEALS (ANIMALS) - PHYSIOLOGY - BEAUFORT SEA Q-11592
SEALS (ANIMALS) - POPULATION - BEAUFORT SEA I-30325
SEDIMENT TRANSPORT - MACKENZIE (RIVER AND BASIN), N.W.T. F-6793
SEDIMENTATION AND DEPOSITION - BEAUFORT SEA A-30031
SEDIMENTATION AND DEPOSITION - Y.T., NORTHERN A-30031
SEISMIC EXPLORATION - ENVIRONMENTAL ASPECTS - CANADIAN ARCTIC C-30236
SEISMIC EXPLORATION - ENVIRONMENTAL ASPECTS - NORMAN WELLS, N.W.T. H-30198
SHIPPING - BEAUFORT SEA L-27545
SHIPPING - PACIFIC OCEAN, NORTH L-27545
SHORE-LINES - ARCTIC REGIONS Q-30856
SHORE-LINES - BAFFIN ISLAND, N.W.T. A-25062
SHORE-LINES - BEAUFORT SEA Q-30058
SHORE-LINES - HUDSON STRAIT, N.W.T. A-25062
SHORE-LINES - MACKENZIE (DELTA), N.W.T. Q-29912
SHORE-LINES - N.W.T. Q-30104
SHORE-LINES - UNGAVA BAY, QUEBEC A-25062
SHORE-LINES - Y.T., NORTHERN Q-29912
SNOW F-30295
SOIL COMPOSITION - TUKTOYAKTUK, N.W.T. H-30147
SOIL TEMPERATURE - NORMAN WELLS, N.W.T. H-30198
SOIL TEMPERATURE - TUKTOYAKTUK, N.W.T. H-30341
SOILS - COMPOSITION - MACKENZIE (DELTA), N.W.T. Q-25798
SOILS - PHYSICAL PROPERTIES - TUKTOYAKTUK, N.W.T. H-30341
SOILS - SALT CONTENT - CANADA Q-30287
SOILS - TRUELOVE LOWLAND, N.W.T. J-29920
STORM SURGES - BEAUFORT SEA D-25801, D-30023
STORMS - BAFFIN BAY-DAVIS STRAIT D-26638
STORMS - BEAUFORT SEA E-15458
STREAM FLOW - MACKENZIE (DELTA), N.W.T. Q-25798
STREAM FLOW - MACKENZIE (RIVER AND BASIN), N.W.T. F-6793
SUMPS - ENVIRONMENTAL ASPECTS - CANADIAN ARCTIC Q-12939, Q-12947, Q-12998
SUMPS - ENVIRONMENTAL ASPECTS - MACKENZIE (DELTA), N.W.T. Q-13030, Q-13528
SUMPS - ENVIRONMENTAL ASPECTS - N.W.T. - D.F. Q-13528
SUMPS - ENVIRONMENTAL ASPECTS - SABINE PENINSULA, N.W.T. Q-13528
TIDES - BAFFIN BAY-DAVIS STRAIT D-27553
TIDES - BEAUFORT SEA D-30007, D-30023
TIDES - HUDSON STRAIT, N.W.T. D-27553
TIDES - LABRADOR SEA D-27553
TIDES - MACKENZIE (DELTA), N.W.T. G-25658
TRANSPORTATION, AUTOMOTIVE - ENVIRONMENTAL ASPECTS - MACKENZIE (DELTA), N.W.T. L-25640, L-29947,
L-29955
TRANSPORTATION, AUTOMOTIVE - ENVIRONMENTAL ASPECTS - RICHARDS ISLAND, N.W.T. L-25623, L-25637,
L-29947, L-29955
TRANSPORTATION, AUTOMOTIVE - ENVIRONMENTAL ASPECTS - SHINGLE POINT, Y.T. L-29955
TRANSPORTATION, AUTOMOTIVE - ENVIRONMENTAL ASPECTS - TUKTOYAKTUK, N.W.T. L-29947, L-29955
TRANSPORTATION, AUTOMOTIVE - ENVIRONMENTAL ASPECTS - TUNUNUK POINT, N.W.T. L-29947, L-29955
TRANSPORTATION, AUTOMOTIVE - CANADIAN ARCTIC L-25747
TRANSPORTATION, AUTOMOTIVE - MACKENZIE (DELTA), N.W.T. L-21270, L-24562, L-24716
TROUT - CANADIAN ARCTIC WATERS Q-12998, Q-13005, Q-13013
TROUT - MACKENZIE BAY, N.W.T. Q-12980
TUNDRA ECOLOGY - ALASKA H-30163
TUNDRA ECOLOGY - DEVON ISLAND, N.W.T. J-29920
TUNDRA ECOLOGY - MACKENZIE (DELTA), N.W.T. H-30163, L-29955, Q-30139, Q-30171
TUNDRA ECOLOGY - N.W.T. - D.F. Q-30139
TUNDRA ECOLOGY - TRUELOVE LOWLAND, N.W.T. J-29920
TUNDRA ECOLOGY - TUKTOYAKTUK, N.W.T. H-30147, H-30341
TUNDRA ECOLOGY - TUNUNUK POINT, N.W.T. L-29947
VEGETATION AND CLIMATE - NORMAN WELLS, N.W.T. H-30198
VEGETATION AND CLIMATE - PERMAFROST REGIONS H-30198
VEHICLES L-21270
VEGETATION - TRUELOVE LOWLAND, N.W.T. J-29920
VISIBILITY - BAFFIN BAY-DAVIS STRAIT, N.W.T. G-26727
VISIBILITY - BEAUFORT SEA G-19305
VISIBILITY - CANADIAN ARCTIC ISLANDS WATERS G-26727
VISIBILITY - SMITH SOUND, GREENLAND/N.W.T. G-26727
WATER - POLLUTION - CANADIAN ARCTIC Q-12939, Q-12947

WATER - POLLUTION - MACKENZIE (DELTA), N.W.T. Q-12955, Q-13528
 WATER - POLLUTION - SABINE PENINSULA, N.W.T. Q-12955, Q-13528
 WATER QUALITY - MACKENZIE (DELTA), N.W.T. Q-25798
 WATER QUALITY - MACKENZIE BAY, N.W.T. Q-12963
 WATER-BIRDS - HABITS AND BEHAVIOUR - ATKINSON POINT (REGION), N.W.T. Q-26484
 WATER-BIRDS - HABITS AND BEHAVIOUR - BEAUFORT SEA Q-26484
 WATER-BIRDS - FAIRLIE ISLANDS, N.W.T. I-21300
 WATER-BIRDS - BANKS ISLAND, N.W.T. I-21300
 WATER-BIRDS - HERSCHEL ISLAND, N.W.T. I-21300
 WATER-BIRDS - MACKENZIE (DELTA), N.W.T. I-21300
 WEATHER FORECASTING - BEAUFORT SEA E-11630
 WHALES - MACKENZIE (ESTUARY), N.W.T. Q-26700
 WHALING - AMUNDSEN GULF, N.W.T. I-9784
 WHALING - BEAUFORT SEA I-9784, T-15512
 WHALING - N.W.T. - D.F. T-15512
 WHALING - N.W.T. - D.M. T-15512
 WHITE WHALE - AMUNDSEN GULF, N.W.T. I-9784
 WHITE WHALE - BEAUFORT SEA I-9784
 WILDLIFE CONSERVATION - CANADIAN ARCTIC Q-30228
 WINDS - BAFFIN BAY-DAVIS STRAIT E-26549
 WINDS - BAFFIN BAY-DAVIS STRAIT, N.W.T. D-24490, D-24503, G-26727
 WINDS - BAFFIN ISLAND, N.W.T. A-25062
 WINDS - BEAUFORT SEA E-25801, E-15458, G-19305
 WINDS - CANADIAN ARCTIC ISLANDS WATERS G-26727
 WINDS - HUDSON STRAIT, N.W.T. A-25062
 WINDS - LABRADOR SEA E-26549
 WINDS - MACKENZIE (DELTA), N.W.T. G-25585, G-25658, G-26670, Q-24520
 WINDS - SMITH SOUND, GREENLAND/N.W.T. G-26727
 WINDS - UNGAVA BAY, QUEBEC A-25062
 ZOOPLANKTON - BAFFIN ISLAND (REGION), N.W.T. I-26409
 ZOOPLANKTON - BEAUFORT SEA J-11636

4-3 752

981

ALASKA - BOTANY - ECOLOGY H-30163
 ALASKA - ECOLOGY Q-25291
 ALASKA - ENVIRONMENTAL PROTECTION Q-25291
 ALASKA - GRASSES H-30260
 ALASKA - PETROLEUM INDUSTRY - ENVIRONMENTAL ASPECTS Q-25291
 ALASKA - PETROLEUM PIPELINES - ENVIRONMENTAL ASPECTS Q-25291
 ALASKA - TUNICRA ECOLOGY H-30163
 AMUNDSEN GULF, N.W.T. - BOWHEAD WHALZ I-9784
 AMUNDSEN GULF, N.W.T. - PETROLEUM INDUSTRY - ENVIRONMENTAL ASPECTS I-9784
 AMUNDSEN GULF, N.W.T. - WHALING I-9784
 AMUNDSEN GULF, N.W.T. - WHITE WHALE I-9784
 ANTAARCTIC REGIONS - PERIODICALS X-7773
 ARCTIC REGIONS - OIL SPILLS - COUNTERMEASURES Q-30856
 ARCTIC REGIONS - OIL SPILLS - ENVIRONMENTAL ASPECTS Q-30856
 ARCTIC REGIONS - OIL SPILLS - SAFETY MEASURES Q-30856
 ARCTIC REGIONS - PERIODICALS X-7773
 ARCTIC REGIONS - SHORE-LINES Q-30856
 ATKINSON POINT (REGION), N.W.T. - OIL SPILLS - COUNTERMEASURES Q-26484
 ATKINSON POINT (REGION), N.W.T. - SEA BIRDS - HABITS AND BEHAVIOUR Q-26484
 ATKINSON POINT (REGION), N.W.T. - WATER-BIRDS - HABITS AND BEHAVIOUR Q-26484
 ATLANTIC OCEAN, NORTH - OIL WELL DRILLING, SUBMARINE Q-30848
 BAFFIN BAY-DAVIS STRAIT - AERIAL SURVEYS I-25232, I-26395
 BAFFIN BAY-DAVIS STRAIT - ATMOSPHERIC TEMPERATURE E-26549
 BAFFIN BAY-DAVIS STRAIT - BENTHOS I-25283, I-26425, J-25224, J-25240, J-25810, J-26506, J-26522
 BAFFIN BAY-DAVIS STRAIT - BENTHOS D-26565, D-26581, D-26603, I-25283
 BAFFIN BAY-DAVIS STRAIT - BOTTOM SEDIMENTS D-26581, D-26603
 BAFFIN BAY-DAVIS STRAIT - BOTTOM SEDIMENTS - PHYSICAL PROPERTIES D-26581, D-26603
 BAFFIN BAY-DAVIS STRAIT - CHEMICAL OCEANOGRAPHY J-25240, J-25259, J-26506, J-26522, J-26530
 BAFFIN BAY-DAVIS STRAIT - FISHES I-26425, J-25224, J-25259, J-25267, J-25810, J-26506, J-26522, J-26530
 BAFFIN BAY-DAVIS STRAIT - HYDROGRAPHY J-26506, J-26522
 BAFFIN BAY-DAVIS STRAIT - ICE COVER G-26611
 BAFFIN BAY-DAVIS STRAIT - ICE FLOES G-26492, G-26557
 BAFFIN BAY-DAVIS STRAIT - ICEBERGS G-26557
 BAFFIN BAY-DAVIS STRAIT - INVERTEBRATES I-25283, J-25267
 BAFFIN BAY-DAVIS STRAIT - MARINE BIOLOGY D-26514, J-25224, J-26530
 BAFFIN BAY-DAVIS STRAIT - MARINE MAMMALS I-25232, I-26395, I-26425, J-25224, J-25240, J-25259, J-25267, J-25810, J-26506, J-26522, J-26530
 BAFFIN BAY-DAVIS STRAIT - MARINE RESOURCES J-25810
 BAFFIN BAY-DAVIS STRAIT - METEOROLOGY E-26549, G-26492, G-26557
 BAFFIN BAY-DAVIS STRAIT - OCEAN CURRENTS D-26514, D-26590, D-26620, D-27553, G-26492
 BAFFIN BAY-DAVIS STRAIT - OCEAN TEMPERATURE D-26514, D-26590, D-27553, J-25240, J-25259, J-25267, J-26506, J-26522, J-26530
 BAFFIN BAY-DAVIS STRAIT - OCEAN WAVES E-26514, D-26638
 BAFFIN BAY-DAVIS STRAIT - OCEAN-ATMOSPHERE INTERACTION D-26638
 BAFFIN BAY-DAVIS STRAIT - OCEANOGRAPHY D-26514
 BAFFIN BAY-DAVIS STRAIT - OIL SPILLS - COUNTERMEASURES Q-26573
 BAFFIN BAY-DAVIS STRAIT - OIL SPILLS AND SEA ICE Q-26573
 BAFFIN BAY-DAVIS STRAIT - OIL SPILLS AND SEA WATER Q-26573
 BAFFIN BAY-DAVIS STRAIT - OIL WELL BLOWOUTS Q-26573
 BAFFIN BAY-DAVIS STRAIT - OIL WELL DRILLING, SUBMARINE - ENVIRONMENTAL ASPECTS Q-30821
 BAFFIN BAY-DAVIS STRAIT - PLANKTON I-26425, J-25224, J-25240, J-25259, J-25267, J-25810, J-26506, J-26522, J-26530
 BAFFIN BAY-DAVIS STRAIT - SALINITY D-26514, D-26590, D-27553, J-25240, J-25259, J-25267, J-26506, J-26522, J-26530
 BAFFIN BAY-DAVIS STRAIT - SEA BIRDS I-25232, I-26395, I-26425, J-25224, J-25240, J-25259, J-25267, J-25810, J-26506, J-26522
 BAFFIN BAY-DAVIS STRAIT - SEA BIRDS - GEOGRAPHICAL DISTRIBUTION J-26530
 BAFFIN BAY-DAVIS STRAIT - SEA ICE D-26514, D-26638, G-26557
 BAFFIN BAY-DAVIS STRAIT - SEA ICE - BREAK-UP G-26611
 BAFFIN BAY-DAVIS STRAIT - SEA ICE - FORMATION G-26611
 BAFFIN BAY-DAVIS STRAIT - SEA ICE - MOVEMENT G-26492
 BAFFIN BAY-DAVIS STRAIT - SEA ICE - SALT CONTENT G-26492
 BAFFIN BAY-DAVIS STRAIT - SEA ICE - STRENGTH G-26492
 BAFFIN BAY-DAVIS STRAIT - SEA ICE - TEMPERATURE G-26492
 BAFFIN BAY-DAVIS STRAIT - SEA ICE - THICKNESS G-26492
 BAFFIN BAY-DAVIS STRAIT - STORMS D-26638
 BAFFIN BAY-DAVIS STRAIT - TIDES D-27553
 BAFFIN BAY-DAVIS STRAIT - WINDS E-26549
 BAFFIN BAY-DAVIS STRAIT, N.W.T. - ICEBERGS D-24490, D-24503, G-26727
 BAFFIN BAY-DAVIS STRAIT, N.W.T. - METEOROLOGY D-24490, D-24503, G-26727
 BAFFIN BAY-DAVIS STRAIT, N.W.T. - NATURAL GAS IN SUBMERGED LANDS Q-30813
 BAFFIN BAY-DAVIS STRAIT, N.W.T. - OCEAN CURRENTS A-25062, D-24503
 BAFFIN BAY-DAVIS STRAIT, N.W.T. - OCEAN WAVES D-24490, D-24503, G-26727
 BAFFIN BAY-DAVIS STRAIT, N.W.T. - OCEANOGRAPHY D-24490, D-24503
 BAFFIN BAY-DAVIS STRAIT, N.W.T. - OIL WELL DRILLING, SUBMARINE Q-30872
 BAFFIN BAY-DAVIS STRAIT, N.W.T. - PACK ICE D-24503
 BAFFIN BAY-DAVIS STRAIT, N.W.T. - PETROLEUM IN SUBMERGED LANDS Q-30813
 BAFFIN BAY-DAVIS STRAIT, N.W.T. - SEA ICE A-25062, G-26727
 BAFFIN BAY-DAVIS STRAIT, N.W.T. - VISIBILITY G-26727
 BAFFIN BAY-DAVIS STRAIT, N.W.T. - WINDS D-24490, D-24503, G-26727
 BAFFIN ISLAND, N.W.T. - AERIAL PHOTOGRAPHY A-25062
 BAFFIN ISLAND, N.W.T. - EFFACHES A-25062
 BAFFIN ISLAND, N.W.T. - COASTS A-25062
 BAFFIN ISLAND, N.W.T. - INUIT - HUNTING, TRAPPING AND FISHING T-26417
 BAFFIN ISLAND, N.W.T. - SHORE-LINES A-25062
 BAFFIN ISLAND, N.W.T. - WINDS A-25062

BAFFIN ISLAND (REGION), N.W.T. - BENTHOS I-26409
 BAFFIN ISLAND (REGION), N.W.T. - FISHES I-26409, T-26417
 BAFFIN ISLAND (REGION), N.W.T. - MARINE MAMMALS I-26409, T-26417
 BAFFIN ISLAND (REGION), N.W.T. - OCEAN TEMPERATURE I-26409
 BAFFIN ISLAND (REGION), N.W.T. - SALINITY I-26409
 BAFFIN ISLAND (REGION), N.W.T. - SEA BIRDS I-26409, T-26417
 BAFFIN ISLAND (REGION), N.W.T. - ZOOPLANKTON I-26409
 BAILLIE ISLANDS, N.W.T. - BIRDS I-21300
 BAILLIE ISLANDS, N.W.T. - WATER-BIRDS I-21300
 BALAENA BAY, N.W.T. - OIL SPILLS - COUNTERMEASURES Q-16241
 BALAENA BAY, N.W.T. - OIL SPILLS - ENVIRONMENTAL ASPECTS Q-15504, Q-16241
 BALAENA BAY, N.W.T. - OIL SPILLS AND SEA ICE Q-16241
 BALAENA BAY, N.W.T. - OIL SPILLS AND SEA WATER Q-15504
 BALAENA BAY, N.W.T. - PHYTOPLANKTON Q-15504
 BALAENA BAY, N.W.T. - PRIMARY PRODUCTION (BIOLOGY) Q-15504
 BALAENA BAY, N.W.T. - SEA ICE - LIGHT TRANSMISSION Q-15504
 BANKS ISLAND, N.W.T. - BIRDS I-21300
 BANKS ISLAND, N.W.T. - WATER-BIRDS I-21300
 BEAUFORT SEA - ALGAE Q-15547
 BEAUFORT SEA - ALGAE H-11622
 BEAUFORT SEA - ARTIFICIAL ISLANDS Q-19321, Q-23345, Q-30104
 BEAUFORT SEA - ATMOSPHERIC TEMPERATURE G-19305
 BEAUFORT SEA - BACTERIA, ANAEROBIC H-11754
 BEAUFORT SEA - BACTERIA, HETEROTROPHIC Q-11657
 BEAUFORT SEA - BACTERIA, PSYCHROPHILIC Q-11657
 BEAUFORT SEA - BENTHOS I-11614
 BEAUFORT SEA - BIOLOGICAL PRODUCTIVITY H-11622, I-11614, J-11606
 BEAUFORT SEA - BIRDS - GEOGRAPHICAL DISTRIBUTION I-29971
 BEAUFORT SEA - BIRDS - MIGRATION I-29971
 BEAUFORT SEA - BOTTOM SEDIMENTS C-6408, D-15466, G-25526, G-26697, H-11754
 BEAUFORT SEA - BOTTOM SEDIMENTS - COMPOSITION D-21245, D-21253, Q-15555
 BEAUFORT SEA - BOWHEAD WHALE I-9784
 BEAUFORT SEA - CHEMICAL OCEANOGRAPHY I-29980, J-11606, Q-15555
 BEAUFORT SEA - CLAY G-25526
 BEAUFORT SEA - CLIMATE E-15458
 BEAUFORT SEA - CLIMATIC CHANGES Q-15547
 BEAUFORT SEA - COASTS A-30031, X-30317
 BEAUFORT SEA - COMPOSITION Q-15555
 BEAUFORT SEA - CONTINENTAL SHELF X-30317
 BEAUFORT SEA - DEEP-SEA DRILLING SHIPS Q-24449, Q-25569, Q-25577
 BEAUFORT SEA - DRILLING MUDS - TOXICOLOGY Q-12980
 BEAUFORT SEA - ENVIRONMENTAL POLICY Q-30074, Q-30090
 BEAUFORT SEA - FAST ICE - FORMATION G-25712
 BEAUFORT SEA - FAST ICE - MOVEMENT G-25658, G-26670
 BEAUFORT SEA - FISHERIES T-15512
 BEAUFORT SEA - FISHES I-29980, I-29998, Q-15555
 BEAUFORT SEA - GAS WELL DRILLING, SUBMARINE - ENVIRONMENTAL ASPECTS Q-29904
 BEAUFORT SEA - GEOCHEMISTRY D-21253
 BEAUFORT SEA - HEAT BUDGET Q-15547
 BEAUFORT SEA - HYDROCARBONS Q-15555
 BEAUFORT SEA - ICE COVER G-30040, Q-24449
 BEAUFORT SEA - ICE FLOES G-15482, G-25780
 BEAUFORT SEA - ICE ISLANDS G-24511, G-25500, G-25704, G-25720, G-26751, Q-30104
 BEAUFORT SEA - ICE SCOURING G-24473, G-25526, G-25542, G-26697, X-30317
 BEAUFORT SEA - ICEBERGS G-26697
 BEAUFORT SEA - ICING - SHIPS E-15458
 BEAUFORT SEA - LOGISTICS G-21237, Q-24449
 BEAUFORT SEA - MARINE ECOLOGY J-11606, X-30317
 BEAUFORT SEA - MARINE FAUNA G-25526, I-11614
 BEAUFORT SEA - MARINE POLLUTION J-16233, Q-15555, Q-30074
 BEAUFORT SEA - MARINE RESOURCES T-15512
 BEAUFORT SEA - METEOROLOGY D-30023, G-21237, G-24457, Q-25577
 BEAUFORT SEA - MINERALOGY D-21253
 BEAUFORT SEA - NATURAL GAS IN SUBMERGED LANDS Q-30813
 BEAUFORT SEA - OCEAN BOTTOM D-21245, G-21237
 BEAUFORT SEA - OCEAN CURRENTS D-4766, D-15466, D-30007, D-30015, G-21237
 BEAUFORT SEA - OCEAN CURRENTS - MEASUREMENT G-19305
 BEAUFORT SEA - OCEAN CURRENTS - VELOCITY G-19305
 BEAUFORT SEA - OCEAN TEMPERATURE C-21261, D-30015, I-29980
 BEAUFORT SEA - OCEAN WAVES D-25801, E-15458
 BEAUFORT SEA - OCEANOGRAPHY D-4766, D-30015, J-11606, Q-25577, X-30317
 BEAUFORT SEA - OIL SPILLS - COUNTERMEASURES Q-16241, Q-19798, Q-26484, Q-26760, Q-26778, Q-29912, Q-30058, Q-30074, Q-30104
 BEAUFORT SEA - OIL SPILLS - ENVIRONMENTAL ASPECTS H-11622, Q-11592, Q-15547, Q-16241
 BEAUFORT SEA - OIL SPILLS AND SEA ICE G-15547, Q-16241, Q-30058, Q-30082
 BEAUFORT SEA - OIL SPILLS AND SEA WATER J-16233, Q-15520, Q-15547, Q-15555, Q-30104
 BEAUFORT SEA - OIL WELL BLOWOUTS Q-15520, Q-30058, Q-30104
 BEAUFORT SEA - OIL WELL FLOWOUTS - ENVIRONMENTAL ASPECTS Q-30082
 BEAUFORT SEA - OIL WELL DRILLING, SUBMARINE E-11630, Q-19798, Q-23345, Q-24449, Q-25569, Q-25577, Q-30872
 BEAUFORT SEA - OIL WELL DRILLING, SUBMARINE - ENVIRONMENTAL ASPECTS Q-12980, Q-15547, Q-15555, Q-30090, Q-30821
 BEAUFORT SEA - PALAEOLOGY - QUATERNARY D-21253
 BEAUFORT SEA - PALAEOLOGY - RECENT G-25526
 BEAUFORT SEA - PALYNOLOGY D-21253
 BEAUFORT SEA - PERMAFROST BENEATH OCEANS C-6408, C-21261, D-21245, X-30317

BEAUFORT SEA - PETROLEUM - BIODEGRADATION Q-11657
 BEAUFORT SEA - PETROLEUM IN SUBMERGED LANDS Q-30813
 BEAUFORT SEA - PETROLEUM INDUSTRY - ENVIRONMENTAL ASPECTS I-9784
 BEAUFORT SEA - PETROLEUM PIPELINES - DESIGN AND CONSTRUCTION Q-24520
 BEAUFORT SEA - PHYTOPLANKTON H-11622
 BEAUFORT SEA - PLANKTON Q-15555
 BEAUFORT SEA - POLAR BEARS - GEOGRAPHICAL DISTRIBUTION I-30333
 BEAUFORT SEA - POLAR BEARS - HABITS AND BEHAVIOUR I-30333
 BEAUFORT SEA - POLAR BEARS - POPULATION I-30333
 BEAUFORT SEA - PRESSURE RIDGES (ICE) G-25500, G-25534, G-25712, G-25739, G-26697, G-29190
 BEAUFORT SEA - PRIMARY PRODUCTION (BIOLOGY) H-11622, J-11606, X-30317
 BEAUFORT SEA - REMOTE SENSING OF SEA ICE G-30040
 BEAUFORT SEA - RIVER DISCHARGES - MACKENZIE (RIVER AND BASIN), N.W.T. F-6793
 BEAUFORT SEA - SALINITY D-30015, I-29980
 BEAUFORT SEA - SATELLITE SEA ICE PHOTOGRAPHS G-15539, G-25712
 BEAUFORT SEA - SEA BIRDS - GEOGRAPHICAL DISTRIBUTION I-29963
 BEAUFORT SEA - SEA BIRDS - HABITS AND BEHAVIOUR Q-26484
 BEAUFORT SEA - SEA BIRDS - MIGRATION I-29963, I-29971
 BEAUFORT SEA - SEA ICE D-4766, D-25801, D-30015, G-15482, G-21237, G-24457, G-25534, G-26697, L-27545, Q-23345, Q-24449, C-25577, X-30317
 BEAUFORT SEA - SEA ICE - BREAK-UP G-15482
 BEAUFORT SEA - SEA ICE - DEFORMATION G-11649
 BEAUFORT SEA - SEA ICE - DENSITY G-25780
 BEAUFORT SEA - SEA ICE - DIELECTRIC PROPERTIES G-30040
 BEAUFORT SEA - SEA ICE - FORECASTING E-11630
 BEAUFORT SEA - SEA ICE - FORMATION G-15482
 BEAUFORT SEA - SEA ICE - MAPS G-30040
 BEAUFORT SEA - SEA ICE - MEASUREMENT G-3530, G-11649, G-19305
 BEAUFORT SEA - SEA ICE - MOVEMENT G-11649, G-15539, G-19305
 BEAUFORT SEA - SEA ICE - PHOTOGRAPHIC ANALYSIS G-24457
 BEAUFORT SEA - SEA ICE - PHYSICAL PROPERTIES G-25780
 BEAUFORT SEA - SEA ICE - SALT CONTENT G-24457, G-25500, G-25780
 BEAUFORT SEA - SEA ICE - STRENGTH G-19283, G-24457, G-25500, G-25780
 BEAUFORT SEA - SEA ICE - SURFACE PROPERTIES G-25739
 BEAUFORT SEA - SEA ICE - TEMPERATURE G-25500, G-25780
 BEAUFORT SEA - SEA ICE - THICKNESS G-15482, G-25739, G-30040
 BEAUFORT SEA - SEA ICE - VELOCITY G-19305
 BEAUFORT SEA - SEA ICE AND CLIMATE Q-15547
 BEAUFORT SEA - SEA WATER - SUSPENSIONS D-15474
 BEAUFORT SEA - SEALING T-15512
 BEAUFORT SEA - SEALS (ANIMALS) - GEOGRAPHICAL DISTRIBUTION I-30325
 BEAUFORT SEA - SEALS (ANIMALS) - HABITS AND BEHAVIOUR I-30325
 BEAUFORT SEA - SEALS (ANIMALS) - PHYSIOLOGY Q-11592
 BEAUFORT SEA - SEALS (ANIMALS) - POPULATION I-30325
 BEAUFORT SEA - SEDIMENTATION AND DEPOSITION A-30031
 BEAUFORT SEA - SHIPPING L-27545
 BEAUFORT SEA - SHORE-LINES Q-30056
 BEAUFORT SEA - STORM SURGES D-25801, D-30023
 BEAUFORT SEA - STORMS E-15458
 BEAUFORT SEA - TIDES D-30007, D-30023
 BEAUFORT SEA - VISIBILITY G-19305
 BEAUFORT SEA - WATER-BIRDS - HABITS AND BEHAVIOUR Q-26484
 BEAUFORT SEA - WEATHER FORECASTING E-11630
 BEAUFORT SEA - WHALING I-9784, I-15512
 BEAUFORT SEA - WHITE WHALE I-9784
 BEAUFORT SEA - WINDS D-25801, E-15458, G-19305
 BEAUFORT SEA - ZOOPLANKTON J-11606
 BEAUFORT SEA (REGION) - PETROLEUM INDUSTRY - PUBLIC RELATIONS Q-15806, Q-29904, Q-30309
 BEAUFORT SEA (REGION) - PETROLEUM INDUSTRY - SOCIAL ASPECTS Q-15806
 BROUGHTON ISLAND, N.W.T. - INUIT - HUNTING, TRAPPING AND FISHING T-26417
 CANADA - INFORMATION SERVICES X-7773, Y-29866
 CANADA - OIL SPILLS - ENVIRONMENTAL ASPECTS Q-30287
 CANADA - PETROLEUM INDUSTRY Q-29858
 CANADA - SOILS - SALT CONTENT Q-30287
 CANADIAN ARCTIC - CLOTHING, COLD WEATHER K-24554, K-25550
 CANADIAN ARCTIC - DRILLING MUDS - ANALYSIS Q-12971
 CANADIAN ARCTIC - DRILLING MUDS - DISPOSAL Q-12939, Q-12947
 CANADIAN ARCTIC - DRILLING MUDS - TOXICOLOGY Q-12939, Q-12998, Q-13005, Q-13013
 CANADIAN ARCTIC - ECOLOGICAL RESEARCH Q-30244
 CANADIAN ARCTIC - ECOLOGY J-30112, Q-25291
 CANADIAN ARCTIC - ECOSYSTEMS J-30112, Q-30201, Q-30210, Q-30228, Q-30252
 CANADIAN ARCTIC - ENVIRONMENTAL POLICY Q-19372, Q-30805
 CANADIAN ARCTIC - ENVIRONMENTAL PROTECTION C-30236, Q-19348, Q-25291, Q-30201, Q-30210, Q-30228, Q-30244, Q-30252, Q-30805
 CANADIAN ARCTIC - GAS PIPELINES Q-29904
 CANADIAN ARCTIC - GEOGRAPHY Q-30210
 CANADIAN ARCTIC - GRASSES H-30260
 CANADIAN ARCTIC - INDIANS Q-29904
 CANADIAN ARCTIC - INDUSTRIAL WASTES - ENVIRONMENTAL ASPECTS Q-30228
 CANADIAN ARCTIC - INUIT Q-29904
 CANADIAN ARCTIC - MARINE POLLUTION Q-12939, Q-12947
 CANADIAN ARCTIC - OIL SPILLS Q-30244
 CANADIAN ARCTIC - OIL SPILLS - COUNTERMEASURES Q-26743
 CANADIAN ARCTIC - OIL SPILLS - ENVIRONMENTAL ASPECTS Q-30228
 CANADIAN ARCTIC - OIL SPILLS AND SEA ICE Q-26743
 CANADIAN ARCTIC - OIL WELL BLOWOUTS Q-21288

CANADIAN ARCTIC - OIL WELL DRILLING Q-21288
 CANADIAN ARCTIC - OIL WELL DRILLING - ENVIRONMENTAL ASPECTS Q-12939, Q-12947, Q-12998, Q-13005,
 Q-13013
 CANADIAN ARCTIC - OIL WELL DRILLING, SUBMARINE - ENVIRONMENTAL ASPECTS Q-12939, Q-12947, Q-19348
 CANADIAN ARCTIC - OIL WELL DRILLING, SUBMARINE - EQUIPMENT AND SUPPLIES K-25550
 CANADIAN ARCTIC - PERIODICALS X-19275
 CANADIAN ARCTIC - PERMAFROST C-30236, Q-30228
 CANADIAN ARCTIC - PETROLEUM INDUSTRY Q-13331, Q-29858, Q-30244
 CANADIAN ARCTIC - PETROLEUM INDUSTRY - EMPLOYEES K-25550
 CANADIAN ARCTIC - PETROLEUM INDUSTRY - ENVIRONMENTAL ASPECTS Q-21288, Q-25291, Q-30201, Q-30210,
 Q-30228, Q-30252, Q-30805, Q-30872
 CANADIAN ARCTIC - PETROLEUM INDUSTRY - EQUIPMENT AND SUPPLIES L-25747, Q-21288
 CANADIAN ARCTIC - PETROLEUM INDUSTRY - PERIODICALS X-19275
 CANADIAN ARCTIC - PETROLEUM INDUSTRY - PUBLIC RELATIONS Q-29904, Q-30309
 CANADIAN ARCTIC - PETROLEUM INDUSTRY - SOCIAL ASPECTS Q-30872
 CANADIAN ARCTIC - PETROLEUM LAW AND LEGISLATION Q-19372
 CANADIAN ARCTIC - PETROLEUM PIPELINES - ENVIRONMENTAL ASPECTS Q-25291, Q-30252
 CANADIAN ARCTIC - PLANT-SOIL RELATIONSHIPS Q-30228
 CANADIAN ARCTIC - POLAR BEARS - HABITS AND BEHAVIOUR I-30333
 CANADIAN ARCTIC - RESEARCH Q-30244
 CANADIAN ARCTIC - SEA BIRDS - GEOGRAPHICAL DISTRIBUTION I-29963
 CANADIAN ARCTIC - SEA BIRDS - MIGRATION I-29963
 CANADIAN ARCTIC - SEISMIC EXPLORATION - ENVIRONMENTAL ASPECTS C-30236
 CANADIAN ARCTIC - SUMMS - ENVIRONMENTAL ASPECTS Q-12939, Q-12947, Q-12998
 CANADIAN ARCTIC - TRANSPORTATION, AUTOMOTIVE L-25747
 CANADIAN ARCTIC - WATER - POLLUTION Q-12939, Q-12947
 CANADIAN ARCTIC - WILDLIFE CONSERVATION Q-30228
 CANADIAN ARCTIC ISLANDS WATERS - ARTIFICIAL ISLANDS Q-19313
 CANADIAN ARCTIC ISLANDS WATERS - ICEBERGS G-26727
 CANADIAN ARCTIC ISLANDS WATERS - METEOROLOGY G-26727
 CANADIAN ARCTIC ISLANDS WATERS - OCEAN WAVES G-26727
 CANADIAN ARCTIC ISLANDS WATERS - SEA ICE G-26727
 CANADIAN ARCTIC ISLANDS WATERS - VISIBILITY G-26727
 CANADIAN ARCTIC ISLANDS WATERS - WINDS G-26727
 CANADIAN ARCTIC WATERS - ARTIFICIAL ISLANDS Q-18155
 CANADIAN ARCTIC WATERS - ENVIRONMENTAL PROTECTION Q-18155, Q-29890
 CANADIAN ARCTIC WATERS - FISHES I-19356
 CANADIAN ARCTIC WATERS - INVERTEBRATES Q-30279
 CANADIAN ARCTIC WATERS - MARINE FAUNA Q-30279
 CANADIAN ARCTIC WATERS - MARINE MAMMALS, PROTECTION OF I-19356
 CANADIAN ARCTIC WATERS - MARINE POLLUTION Q-18155, Q-29890, Q-30279
 CANADIAN ARCTIC WATERS - MARINE RESOURCES I-19356, Q-18155
 CANADIAN ARCTIC WATERS - NATURAL GAS IN SUBMERGED LANDS Q-30813
 CANADIAN ARCTIC WATERS - OIL SPILLS Q-13331
 CANADIAN ARCTIC WATERS - OIL SPILLS - COUNTERMEASURES Q-19364, Q-29890, Q-30074, Q-30104
 CANADIAN ARCTIC WATERS - OIL SPILLS - ENVIRONMENTAL ASPECTS Q-18155, Q-19364, Q-19801, Q-29890,
 Q-30279
 CANADIAN ARCTIC WATERS - OIL SPILLS AND SEA ICE Q-19364, Q-30082
 CANADIAN ARCTIC WATERS - OIL SPILLS AND SEA WATER Q-13331, Q-19801, Q-30104
 CANADIAN ARCTIC WATERS - OIL WELL DRILLING, SUBMARINE Q-18155
 CANADIAN ARCTIC WATERS - OIL WELL DRILLING, SUBMARINE - ENVIRONMENTAL ASPECTS Q-18155, Q-29890,
 Q-30090, Q-30821, Q-30864
 CANADIAN ARCTIC WATERS - OIL WELL DRILLING, SUBMARINE - LAW AND LEGISLATION Q-19372
 CANADIAN ARCTIC WATERS - PETROLEUM IN SUBMERGED LANDS Q-30813
 CANADIAN ARCTIC WATERS - PETROLEUM INDUSTRY - ENVIRONMENTAL ASPECTS Q-30864
 CANADIAN ARCTIC WATERS - SEA BIRDS I-19356
 CANADIAN ARCTIC WATERS - SEA ICE Q-30244
 CANADIAN ARCTIC WATERS - SEALS (ANIMALS) - HABITS AND BEHAVIOUR I-30325
 CANADIAN ARCTIC WATERS - TROUT Q-12998, Q-13005, Q-13013
 CANADIAN WATERS - MARINE POLLUTION Q-30066
 CANADIAN WATERS - OIL SPILLS - ENVIRONMENTAL ASPECTS Q-30066
 CANADIAN WATERS - OIL SPILLS AND PLANTS Q-30066
 CANADIAN WATERS - OIL WELL DRILLING, SUBMARINE - ENVIRONMENTAL ASPECTS Q-30864
 CANADIAN WATERS - OIL WELL DRILLING, SUBMARINE - LAW AND LEGISLATION Q-30848
 CANADIAN WATERS - PETROLEUM INDUSTRY - ENVIRONMENTAL ASPECTS Q-30864
 CASSIOWA HILLS, N.W.T. - FIRE ECOLOGY H-30163
 DEVON ISLAND, N.W.T. - TUNDRA ECOLOGY J-29920
 EAGLE LAKE, ALBERTA - LAKE ICE - CRYSTAL STRUCTURE G-25690, G-26662
 EAGLE LAKE, ALBERTA - LAKE ICE - DEFORMATION G-25666
 EAGLE LAKE, ALBERTA - LAKE ICE - STRAIN G-25682, G-25690, G-26654, G-26662
 EAGLE LAKE, ALBERTA - LAKE ICE - STRENGTH G-21296, G-25666, G-25674, G-25682, G-25690, G-26476,
 G-26654, G-26662
 EAGLE LAKE, ALBERTA - LAKE ICE - STRESSES G-25666, G-25674, G-25690
 EAGLE LAKE, ALBERTA - LAKE ICE - TEMPERATURE G-25682, G-25690, G-26654, G-26662
 EAGLE LAKE, ALBERTA - LAKE ICE - THICKNESS G-21296
 ELLIOTT, ALASKA - FIRE ECOLOGY H-30163
 ESKIMO LAKES, N.W.T. - BACTERIA, ANAEROBIC H-11754
 ESKIMO LAKES, N.W.T. - BOTTOM SEDIMENTS H-11754
 FLEMISH PASS, LABRADOR SEA - BENTHOS J-26506, J-26522
 FLEMISH PASS, LABRADOR SEA - BOTTOM SEDIMENTS D-26565
 FLEMISH PASS, LABRADOR SEA - CHEMICAL OCEANOGRAPHY J-26506, J-26522
 FLEMISH PASS, LABRADOR SEA - FISHES J-26506, J-26522
 FLEMISH PASS, LABRADOR SEA - HYDROGRAPHY J-26506, J-26522
 FLEMISH PASS, LABRADOR SEA - MARINE BIOLOGY D-26514
 FLEMISH PASS, LABRADOR SEA - MARINE MAMMALS J-26506, J-26522
 FLEMISH PASS, LABRADOR SEA - OCEAN CURRENTS D-26514

9/9

FLEMISH PASS, LABRADOR SEA - OCEAN TEMPERATURE D-26514, J-26506, J-26522
 FLEMISH PASS, LABRADOR SEA - OCEAN WAVES D-26514
 FLEMISH PASS, LABRADOR SEA - OCEANOGRAPHY D-26514
 FLEMISH PASS, LABRADOR SEA - PLANKTON J-26506, J-26522
 FLEMISH PASS, LABRADOR SEA - SALINITY D-26514, J-26506, J-26522
 FLEMISH PASS, LABRADOR SEA - SEA BIRDS J-26506, J-26522
 FLEMISH PASS, LABRADOR SEA - SEA ICE D-26514
 FROBISHER BAY, N.W.T. - INUIT - HUNTING, TRAPPING AND FISHING T-26417
 HAY (RIVER AND BASIN), N.W.T. - RIVER ICE - STRENGTH G-26476
 HERSCHEL ISLAND, N.W.T. - BIRDS I-21300
 HERSCHEL ISLAND, N.W.T. - WATER-BIRDS I-21300
 HUDSON BAY - DRILLING MUDDS - ANALYSIS Q-12971
 HUDSON BAY - DRILLING MUDDS - TOXICOLOGY Q-13005, Q-13021
 HUDSON BAY - OIL WELL DRILLING, SUBMARINE Q-13021
 HUDSON BAY - OIL WELL DRILLING, SUBMARINE - ENVIRONMENTAL ASPECTS Q-13005
 HUDSON STRAIT, N.W.T. - AERIAL PHOTOGRAPHY A-25062
 HUDSON STRAIT, N.W.T. - AERIAL SURVEYS I-26395
 HUDSON STRAIT, N.W.T. - BEACHES A-25062
 HUDSON STRAIT, N.W.T. - BENTHOS I-25275, J-26522
 HUDSON STRAIT, N.W.T. - CHEMICAL OCEANOGRAPHY J-26522
 HUDSON STRAIT, N.W.T. - COASTS A-25062
 HUDSON STRAIT, N.W.T. - FISHES I-25275, J-26522
 HUDSON STRAIT, N.W.T. - HYDROGRAPHY J-26522
 HUDSON STRAIT, N.W.T. - MARINE MAMMALS I-25275, I-26395, J-26522
 HUDSON STRAIT, N.W.T. - OCEAN CURRENTS A-25062, D-26620, D-27553
 HUDSON STRAIT, N.W.T. - OCEAN TEMPERATURE D-27553, J-26522
 HUDSON STRAIT, N.W.T. - PLANKTON I-25275, J-26522
 HUDSON STRAIT, N.W.T. - SALINITY D-27553, J-26522
 HUDSON STRAIT, N.W.T. - SEA BIRDS I-25275, I-26395, J-26522
 HUDSON STRAIT, N.W.T. - SEA ICE A-25062
 HUDSON STRAIT, N.W.T. - SHORE-LINES A-25062
 HUDSON STRAIT, N.W.T. - TIDES D-27553
 HUDSON STRAIT, N.W.T. - WINDS A-25062
 INUVIK, N.W.T. - FIRE ECOLOGY H-30163
 INUVIK, N.W.T. - GRASSES H-30180
 INUVIK, N.W.T. - OIL SPILLS AND PLANTS Q-30120, Q-30171
 INUVIK, N.W.T. - REVEGETATION H-30350
 JONES SOUND (REGION), N.W.T. - INUIT - HUNTING, TRAPPING AND FISHING J-29920
 KUGMALLIT BAY, N.W.T. - SEA ICE - DEFORMATION G-11649
 KUGMALLIT BAY, N.W.T. - SEA ICE - MEASUREMENT G-11649
 KUGMALLIT BAY, N.W.T. - SEA ICE - MOVEMENT G-11649
 LABRADOR SEA - ATMOSPHERIC TEMPERATURE E-26549
 LABRADOR SEA - BENTHOS J-25240, J-25810, J-26506
 LABRADOR SEA - CHEMICAL OCEANOGRAPHY J-25240, J-26506
 LABRADOR SEA - DEEP-SEA DRILLING SHIPS Q-19330
 LABRADOR SEA - FISHES J-25810, J-26506
 LABRADOR SEA - HYDROGRAPHY J-26506
 LABRADOR SEA - ICE COVER G-26611
 LABRADOR SEA - ICE FLOES G-26492, G-26557
 LABRADOR SEA - ICEBERGS G-26557
 LABRADOR SEA - MARINE BIOLOGY D-26514
 LABRADOR SEA - MARINE MAMMALS J-25240, J-25810, J-26506
 LABRADOR SEA - MARINE RESOURCES J-25810
 LABRADOR SEA - METEOROLOGY E-26549, G-26492, G-26557
 LABRADOR SEA - OCEAN CURRENTS D-26514, D-27553, G-26492
 LABRADOR SEA - OCEAN TEMPERATURE D-26514, D-27553, J-25240, J-26506
 LABRADOR SEA - OCEAN WAVES D-26514
 LABRADOR SEA - OCEANOGRAPHY D-26514
 LABRADOR SEA - PLANKTON J-25240, J-25810, J-26506
 LABRADOR SEA - SALINITY D-26514, D-27553, J-25240, J-26506
 LABRADOR SEA - SEA BIRDS J-25240, J-25810, J-26506
 LABRADOR SEA - SEA ICE D-26514, G-26557
 LABRADOR SEA - SEA ICE - BREAK-UP G-26611
 LABRADOR SEA - SEA ICE - FORMATION G-26611
 LABRADOR SEA - SEA ICE - MOVEMENT G-26492
 LABRADOR SEA - SEA ICE - SALT CONTENT G-26492
 LABRADOR SEA - SEA ICE - STRENGTH G-26492
 LABRADOR SEA - SEA ICE - TEMPERATURE G-26492
 LABRADOR SEA - SEA ICE - THICKNESS G-26492
 LABRADOR SEA - TIDES D-27553
 LABRADOR SEA - WINDS E-26549
 LABRADOR WATERS - NATURAL GAS IN SUBMERGED LANDS Q-30813
 LABRADOR WATERS - OIL WELL DRILLING, SUBMARINE - ENVIRONMENTAL ASPECTS Q-30821
 LABRADOR WATERS - PETROLEUM IN SUBMERGED LANDS Q-30813
 LAKE HARBOUR, N.W.T. - INUIT - HUNTING, TRAPPING AND FISHING T-26417
 MACKENZIE (DELTA), N.W.T. - AIR QUALITY Q-25798
 MACKENZIE (DELTA), N.W.T. - ATMOSPHERIC TEMPERATURE G-25585, G-25658, G-26670, L-25640
 MACKENZIE (DELTA), N.W.T. - BIRDS I-21300, Q-25798
 MACKENZIE (DELTA), N.W.T. - BOTANY Q-25798
 MACKENZIE (DELTA), N.W.T. - BOTANY - ECOLOGY H-30163, Q-30139
 MACKENZIE (DELTA), N.W.T. - CLOTHING, COLD WEATHER K-25615
 MACKENZIE (DELTA), N.W.T. - DIPTERA Q-13048
 MACKENZIE (DELTA), N.W.T. - DRILLING MUDDS - ANALYSIS Q-12971
 MACKENZIE (DELTA), N.W.T. - DRILLING MUDDS - DISPOSAL Q-12955, Q-13528
 MACKENZIE (DELTA), N.W.T. - DRILLING MUDDS - TOXICOLOGY Q-13005, Q-13021, Q-13030, Q-13048
 MACKENZIE (DELTA), N.W.T. - EMPLOYMENT FORECASTING Q-24481

MACKENZIE (DELTA), N.W.T. - ENVIRONMENTAL PROTECTION Q-29912
 MACKENZIE (DELTA), N.W.T. - FAST ICE - MOVEMENT G-25585, G-25658, G-26670
 MACKENZIE (DELTA), N.W.T. - FAST ICE - TEMPERATURE G-25585, G-25658
 MACKENZIE (DELTA), N.W.T. - FISHES I-29998, Q-25798
 MACKENZIE (DELTA), N.W.T. - FISHES, FRESH-WATER I-29998
 MACKENZIE (DELTA), N.W.T. - GAS WELL DRILLING - ENVIRONMENTAL ASPECTS Q-13528
 MACKENZIE (DELTA), N.W.T. - GEOLOGY Q-25798
 MACKENZIE (DELTA), N.W.T. - GRASSES H-30180
 MACKENZIE (DELTA), N.W.T. - GRAVEL B-24546
 MACKENZIE (DELTA), N.W.T. - GROUND-EFFECT MACHINES L-21270, L-24562
 MACKENZIE (DELTA), N.W.T. - HYDROLOGY Q-25798
 MACKENZIE (DELTA), N.W.T. - ICE CORES G-19283
 MACKENZIE (DELTA), N.W.T. - LABOUR SUPPLY Q-24481
 MACKENZIE (DELTA), N.W.T. - LOGISTICS L-24562
 MACKENZIE (DELTA), N.W.T. - MAMMALS Q-25798
 MACKENZIE (DELTA), N.W.T. - MARINE FAUNA Q-25798
 MACKENZIE (DELTA), N.W.T. - METEOROLOGY Q-25798
 MACKENZIE (DELTA), N.W.T. - NATURAL GAS - ECONOMIC ASPECTS Q-24481
 MACKENZIE (DELTA), N.W.T. - OCEANOGRAPHY Q-24520
 MACKENZIE (DELTA), N.W.T. - OIL SPILLS - COUNTERMEASURES Q-29912
 MACKENZIE (DELTA), N.W.T. - OIL SPILLS AND PLANTS Q-30120, Q-30171
 MACKENZIE (DELTA), N.W.T. - OIL SPILLS AND SEA WATER J-16233
 MACKENZIE (DELTA), N.W.T. - OIL SPILLS AND SOILS Q-30120
 MACKENZIE (DELTA), N.W.T. - OIL WELL DRILLING - ENVIRONMENTAL ASPECTS Q-12955, Q-13005, Q-13021,
 Q-13030, Q-13048, Q-13528
 MACKENZIE (DELTA), N.W.T. - OIL WELL DRILLING, SUBMARINE - ENVIRONMENTAL ASPECTS I-29998
 MACKENZIE (DELTA), N.W.T. - OIL WELL DRILLING RIGS - TRANSPORTATION L-24562
 MACKENZIE (DELTA), N.W.T. - PERMAFROST - THICKNESS L-29955
 MACKENZIE (DELTA), N.W.T. - PERMAFROST BENEATH OCEANS Q-24520
 MACKENZIE (DELTA), N.W.T. - PETROLEUM - ECONOMIC ASPECTS Q-24481
 MACKENZIE (DELTA), N.W.T. - PETROLEUM INDUSTRY - ECONOMIC ASPECTS Q-24481
 MACKENZIE (DELTA), N.W.T. - PETROLEUM INDUSTRY - EMPLOYEES K-25615, Q-24481
 MACKENZIE (DELTA), N.W.T. - PETROLEUM INDUSTRY - ENVIRONMENTAL ASPECTS I-21300, Q-30139
 MACKENZIE (DELTA), N.W.T. - PETROLEUM INDUSTRY - EQUIPMENT AND SUPPLIES K-25615, L-24716
 MACKENZIE (DELTA), N.W.T. - PETROLEUM INDUSTRY - PLANT FACILITIES Q-25798
 MACKENZIE (DELTA), N.W.T. - PETROLEUM INDUSTRY - SOCIAL ASPECTS Q-25798
 MACKENZIE (DELTA), N.W.T. - PETROLEUM PIPELINES - COSTS Q-24520
 MACKENZIE (DELTA), N.W.T. - PETROLEUM PIPELINES - DESIGN AND CONSTRUCTION Q-24520
 MACKENZIE (DELTA), N.W.T. - PHYSICAL GEOGRAPHY A-30031
 MACKENZIE (DELTA), N.W.T. - PHYTOGEOGRAPHY H-30155
 MACKENZIE (DELTA), N.W.T. - PLANTS H-30155
 MACKENZIE (DELTA), N.W.T. - POPULATION Q-25798
 MACKENZIE (DELTA), N.W.T. - REVEGETATION H-30180, Q-30139
 MACKENZIE (DELTA), N.W.T. - ROADS L-25631, L-25640
 MACKENZIE (DELTA), N.W.T. - SALINITY G-19283
 MACKENZIE (DELTA), N.W.T. - SEA ICE Q-24520
 MACKENZIE (DELTA), N.W.T. - SEA ICE - CRYSTAL STRUCTURE G-19283
 MACKENZIE (DELTA), N.W.T. - SEA ICE - MECHANICAL PROPERTIES G-25488
 MACKENZIE (DELTA), N.W.T. - SEA ICE - SALT CONTENT G-19283
 MACKENZIE (DELTA), N.W.T. - SEA ICE - STRENGTH G-19283, G-19291, G-25488
 MACKENZIE (DELTA), N.W.T. - SEA ICE - STRESSES G-25488
 MACKENZIE (DELTA), N.W.T. - SEA ICE - TEMPERATURE G-19283
 MACKENZIE (DELTA), N.W.T. - SEA ICE - THICKNESS G-19263
 MACKENZIE (DELTA), N.W.T. - SHORE-LINES Q-29912
 MACKENZIE (DELTA), N.W.T. - SOCIAL CONDITIONS Q-25798
 MACKENZIE (DELTA), N.W.T. - SOILS - COMPOSITION Q-25798
 MACKENZIE (DELTA), N.W.T. - STREAM FLOW Q-25798
 MACKENZIE (DELTA), N.W.T. - SUMPS - ENVIRONMENTAL ASPECTS Q-13030, Q-13528
 MACKENZIE (DELTA), N.W.T. - TILES G-25658
 MACKENZIE (DELTA), N.W.T. - TRANSPORTATION, AUTOMOTIVE L-21270, L-24562, L-24716
 MACKENZIE (DELTA), N.W.T. - TRANSPORTATION, AUTOMOTIVE - ENVIRONMENTAL ASPECTS L-25640, L-29947,
 L-29955
 MACKENZIE (DELTA), N.W.T. - TUNDRA ECOLOGY H-30163, L-29955, Q-30139, Q-30171
 MACKENZIE (DELTA), N.W.T. - WATER - POLLUTION Q-12955, Q-13528
 MACKENZIE (DELTA), N.W.T. - WATER QUALITY Q-25798
 MACKENZIE (DELTA), N.W.T. - WATER-BIRDS I-21300
 MACKENZIE (DELTA), N.W.T. - WINDS G-25585, G-25658, G-26670, Q-24520
 MACKENZIE (ESTUARY), N.W.T. - ARTIFICIAL ISLANDS - ENVIRONMENTAL ASPECTS Q-26700
 MACKENZIE (ESTUARY), N.W.T. - BENTHOS Q-26700
 MACKENZIE (ESTUARY), N.W.T. - BIRDS Q-26700
 MACKENZIE (ESTUARY), N.W.T. - CHEMICAL OCEANOGRAPHY Q-26700
 MACKENZIE (ESTUARY), N.W.T. - FISHES Q-26700
 MACKENZIE (ESTUARY), N.W.T. - MAMMALS Q-26700
 MACKENZIE (ESTUARY), N.W.T. - MARINE MAMMALS Q-26700
 MACKENZIE (ESTUARY), N.W.T. - OCEANOGRAPHY Q-26700
 MACKENZIE (ESTUARY), N.W.T. - PLANKTON Q-26700
 MACKENZIE (ESTUARY), N.W.T. - WHALES Q-26700
 MACKENZIE (RIVER AND BASIN), N.W.T. - DISCHARGES - BEAUFORT SEA F-6793
 MACKENZIE (RIVER AND BASIN), N.W.T. - HYDROLOGY F-6793
 MACKENZIE (RIVER AND BASIN), N.W.T. - SEDIMENT TRANSPORT F-6793
 MACKENZIE (RIVER AND BASIN), N.W.T. - STREAM FLOW F-6793
 MACKENZIE BAY, N.W.T. - DRILLING MUDDS - DISPOSAL Q-12963
 MACKENZIE BAY, N.W.T. - DRILLING MUDDS - TOXICOLOGY Q-12980
 MACKENZIE BAY, N.W.T. - ICE CRYSTALS - ORIENTATION G-25518
 MACKENZIE BAY, N.W.T. - ICE ISLANDS G-24511, G-25500
 MACKENZIE BAY, N.W.T. - ICE-BREAKING G-24511

9-1

MACKENZIE BAY, N.W.T. - MARINE POLLUTION Q-12963, Q-12980
 MACKENZIE BAY, N.W.T. - OIL WELL DRILLING, SUBMARINE - ENVIRONMENTAL ASPECTS Q-12963, Q-12980
 MACKENZIE BAY, N.W.T. - PRESSURE RIDGES (ICE) G-25500, G-29190
 MACKENZIE BAY, N.W.T. - SEA ICE - SALT CONTENT G-25500, G-25518
 MACKENZIE BAY, N.W.T. - SEA ICE - STRENGTH G-25500, G-25518
 MACKENZIE BAY, N.W.T. - SEA ICE - TEMPERATURE G-25500
 MACKENZIE BAY, N.W.T. - SEA ICE - THICKNESS G-29190
 MACKENZIE BAY, N.W.T. - TROUT Q-12980
 MACKENZIE BAY, N.W.T. - WATER QUALITY C-12963
 MACKENZIE BAY, N.W.T./Y.T. - OIL SPILLS - COUNTERMEASURES Q-16241
 MACKENZIE BAY, N.W.T./Y.T. - OIL SPILLS - ENVIRONMENTAL ASPECTS Q-16241
 MACKENZIE BAY, N.W.T./Y.T. - OIL SPILLS AND SEA ICE Q-16241
 MACKENZIE BAY, N.W.T./Y.T. - OIL SPILLS AND SEA WATER J-16233
 MOSQUITO FORK, ALASKA H-30163
 N.W.T. - ECONOMIC CONDITIONS Q-15806
 N.W.T. - NATIONAL PARKS AND RESERVES S-30830
 N.W.T. - PETROLEUM INDUSTRY - PUBLIC RELATIONS Q-15806
 N.W.T. - PETROLEUM INDUSTRY - SOCIAL ASPECTS Q-15806
 N.W.T. - SHORE-LINES Q-30104
 N.W.T. - SOCIAL CONDITIONS Q-15806
 N.W.T. - D.F. - BOTANY - ECOLOGY Q-30139
 N.W.T. - D.F. - DRILLING MUDDS - DISPOSAL Q-13528
 N.W.T. - D.F. - FISHERIES T-15512
 N.W.T. - D.F. - FUR TRADE T-15512
 N.W.T. - D.F. - INDIANS - ECONOMIC CONDITIONS T-15512
 N.W.T. - D.F. - INDIANS - HUNTING, TRAPPING AND FISHING T-15512
 N.W.T. - D.F. - INUIT - ECONOMIC CONDITIONS T-15512
 N.W.T. - D.F. - INUIT - HUNTING, TRAPPING AND FISHING T-15512
 N.W.T. - D.F. - MARTHA RESOURCES T-15512
 N.W.T. - D.F. - METIS - ECONOMIC CONDITIONS T-15512
 N.W.T. - D.F. - METIS - HUNTING, TRAPPING AND FISHING T-15512
 N.W.T. - D.F. - NATURAL GAS Q-30813
 N.W.T. - D.F. - OIL WELL DRILLING - ENVIRONMENTAL ASPECTS Q-13528
 N.W.T. - D.F. - PETROLEUM INDUSTRY - ENVIRONMENTAL ASPECTS Q-30139
 N.W.T. - D.F. - REVEGETATION Q-30139
 N.W.T. - D.F. - SEALING T-15512
 N.W.T. - D.F. - SUNFS - ENVIRONMENTAL ASPECTS Q-13528
 N.W.T. - D.F. - TUNDRA ECOLOGY C-30139
 N.W.T. - D.F. - WHALING T-15512
 N.W.T. - D.M. - FISHERIES T-15512
 N.W.T. - D.M. - FUR TRADE T-15512
 N.W.T. - D.M. - INDIANS - ECONOMIC CONDITIONS T-15512
 N.W.T. - D.M. - INDIANS - HUNTING, TRAPPING AND FISHING T-15512
 N.W.T. - D.M. - INUIT - ECONOMIC CONDITIONS T-15512
 N.W.T. - D.M. - INUIT - HUNTING, TRAPPING AND FISHING T-15512
 N.W.T. - D.M. - MARINE POLLUTION Q-15555
 N.W.T. - D.M. - MARINE RESOURCES T-15512
 N.W.T. - D.M. - METIS - ECONOMIC CONDITIONS T-15512
 N.W.T. - D.M. - METIS - HUNTING, TRAPPING AND FISHING T-15512
 N.W.T. - D.M. - SEALING T-15512
 N.W.T. - D.M. - WHALING T-15512
 NORMAN WELLS, N.W.T. - ENERGY BUDGET H-30198
 NORMAN WELLS, N.W.T. - FORESTS AND FORESTRY H-30198
 NORMAN WELLS, N.W.T. - PERMAFROST - TEMPERATURE H-30198
 NORMAN WELLS, N.W.T. - REVEGETATION H-30350
 NORMAN WELLS, N.W.T. - SEISMIC EXPLORATION - ENVIRONMENTAL ASPECTS H-30198
 NORMAN WELLS, N.W.T. - SOIL TEMPERATURE H-30198
 NORMAN WELLS, N.W.T. - VEGETATION AND CLIMATE H-30198
 PACIFIC OCEAN, NORTH - SHIPPING L-27545
 PANGNITUNG, N.W.T. - INUIT - HUNTING, TRAPPING AND FISHING T-26417
 PARAY PENINSULA (REGION), N.W.T. - OIL SPILLS - COUNTERMEASURES Q-16241
 PARAY PENINSULA (REGION), N.W.T. - OIL SPILLS - ENVIRONMENTAL ASPECTS Q-16241
 PARAY PENINSULA (REGION), N.W.T. - OIL SPILLS AND SEA ICE Q-16241
 PORT SURRELL, N.W.T. - INUIT - HUNTING, TRAPPING AND FISHING T-26417
 PRUDCE BAY (REGION), ALASKA - REVEGETATION H-30350
 PTARMIGAN BAY, N.W.T. - SEA ICE - DEFORMATION G-11649
 PTARMIGAN BAY, N.W.T. - SEA ICE - MEASUREMENT G-11649
 PTARMIGAN BAY, N.W.T. - SEA ICE - MOVEMENT G-11649
 PYM POINT, N.W.T. - DRILLING MUDDS - ANALYSIS Q-12971
 PYM POINT, N.W.T. - DRILLING MUDDS - TOXICOLOGY Q-13005
 PYM POINT, N.W.T. - OIL WELL DRILLING - ENVIRONMENTAL ASPECTS Q-13005
 RICHARDS ISLAND, N.W.T. - ATMOSPHERIC TEMPERATURE L-25631
 RICHARDS ISLAND, N.W.T. - GRAVEL B-24546
 RICHARDS ISLAND, N.W.T. - METEOROLOGY L-25631
 RICHARDS ISLAND, N.W.T. - ROADS L-25623, L-25631
 RICHARDS ISLAND, N.W.T. - TRANSPORTATION, AUTOMOTIVE - ENVIRONMENTAL ASPECTS L-25623, L-25631, L-29947, L-29955
 SABINE PENINSULA, N.W.T. - DRILLING MUDDS - ANALYSIS Q-12971
 SABINE PENINSULA, N.W.T. - DRILLING MUDDS - DISPOSAL Q-12955
 SABINE PENINSULA, N.W.T. - DRILLING MUDDS - TOXICOLOGY Q-13005
 SABINE PENINSULA, N.W.T. - GAS WELL DRILLING - ENVIRONMENTAL ASPECTS Q-13528
 SABINE PENINSULA, N.W.T. - OIL WELL DRILLING - ENVIRONMENTAL ASPECTS Q-12955, Q-13005, Q-13528
 SABINE PENINSULA, N.W.T. - HUMPS - ENVIRONMENTAL ASPECTS Q-13528
 SABINE PENINSULA, N.W.T. - WATER - POLLUTION Q-12955, Q-13528
 SHINGLE POINT, Y.T. - TRANSPORTATION, AUTOMOTIVE - ENVIRONMENTAL ASPECTS L-29955
 SMITH SOUND, GREENLAND/N.W.T. - ICEBERGS G-26727

SMITH SOUND, GREENLAND/N.W.T. - METEOROLOGY G-26727
 SMITH SOUND, GREENLAND/N.W.T. - OCEAN WAVES G-26727
 SMITH SOUND, GREENLAND/N.W.T. - SEA ICE G-26727
 SMITH SOUND, GREENLAND/N.W.T. - VISIBILITY G-26727
 SMITH SOUND, GREENLAND/N.W.T. - WINDS G-26727
 TRUELOVE LOWLAND, N.W.T. - BOTANY J-29920
 TRUELOVE LOWLAND, N.W.T. - ECOSYSTEMS J-29920
 TRUELOVE LOWLAND, N.W.T. - GEOLOGY J-29920
 TRUELOVE LOWLAND, N.W.T. - HYDROLOGY J-29920
 TRUELOVE LOWLAND, N.W.T. - INVERTEBRATES J-29920
 TRUELOVE LOWLAND, N.W.T. - LINNOLOGY J-29920
 TRUELOVE LOWLAND, N.W.T. - METEOROLOGY J-29920
 TRUELOVE LOWLAND, N.W.T. - MICRO-ORGANISMS J-29920
 TRUELOVE LOWLAND, N.W.T. - PERMAFROST J-29920
 TRUELOVE LOWLAND, N.W.T. - PRIMAARY PRODUCTION (BIOLOGY) J-29920
 TRUELOVE LOWLAND, N.W.T. - SOILS J-29920
 TRUELOVE LOWLAND, N.W.T. - TUNDRA ECOLOGY J-29920
 TRUELOVE LOWLAND, N.W.T. - VERTEBRATES J-29920
 TUKTOYAKTUK, N.W.T. - BOTANY - ECOLOGY H-30147, H-30341
 TUKTOYAKTUK, N.W.T. - FIRE ECOLOGY H-30341
 TUKTOYAKTUK, N.W.T. - GRASSES H-30180
 TUKTOYAKTUK, N.W.T. - OIL SPILLS AND PLANTS Q-30120, Q-30171
 TUKTOYAKTUK, N.W.T. - OIL SPILLS AND SOILS H-30341
 TUKTOYAKTUK, N.W.T. - PLANTS - NUTRITION H-30147
 TUKTOYAKTUK, N.W.T. - PRIMAARY PRODUCTION (BIOLOGY) H-30147
 TUKTOYAKTUK, N.W.T. - REVEGETATION H-30350
 TUKTOYAKTUK, N.W.T. - ROADS - ENVIRONMENTAL ASPECTS H-30341
 TUKTOYAKTUK, N.W.T. - SOIL COMPOSITION H-30147
 TUKTOYAKTUK, N.W.T. - SOIL TEMPERATURE H-30341
 TUKTOYAKTUK, N.W.T. - SOILS - PHYSICAL PROPERTIES H-30341
 TUKTOYAKTUK, N.W.T. - TRANSPORTATION, AUTOMOTIVE - ENVIRONMENTAL ASPECTS 1-29947, 1-29955
 TUKTOYAKTUK, N.W.T. - TUNDRA ECOLOGY H-30147, H-30341
 TUKTOYAKTUK HARBOUR, N.W.T. - SEA ICE - CRYSTAL STRUCTURE G-19291
 TUKTOYAKTUK HARBOUR, N.W.T. - SEA ICE - SALT CONTENT G-19291
 TUKTOYAKTUK HARBOUR, N.W.T. - SEA ICE - STRENGTH G-19291, G-21296
 TUKTOYAKTUK HARBOUR, N.W.T. - SEA ICE - STRESSES G-19291
 TUKTOYAKTUK HARBOUR, N.W.T. - SEA ICE - TEMPERATURE G-19291
 TUKTOYAKTUK HARBOUR, N.W.T. - SEA ICE - THICKNESS G-19291, G-21296
 TUKTOYAKTUK PENINSULA (REGION), N.W.T. - OIL SPILLS AND SEA WATER J-16233
 TUNUNUK POINT, N.W.T. - OIL SPILLS AND PLANTS Q-30120, Q-30171
 TUNUNUK POINT, N.W.T. - TRANSPORTATION, AUTOMOTIVE - ENVIRONMENTAL ASPECTS 1-29947, 1-29955
 TUNUNUK POINT, N.W.T. - TUNDRA ECOLOGY I-29947
 UNGAVA BAY, QUEBEC - AERIAL PHOTOGRAPHY A-25062
 UNGAVA BAY, QUEBEC - AERIAL SURVEYS I-26395
 UNGAVA BAY, QUEBEC - BEACHES A-25062
 UNGAVA BAY, QUEBEC - BENTHOS I-25275, I-25283
 UNGAVA BAY, QUEBEC - BOTTOM SEDIMENTS I-25283
 UNGAVA BAY, QUEBEC - COASTS A-25062
 UNGAVA BAY, QUEBEC - FISHES I-25275
 UNGAVA BAY, QUEBEC - INVERTEBRATES I-25283
 UNGAVA BAY, QUEBEC - MARINE MAMMALS I-25275, I-26395
 UNGAVA BAY, QUEBEC - OCEAN CURRENTS A-25062
 UNGAVA BAY, QUEBEC - PLANKTON I-25275
 UNGAVA BAY, QUEBEC - SEA BIRDS I-25275, I-26395
 UNGAVA BAY, QUEBEC - SEA ICE A-25062
 UNGAVA BAY, QUEBEC - SHORE-LINES A-25062
 UNGAVA BAY, QUEBEC - WINDS A-25062
 Y.T. - NATIONAL PARKS AND RESERVES S-30830
 Y.T., NORTHERN - BIRDS - GEOGRAPHICAL DISTRIBUTION I-29971
 Y.T., NORTHERN - BIRDS - MIGRATION I-29971
 Y.T., NORTHERN - COASTS A-30031
 Y.T., NORTHERN - ENVIRONMENTAL PROTECTION Q-29912
 Y.T., NORTHERN - FISHERIES I-29980
 Y.T., NORTHERN - GEOMORPHOLOGY A-30031
 Y.T., NORTHERN - LANDFORMS A-30031
 Y.T., NORTHERN - OIL SPILLS - COUNTERMEASURES Q-29912
 Y.T., NORTHERN - PHYSICAL GEOGRAPHY A-30031
 Y.T., NORTHERN - SEA BIRDS - GEOGRAPHICAL DISTRIBUTION I-29971
 Y.T., NORTHERN - SEDIMENTATION AND DEPOSITION A-30031
 Y.T., NORTHERN - SHORE-LINES Q-29912
 YELLOWKNIFE, N.W.T. - OIL SPILLS - COUNTERMEASURES Q-26450

AMOCO CANADA PETROLEUM COMPANY LTD.
14, 41

ARCTIC PETROLEUM OPERATORS' ASSOCIATION
6, 15, 20, 34, 37, 38, 55, 58, 63, 71, 98

DOMI PETROLEUM LTD.
97, 100, 107, 108, 114, 130, 141

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13, 24, 45

ESSO RESOURCES CANADA LTD.
1, 2, 3, 9, 11, 12, 16, 21, 25, 28, 29, 31, 33, 39, 40, 42, 43, 51, 52, 53, 54, 56,
57, 61, 65, 66, 67, 68, 69, 70, 73, 75, 76, 77, 82, 83, 84, 85, 86, 87, 88, 91, 93,
99, 103, 104, 105, 106, 109, 110, 111, 113, 115, 119, 122, 123, 124, 125, 126, 127,
128, 129, 134, 135, 138, 140, 143, 144, 145, 146, 148, 149

GULF OIL CANADA LTD.
4, 7, 17, 19, 23, 30, 32, 35, 36, 48, 49, 60, 72, 78, 89, 131, 133, 151, 152, 154

PANARCTIC OILS LTD.
74, 79, 92, 95, 96, 118

SUN OIL COMPANY LTD.
46, 47, 50, 64, 80, 81, 90, 94, 101, 102, 117, 121, 142

452
361

LIST OF APOA PROJECTS

<u>APOA Project No.</u>	<u>Operator</u>	<u>Current Number of Participants</u>	<u>Description</u>	<u>Status</u>	<u>Total Cost</u>	<u>Cost to Next Participant</u>
1	Imperial	8	"Nutcracker" Large Scale Ice Strength Tests	Completed	\$ 166,790.	\$ 36,000.
2	Imperial	16	Sea Ice Survey - Properties and Movement of Ice and Current Measurements	Completed	378,265.	\$ 15,270.
3	Imperial	15	Ocean Floor Sampling	Completed	\$ 458,027.	\$ 22,404.
4 ⁽¹⁰⁾	Gulf	10	Geological Analysis of Ocean Floor Samples	Completed	\$ 11,757.	\$ 1,069.
5	APOA	All	Study of Mackenzie Delta Tundra Disturbance	Cancelled	\$ 1,300.	-
6	-	-	Summer Ice Reconnaissance	Cancelled	-	-
7	Gulf	9	Cross-Country Vehicle Study	Completed	\$ 6,671.	\$ 667.
8	APOA	All	Arctic Drilling Guidelines	Completed	-	-
9	Imperial	8	Large Scale Ice Strength Test Phase II of "Nutcracker"	Completed	\$ 60,000.	\$ 7,500.
10	-	-	Testing with Synthetic Ice	Cancelled	-	-
11	Imperial	3	Ornithological Study - Mackenzie Delta	Completed	\$ 7,660.	\$ 1,530.
12 ⁽¹⁾	Imperial	9	All Season Exploratory Drilling System - 0 to 200 Feet of Water	Completed	\$ 176,488.	\$ 17,659.
13 ⁽²⁾	Kif	16	Seasonal Drilling from a Barge	Completed	\$ 134,601.	\$ 8,310.
14	Amcu	12	Summer Ice Reconnaissance Beaufort Sea	Completed	\$ 18,670.	\$ 1,856.
15	APOA	All	Mackenzie Institute - Travel Costs for an Edmonton Meeting	Completed	\$ 1,140.	-
16	Imperial	8	Theoretical Analysis of Ice Failure	Completed	\$ 10,000.	\$ 1,100.

APOA Project No	Operator	Current Number of Participants	Description	Status	Total Cost	Cost to Host Participant
17	Gulf	9	Pressure Ridge and Ice Island Scouring	Completed	\$ 102,472	\$ 10,247
18	-	-	Arctic Drilling Concepts Review	Cancelled	-	-
19	Gulf	14	Analysis of Records Showing Sea Bottom Scouring	Completed	\$ 16,239	\$ 1,159
20	APOA	29	Cementing, Casing and Blowout Procedures for DIAMOND	Completed	\$ 28,500	Agreed
21	Imperial	5	Large Wheeled-Low Pressure Vehicle	Completed	\$ 40,000	\$ 8,000
22	-	-	Transportation of Hydrocarbons from Arctic Is.	Cancelled	-	-
23	Gulf	1	Soil Strength of Beaufort Sea Samples by GSC	Completed	\$ 3,000	-
24	Elf	11	Arctic Clothing Research	Completed	\$ 18,240	\$ 1,658
25	Imperial	10	Model Test Simulating Ice on Fixed Structures	Completed	\$ 43,855	\$ 4,385
26	-	-	Model Test Simulating Ice on Drilling Barge	Cancelled	-	-
27	APOA	29	Co-ordination of Arctic Environmental Research	Cancelled	\$ 27,800/yr	Agreed
28	Imperial	7	Biological Effects of Oil in Arctic Seawater	Completed	\$ 17,250	\$ 2,464
29	Imperial	3	Habakkuk - Investigation of Floating Island	Completed	\$ 600	-
30(3)	Gulf	12	Beaufort Sea Exploratory Drilling Systems	Completed	\$ 33,301	\$ 2,775
31	Imperial	3	Aerial Reconnaissance of Ice - Beaufort Sea	Completed	\$ 7,585	\$ 2,528
32(4)	Gulf	11	Analyze 1971 Scour Records and Run 1972 Program	Completed	\$ 18,236	\$ 1,658

2.2
H6

363

APCA Project No.	Operator	Current Number of Participants	Description	Status	Total Cost	Cost to Next Participant
31	Imperial	6	Landfast Ice Movement - Mackenzie Delta	Completed	\$ 90,000.	\$ 7,000.
32	APOA	-	Northern Resources Study - Boreal Institute	Completed	\$ 25,000.	Acreage
33	Gulf	8	Environmental Study of the Baffin Bay - Davis Strait	Completed	\$ 42,659.	\$ 6,762.
36	Gulf	11	Ice Island Destruction - Beaufort Sea	Completed	\$ 24,508.	\$ 3,042.
37	APOA	-	Arctic Environmental Research - Dr. Bliss U. of A.	Completed	\$ 207,300.	Acreage
38	APOA	-	Testing of the Effects on Terrain by Various Types of Vehicles	Completed	-	-
39 ⁽⁵⁾	Imperial	4	Submarine Pipeline Study Offshore Mackenzie Delta	Completed	\$ 75,000.	\$ 19,375.
40 ⁽⁶⁾	Imperial	8	Evaluation of Mechanical Properties of Saline Model Ice	Completed	\$ 19,800.	\$ 2,200.
41	Amoco	11	Evaluation of the Properties of Michel's Model Ice	Completed	\$ 7,000.	\$ 700.00
42	Imperial	6	Survey of Gravel - Mackenzie Delta	Completed	\$ 16,500.	\$ 1,000.
43	Imperial	3	Environmental Impact Assessment Program - Mackenzie Delta	Completed	\$ 648,000.	Acreage
44	-	-	Photo Reconnaissance and Ice Movement - Beaufort Sea 1972-1973	Cancelled	-	-
45	Elf	13	Arctic Clothing Research - Phase II	Completed	\$ 19,050	\$ 1,361.

APOA Project No.	Operator	Current Number of Participants	Description	Status	Total Cost	Cost to host Participant
46	Sun	1	Ice Reconnaissance - Beaufort Sea, April 1972	Completed	\$ 12,600.	\$ 2,000.
47	Sun	4	Ice Chipper Evaluation Test	Completed	\$ 42,000.	\$ 3,000.
48	Gulf	4	Study of Vehicular Traffic on the Mackenzie Delta Tundra	Completed	\$ 15,355.	\$ 3,071.
49	Gulf	12	Study of Arctic Transportation Equipment - Mackenzie Delta Area	Completed	\$ 10,034.	\$ 772.
50	Sun	3	Ice Thickness Measurement	Completed	\$ 27,900.	\$ 5,000.
51	Imperial	7	Ice Movement Beaufort Sea 1972-1973	Completed	\$ 217,525.	\$ 20,000.
52 (7)	Imperial	7	Measuring the Crushing Strength of Ice	Completed	\$ 145,873.	\$ 13,234.
53	Imperial	4	Count of Ice Islands in the Beaufort Sea 1972	Completed	\$ 11,370.	\$ 2,274.
54	Imperial	3	Ice Geology - Southern Beaufort Sea	Completed	\$ 50,000.	\$ 10,000.
55	APOA	18	Arctic Environmental Research 1973	Completed	\$ 237,511.	Acreage
56 (8)	Imperial	3	Preparation of Specification for Large Arctic Truck	Completed	\$ 5,000.	-
57	Imperial	7	Effects of Ice Adhesion (ad freeze) on a Conical Structure	Completed	\$ 68,000.	-
58	APOA	30	Task Force re Northern Native Job Training	Completed	\$ 200,000.	Acreage
59	-	-	1973 Beaufort Sea Scouring Study Phase III	Cancelled	-	-
60	Gulf	11	1973 Summer Ice Study Beaufort Sea	Completed	\$ 88,336.	\$ 7,361.
61	Imperial	4	Environmental Impact Assessment Prog. Mackenzie Delta Phase II	Completed	\$ 600,000.	Proportional

Alaska Project No.	Operator	Current Number of Participants	Description	Status	Total Cost	Cost to Next Participant
62	-	-	Part 3 Beaufort Gas Plant Study	Withdrawn by Operator		
63	APUA	-	Arctic Institute of North America's Beaufort Sea Symposium	Completed	\$ 12,000.	-
64	Sun	7	Ice Mechanism and Ice Strengthening 1973-74 Arctic Field Test Program - Kooluk Bay	Completed	\$ 355,000.	\$ 75,000.
65	Imperial	6	Small Prototype Cone Test	Completed	\$ 238,269.	\$ 34,038.
66	Imperial	6	Ice Crushing Tests 1973/74	Completed	\$ 190,000.	\$ 20,000.
67 ⁽⁹⁾	Imperial	4	Landfast Ice Movement - Beaufort Sea 1973/74	Completed	\$ 105,000	\$ 10,000.
68	Imperial	6	Properties of Model Ice Ridges	Completed	\$ 29,000.est.	\$ 4,412.
69	Imperial	6	Analytic Study of Ice Scour	Completed	\$ 30,738.	\$ 3,842.
70	Imperial	3	Wind/Wave Hindcast, Canadian Beaufort Sea	Completed	\$ 49,800.	\$ 12,000.
71	APQA	27	Northern Native Job Training Task Force - 1974	Completed	\$ 310,000.	Acreage
72	Gulf	18	Beaufort Sea Environmental Program	Completed	\$4,600,000.	Acreage
73	Imperial	17	Research Program on Pollution from Drilling Fluids	Completed	\$ 206,280.	Acreage
74	Panarctic	2	Banks Island Development: Environmental Considerations	Completed	\$ 334,000.	Proportional
75	Imperial	3	Field Study of First Year Ice Pressure Ridges	Completed	\$ 163,195.	\$ 20,000.

APOA Project No.	Operator	Current Number of Participants	Description	Status	Total Cost	Cost to Next Participant
76	Imperial	1	Summer Environmental Studies - East Mackenzie Bay, Mackenzie Delta, N.W.T.	Completed	\$ 451,000.	Proportional
77 ⁽¹²⁾	Imperial	7	Modeling of Small Cone Prototype Tests	Completed	\$ 60,654.	\$ 8,693.
78	Gulf	14	Environmental Data Gathering Program Baffin Bay, Davis Strait and Arctic Islands	Completed	\$ 12,646.	\$ 1,873.00
79	Panarctic	11	Arctic Island Ice Movement Study 1974-1975	Completed	\$ 246,000.	Proportional
80	Sun	8	Development of a Seal-Submersible Drilling System for the Arctic Offshore Area - Phase I	Completed	\$1,345,400.	Proportional
81	Sun	2	Ice Mechanics Projects 1974-75	Completed	\$ 714,000.	\$ 75,000.
82 ⁽¹²⁾	Imperial	6	Small Prototype ConeTest - Phase II	Completed	\$ 300,000.	\$ 30,200.
83 ⁽¹⁴⁾	Imperial	4	Land Fast Ice Movement - Beaufort Sea 1974-75	Completed	\$ 118,000.	\$ 10,000.
84	Imperial	6	Conduct In Situ Ice Property Measurements in the Beaufort Sea	Completed	\$ 58,000.	\$ 8,000.
85 ⁽¹³⁾	Imperial	6	Airfreeze on Conical Structures	Completed	\$ 55,000.	\$ 9,285.
86 ⁽¹⁵⁾	Imperial	6	Study of Pressure Ridge/Cone Interaction	Completed	\$ 70,000.	\$ 10,000.
87 ⁽¹³⁾	Imperial	6	Mathematical Model in Ice/Cone Interaction	Completed	\$ 7,500.	\$ 1,071.
88	Imperial	5	Gravel Testing Program, Ya Ya Lake	Completed	\$ 165,000.	Proportional
89	Gulf	7	Thickness of Multi-Year Pressure Ridges	Completed	\$ 59,000.	\$ 11,514.
90	Sun	4	Mobile Arctic Ice Chipper	Completed	\$ 103,700.	\$ 5,000.
91	Imperial	7	Field Study of Multi-Year Ice Pressure Ridges	Completed	\$ 125,000.	\$ 25,000.

APDA Project No.	Operator	Current Number of Participants	Description	Status	Total Cost	Cost to Next Participant
92	Panarctic	12	Arctic Island Sea Ice Movement Analysis from Ice Reconnaissance and Satellite Imagery Data	Completed	\$ 45,100.	Proportional
93	Imperial	2	Proposal to Conduct III Aspect Ratio Ice Crushing Tests	Completed	\$ 55,000.	\$ 12,000.
94 (16)	Sun	3	Sedco ICSD/ Phase II Development	In Progress	112,300.	Proportional
95	Panarctic	8	Arctic Islands Winter Ice Movement Study 1975-1976	Completed	\$ 448,600.	\$ 53,533.
96	Panarctic	10	Statistical Study of Late Winter Ice Thickness Distribution in the Arctic Islands from Seismic Data 1971-1975	Completed	\$ 40,000.	Proportional
97	Dome	4	Proposal for Full Scale Laboratory Tests of the Lockheed Clean Sweep Arctic Boat R2003 Oil Recovery System	Completed	\$ 39,690.	Proportional
98	Panarctic	19	Arctic Science And Technology Information Feasibility Study	Completed	\$ 30,000.	Acreage
99	Imperial	4	Ice Island Count - Southern Beaufort Sea 1974-75-76	In Progress	\$ 30,000.	\$ 7,500.
100	Dome	4	Test Program to Evaluate a New Concept of Oil Containment Boom for Use in Ice Infested Arctic Waters	Completed	\$ 47,840.	Proportional
101 (17)	Sun	2	Field Testing of the Mobil Ice Chipper II	Completed	\$ 10,000.	Proportional

ARPA Project No.	Operator	Contract Number of Participants	Description	Status	Total Cost	Cost to Host Participant
102	Bum	5	Multi Year Pressure Ridge Study in Queen Elizabeth Islands	Completed	\$ 150,000.	Proportional
103	Imperial	1	Study of Interaction Between Ice Shoals & Wide Structures	Completed	\$ 240,000.	\$ 40,000.
104	Imperial	1	Conduct In Situ Ice Pressure Measurements Around Artificial Islands in Southern Beaufort Sea - Phase I	Completed	\$ 547,000.	\$ 49,000.
105	Imperial	4	Conduct In Situ Ice Pressure Measurements Around Artificial Islands in Southern Beaufort Sea - Phase II	Completed	\$ 410,000.	\$ 40,000.
106	Imperial	2	Continuous Tracking of an Ice Sheet by a Circular Indicator	Completed	\$ 157,000.	\$ 11,000.
107	Esso	1	Open Water Burning of Oil	Completed	\$ 21,335.	Proportional
108	Esso	1	Burning an Oil Blowout Flame	Completed	\$ 46,830.	Proportional
109	Imperial	4	Modeling of Ice Pile-up and Widening on Islands	Completed	\$ 42,000.	\$ 7,000.
110	Imperial	4	Design Studies of Conical and Cylindrical Bottom Loaded Structures for Southern Beaufort Sea	Completed	\$ 990,000.	\$ 75,000.
111	Imperial	2	Ice Defense Systems Experimental Evaluation	Completed	\$ 44,000.	\$ 7,500.
112 ⁽¹¹⁰⁾	Gulf	-	Geometry of a Continuous Multi-Year Pressure Ridge	Cancelled	\$ 15,000.	\$ 1,000.
113	Imperial	1	Statistical Study of Passage Into Beaufort Sea Via Polaris Narrow	Completed	\$ 6,000.	\$ 1,000.
114	Esso	4	Preliminary Tests of Kind State Devices in Beaufort Sea	Completed	\$ 52,000.	\$ 11,150.
115	Imperial	7	Polar Bear Research	In Progress	\$ 10,000.	\$ 1,600.

AFSA Project No.	Operator	Current Number of Participants	Description	Status	Total Cost	Cost to Next Participant
116	Dome	-	Drilling from Ship - Shore Fast Ice	Cancelled	\$ 10,000.	\$ 1,000.
117	Sun	5	Statistical Study of Ice Thickness From Seismic Data - 1976	Completed	\$ 25,000.	Proportional
118	Panarctic	6	Arctic Islands Winter Ice Movement Study 1976/77	In Progress	\$ 520,000.	Proportional
119	Imperial	5	Remote Detection of Oil In/Under Ice	In Progress	\$ 50,000.	Proportional
120	Panarctic	-	Safe Ice Detector - Project SID	Cancelled	\$ 170,000.	
121	Sun	-	Multi-Year Pressure Ridge Study Arctic Islands Northwest Territories	Deferred till 1978	\$ 160,000.	
122	Imperial	2	In-Situ Ice Pressure Measurements 1976/77	In Progress	\$ 790,000.	\$ 159,100.
123	Imperial	2	Continuous Crushing of Ice 1976/77	In Progress	\$ 196,000.	\$ 39,300.
124	Imperial	3	Experimental Study of Ice Pile-Up	In Progress	\$ 100,000.	\$ 20,000.
125	Imperial	2	Experimental Ridge CRI Interaction 1976/77	Completed	\$ 100,000.	\$ 20,000
126	Imperial	7	Biological Review of Davis Straits	Completed	\$ 28,463.	\$ 3,557.
127 ⁽²¹⁾	Imperial	6	Davis Strait Biological Sampling Analysis and Observations	Completed	\$ 154,000.	\$ 15,400 Max.
128	Imperial	6	Davis Strait Pack Ice Studies 1976-1977	Completed	\$ 152,350.	\$ 13,850 Max.
129	Imperial	6	Davis Strait Ocean Current Measurements and Analysis 1976	Completed	\$ 270,000.	\$ 27,000 Max.
130	Dome	2	Design Studies of Production Structure for the Southern Beaufort Sea	Completed	\$ 81,000.	\$ 20,000.

AFOA Project No.	Operator	Current Number of Participants	Description	Status	Total Cost	Cost to Each Participant
131	Gulf	3	Feasibility Study of a Bottom Mounted Under Ice Profiling System (Phase I)	Completed	\$ 18,000	\$ 4,500
132	AFOA	-	Instrumentation of Drilling Fluid Sumps	Proposed	\$11	-
133	Gulf	3	Investigation of Sea-Bed Scouring in the Beaufort Sea (Phase III)	Completed	\$ 13,000	\$ 3,600
134 ⁽²⁰⁾	Imperial	6	Biological and Oceanographic Study - Davis Strait Area	Completed	\$ 366,000	\$ 34,100
135 ⁽¹⁹⁾	Imperial	6	1976 Biological Surveys - Davis Strait	Completed	\$ 74,500	Max. of \$12,500 per participant
136	Dome	4	Shoreline Study - Southern Beaufort Sea	In Progress	\$ 52,000	\$ 10,400
137	Dome	-	Tests of Ignition and Berdine Devices for Burning Oil on Ice, See APOA 141	Cancelled	\$ 26,500	-
138 ⁽²²⁾	Imperial	6	Davis Strait Environmental Program - Second Half 1977	Completed	\$1988,000	\$ 191,000 Max.
139	Gulf	-	Development Of An Ice Movement Monitoring System In The Beaufort Sea	Proposed	\$ 71,500	-
140	Imperial	2	Proposal To Conduct Davis Strait Pack Ice Incursion 1977-1978	In Progress	\$ 265,855	\$ 49,000 Plus Late Part Pen.
141	Dome	6	Ignition and Burning Of Crude Oil On Water Pools Under Arctic Spring Time Conditions	Completed	\$ 28,287	Proportional
142	Sun	3	Statistical Study of Late Winter Ice Thickness Distribution In the Arctic Islands from Seismic Data 1977	In Progress	\$ 13,000	Proportional
143	Imperial	1	Model Experiments to Determine The Forces and Behaviour of Moving Ice Floes Against	Completed	\$ 43,000	11,000 Max. Per Part.

ALCA Project No.	Operator	Current Number of Participants	Description	Status	Total Cost	Cost to Next Participant
144	Esso		Caisson retained island & ice ridge interaction studies.			
145	Esso		Design report for a caisson retained island	Completed	\$800,000	Max. \$200,000
146	Esso	Aquitaine Can-Cities	1978 Davis Strait Biological Program	In Progress		
147	Esso		Ice Keel Profiling in the Beaufort Sea	Proposed	\$64,000	
148	Esso	1	1978 Proposal to Conduct Studies of Continuous Crushing of Ice with a augmented Indentor.	In Progress		
149	Esso	1	Oilspill and Iceberg Studies conducted for preparation of an Environmental Impact Statement for Davis Strait.	In Progress		
150	Gulf Oil		Ice Scour model tests - Halder, S.I., - Frontier Research.	Proposed	\$137,500	Proportional (Min. 4 Partners)
151	Gulf Oil		Analysis of 1978 Beaufort Sea Side Scan Sonar records for sea bottom scouring	In Progress	\$ 20,000	
152	Gulf Oil		Beaufort Sea Permafrost Completions	Complete	\$ 38,000	
153	Esso		In Situ Gas Hydrates Survey	Proposed	\$ 16,000	
154	Gulf Oil		High Resolution Ice Tracking System - Beaufort Sea, Phases II & III. Buoy construction and deployment.	In Progress Ph. II	\$121,600	Equal share basis.
155	Esso		Davis Strait Pack Ice Characterization	Proposed	\$104,000	

APQA Project No. 1

Title: The Nutcracker Ice Strength Tests 1969-70

Purpose and Method: Special test devices were manufactured to simulate the interaction between a moving ice sheet and a cylindrical pile. The devices consisted of two tubular members about seventeen feet long which were hinged at the bottom and which could be pushed apart at the top by three hydraulic rams. Because of their principle of operation the devices were named 'Nutcrackers'.

Four Nutcrackers were used in the harbour at Tuktoyaktuk in the winter of 1969-70. They had been anchored in place in September and in January the first tests were conducted. A total of seven tests were conducted at various loading rates and ice thickness.

Brazil tests were also conducted on the harbour ice, samples of which were also collected for crystal structure studies.

Operator: Imperial Oil Limited

Consultants: Prof. B. Michel, Prof. J. B. Nuttall

Reports:

1. The Nutcracker Ice Strength Tests 1969-70 by K. R. Croasdale Imperial Oil Limited, IPRT-9ME-70.
2. The Nutcracker Ice Strength Tester and its Operation in the Beaufort Sea. K. R. Croasdale. IAHR Symposium, Reykjavik 1970.

Cost: \$166,790

May 15, 1972

APOA Project No. 2

Title: Beaufort Sea: Ice Movement and Current Survey - 1970

Purpose
and Method:

To measure fast ice movement under ice currents and physical properties of the ice at selected sites in the Southern Beaufort Sea.

To measure gross ice movement repeated surveys were made of fourteen selected sites between Herschel Island and Cape Bathurst. The surveys were made using a Cubic Autotape electronic positioning system. The surveys were made during the period March 6 to May 17.

At three sites, devices were installed to measure the rate of ice movement over certain time intervals. Inclometers were installed beneath the ice on taut wires connecting ice to the sea bed. The inclination of the wires and hence ice movement was measured and recorded for several minutes every six hours.

At five locations current meters were installed to measure currents below the ice.

At all the sites an ice sampling program was conducted. This consisted of measuring ice thickness, salinity and temperature profiles, small scale strength (brail), crystal structure and snow cover.

Operator: Imperial Oil Limited

Consultants: Oceanographic Services Inc., Canadian Engineering Surveys Co. Ltd., Prof. B. Michel.

- Reports:
1. The Beaufort Sea Ice Sampling Project - 1970, K. R. Crossdale, Imperial Oil Limited, IPRT-11ME-70
 2. Ice and Current Measurements Program Beaufort Sea, Spring 1970, Oceanographic Services Inc.
 3. Logistics Operations APOA Beaufort Sea Projects 1970 J. G. Smith, Imperial Oil Limited, IPRC-9MZ-70.

Cost: \$378,265.

August 1, 1975

APQA Project No. 1

Title: Ocean Floor Sampling Beaufort Sea 1970

Purpose and Method: To obtain preliminary data of the nature and properties of the sea bed sediments; to make a preliminary assessment of the suitability of the sediments for support of offshore structures, and construction of artificial islands.

During the period March 4 to May 16, 1970 eleven offshore bore holes were drilled between Herschel Island and Cape Bathurst. The bore holes ranged in depth from 72 to 233 feet below the ice surface. The sea bed was sampled to depths ranging from 60 to 100 feet.

The holes were drilled with a Heli Drill supplied and operated by Big Indian Drilling Co. Ltd. Samples were obtained with a 2 inch O.D. split spoon and with 2 inch diameter tube samplers. During sample recovery blow counts were recorded.

The recovered samples were subjected to standard soils testing.

Operator: Imperial Oil Limited

Consultants: Golder Brawner and Associates; Big Indian Drilling Co. Ltd.

Reports:

1. 1970 Bottom Sampling Program - South Coast of Beaufort Sea. Golder Brawner and Associates.
2. Logistics Operations APQA Beaufort Sea Projects 1970 J. G. Smith, Imperial Oil Limited. LPAC-942-70.

Cost: \$458,007.

August 1, 1975

APOA Project No. 4

Title: Geological Analysis of Ocean Floor Samples

Purpose and Method: The project consisted of studies of the palynology, micropaleontology, organic geochemistry, mineralogy and sedimentology of the sea bottom soil samples obtained at eleven locations in the Beaufort Sea during APOA Project 3. The project also included a study of ice and frozen soil samples from two locations by Dr. J. R. MacKay of U.B.C.

Operator: Gulf Oil Canada Limited

Consultant: Grant A. Bartlett - Queens University -
Stratocorp Limited

Reports:

1. "Geological Sampling and Analytical Program - Beaufort Sea" by M. M. Lerand, Gulf Oil Canada Limited, May 1971.
2. "Offshore Permafrost, Southern Beaufort Sea", by J. Ross MacKay, Department of Geography, University of British Columbia, February 1972.

Cost: \$11,757

May 15, 1972

APOA Project No. 3

Title: Study of Mackenzie Delta Tundra Disturbance

Purpose
and Method:

An investigation of the environmental effects of petroleum seismic activities in the Mackenzie Delta was to have been undertaken by Northerners through the Mackenzie Institute. Three local residents plus five advisers were to have been involved.

The work was commenced but due to a move away from the area by the principal investigator, no documentation was received. APOA is awaiting a memorandum from the Inuvik Research Center regarding the project. It is doubtful the project will be resumed.

Operator: APOA

Consultants: Mackenzie Institute

Reports: Nil to date

Cost: \$3,000 (\$1,500 paid to date)

APQA Project No. 7

Title: Cross-Country Vehicle Study

Purpose
and Method:

To evaluate, from an engineering concept, both wheel and special vehicles that are at the present time or may be considered in the future for Arctic and sub Arctic operation by the petroleum industry. Emphasis was placed on the Mackenzie River Delta under all climate conditions.

The study relates to the Engineering and operational aspects of the Surface Transport Equipment. Component designs, structural aspects, performance evaluation and all of the usual aspects related to equipment engineering were examined.

Operator: Gulf Oil Canada Limited

Consultant: J. E. Rymes Engineering Ltd.

Reports: "Preliminary Arctic Engineering Study of Surface Transport Vehicles" -
J. E. Rymes Engineering Ltd., December 1970

Cost: \$6,671

APCA Project No. 9

Title:

APCA Drilling Committee

Purpose
and Method:

The APCA Drilling Committee was formed early in 1970 to act as a technical advisory group on Arctic operating problems generally common to member companies who were, or expect to be, involved in drilling operations in the Arctic. The problems to be dealt with included well control and blowout prevention, safety practices, environmental control, construction, communications and navigation, transportation and other drilling operations. It was agreed that an "APCA Drilling Guide" would be used to publish the technology selected by the committee. Preventative maintenance and planning were to be stressed. Several bulletins were published in Oilweek. Forty bulletins were assembled into a single volume for distribution throughout industry and government.

As the scope of the drilling committee expanded and the need for funds became apparent, APCA Project No. 10 was initiated and funded by APCA members in proportion to their acreage holdings.

Operator:

APCA

Consultants:

Representatives volunteered by member companies and V. H. Hunter and Associates.

Reports:

"Arctic Drilling Operations Guide"

Cost:

Nil (See APCA Project No. 10)

APOA Project No. 2

Title: The Nutcracker Ice Strength Tests, 1970-71

Purpose and Method: To extend APOA Project 1 in order to obtain a better understanding of the parameters governing the interaction between moving ice and fixed structures.

The four Nutcracker test devices used in 1969-70 were again operated in Tuktoyaktuk Harbour. A total of three tests were conducted. Ice was collected from around the units for subsequent laboratory testing which included unconfined compression tests.

Following the Arctic tests a portable unit based on the same principle was made for tests on local lake ice. The aim being to generate a large number of results quickly and investigate such effects as the variation in ice pressure with rate of movement and size ratio. The portable unit required a hole to be cut in the ice sheet into which was placed the loading plates. The loading face was thirty inches wide and was moved by hydraulic rams up to twelve inches. Load and movement were measured and recorded during each test. Ice was again collected for subsequent classification and small scale testing.

Operator: Imperial Oil Limited

Report: The Nutcracker Ice Strength Test 1970-71 -
E. R. Crossdale, Imperial Oil Limited, IPRT-JME-71

Cost: \$60,000

APOA Project No. 11

Title: Mackenzie Delta Ornithological Study

Purpose
and Method:

To delineate important and critical nesting, moulting, gathering ground, staging and migration routes of the birds in the Mackenzie Delta region. The study area was later expanded to include the coastal region from Herschel Island to the Baillie Islands and north to the bird sanctuary of Banks Island. Field work was conducted in four stages to coincide with major changes in ornithological activities such as spring arrival, nesting, moulting and fall staging. The project started in June, 1970, and was completed in October of the same year. Throughout the study the Canadian Wildlife Service provided valuable advice and practical assistance.

All pertinent field observations were displayed on topographic maps on a scale of 1:125,000. The accompanying written report provides estimates of bird numbers and describes the habits of migratory and other species of birds that were observed. Some preliminary assessments of the potential impact of oil exploration and production on birds which utilize the study area are included.

Operator: Imperial Oil Limited

Consultant: Environmental Research Associates

Cost: \$7,660

May 15, 1972

APOA Project No. 12

Title: Feasibility Study of Exploratory Drilling in the Beaufort Sea

Purpose and Method: To develop preliminary structural designs and mode of operation for year-round and seasonal Arctic off-shore exploratory drilling concepts, to a stage where meaningful economic and operating evaluation is possible. The study area was confined to within the 200 ft. isobath, stretching east-west from Cape Bathurst to Herschel Island, encompassing therefore, both polar pack ice and shore-fast ice.

The project was started in November 1970 and was completed in October 1971. Design criteria were developed for eight design zones within the study area, each assigned a set of criteria for ice design and foundation design, using all available field information on soils, ice and sea conditions published as well as those generated by other APOA projects. Conceptual candidates, bottom-founded and floating, were screened and the most promising were evaluated further.

In the first part of the study some 59 alternate designs for year-round concepts were developed and seven seasonal concepts were considered. In the case of year-round concepts, preliminary designs for concepts were provided together with fairly comprehensive cost estimates for concepts, ancillary and support units such as dredges, derrick barges, supply boats, etc. Also considered were methods of construction, logistics problems and preliminary schedules for final design and construction, transportation and operations. Problems of mobilizing a major structure in the Arctic or round Point Barrow and those of Arctic field construction were investigated. A study of summer ice and summer sea conditions enabled an estimate to be made of the number of days available for field construction in any part of the study area.

In the second part of the study a more detailed study was performed on a conical structure for a maximum water depth of 120 ft. A detailed cost estimate was worked out to include all charges for design, construction, towing, insurance and ancillary equipment.

Operator: Imperial Oil Ltd.

Consultant: Acres/Santa Fe Powerco Arctic Services

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- 2 -

Reports: Feasibility Study Exploratory Drilling in the Beaufort
Sea, Volumes I and II - October 1971, Acres/Santa Fe
Pomeroy Arctic Services

Cost: \$176,488.

August 1, 1975

APDA Project No. 13

Title: Arctic Drilling Barge Study

Purpose and Method: Evaluate the technical and economic feasibility of using a floating drilling barge for exploratory oil drilling in the Southern Canadian Beaufort Sea.

The first part of the project consists of a hindcast study of wind and wave conditions. As wind measurements for offshore locations are practically nonexistent, winds for a period of 15 years for the summer months were calculated from weather maps, and waves calculated from those winds and fetches. The report gives statistical analysis of winds speed, direction and duration and waves height, direction, period and duration for five different locations in the area.

The second part of the project being a study of the feasibility of using a barge for exploratory drilling in the area, includes a statistical study of ice conditions, a general design of the barge, support vessels, base camp, with possible construction schedule and cost estimate.

Operator: Elf Oil Exploration and Production Canada Ltd.

Consultants: Institute for Storm Research, Houston, Texas; Westburne-Foundation-Sedco, Calgary, Alberta

Reports:

1. "Arctic Drilling Barge Study", Westburne-Foundation-Sedco, June, 1971.
2. "Winds, Waves, and Storms in the Southern Beaufort Sea", Dr. John C. Freeman, Institute for Storm Research, Volumes I, II, and III, January, 1971.

Costs: \$134,601.00 (excluding report costs)

April 22, 1975

APOA Project No. 14

Title:

Beaufort Sea Summer Ice Study

Purpose
and Method:

1. Objective:

To study ice conditions in the Beaufort Sea and gain an understanding of operating conditions in the open water season.

2. Data Collected

- a) Thirteen flows were studied from Herschel Island to Pullen Island. Data collected included flow size, ice compression and Brazil strengths, salinities, temperatures and description.
- b) Photographs of ice conditions from Herschel Island to Pullen Island.
- c) Aerial photographs of ice conditions from Herschel Island to Kay Pt.
- d) Results of a reconnaissance flight from Kowak North to 71° Lat., West to 134° Long., and South to Tuktoyaktuk.
- e) Observations of freezeup processes.
- f) Meteorological data at various locations.
- g) Logistics of operation.

Operator:

Amoco Canada Petroleum Company Ltd., - 12 participants.

Report:

"Beaufort Sea Summer Ice Study"
K. G. Kolts and R. R. G. Scott, Amoco Canada Petroleum Company Ltd., 1971

Cost:

\$18,670

June 10, 1973

APOA Project No. 16

Title: Theoretical Analysis of Ice Failure

Purpose and Method:

1. To provide a theoretical model for the problem of interaction between an ice sheet and a pile.
2. To perform small scale laboratory tests on ice samples from the Nutcracker field test sites.

For the theoretical model the ice is assumed to be an isotropic ideal elastic-plastic material. Solution to the indentation problem is obtained using upper and lower bound limit theorems. Solutions have been obtained for both flat and cylindrical indenters for various degrees of roughness.

Unconfined and plane strain compression tests have been carried out on fresh water ice. In all cases the load was applied in the plane of the natural ice sheet. Unconfined specimens measured 4" x 4" x 8" and plane strain specimens 2.5" x 6" x 12". Tests were carried out at various strain rates in the range 10^{-3} to 10^{-1} secs⁻¹, and at two temperatures -1.5°C and -10°C.

Operator: Imperial Oil Limited

Consultants: Professors N. R. Morgenstern and J. B. Nuttall
(U of Alberta)

Reports:

1. The Interpretation of Ice Strength from In-Situ Indentation Tests, N. R. Morgenstern and J. B. Nuttall, March 1971.
2. Compression Tests on Fresh Water Ice, J. B. Nuttall and N. R. Morgenstern.

Cost: \$10,000

May 15, 1972

APOA Project No. 28

Title: Biological Effects of Oil in Arctic Seawater

Purpose and Method: To study the effects of oil in arctic seawater and in particular to:

- (1) measure the rate of bacterial degradation of oils,
- (2) determine the effect of oil on primary productivity and inshore benthos,
- (3) measure the effect on the intertidal zone.

The first year was spent in working in cooperation with the Fisheries Research Board at Halifax on the Canadian east coast. It is proposed that the second phase will involve measurements in the Beaufort Sea area around the Mackenzie Delta.

Operator: Imperial Oil Limited

Consultant: Dr. Max Dunbar, Marine Sciences Centre,
McGill University

Report: Progress Report - Oil in Arctic Seawater program.

Cost: \$17,250

May 15, 1972

APOA Project No. 29

Title: Habakkuk - Investigation of Research on Artificial Ice Island

Purpose and Method: The purpose of this project was to review the NRC files and summarize the pertinent data from research done towards construction of ice islands for use as wartime aircraft carriers. The investigation was undertaken by Imperial Oil but, due to administrative policies at NRC, it was necessary for the release of the summary to come through proper government channels. NRC will make the report available to APLA members.

Operator: Imperial Oil Limited

Consultant: -

Cost: \$600

May 15, 1972

APOA Project No. 30

Title: Beaufort Sea Exploratory Drilling Systems

Purpose

and Method:

To determine a most suitable drilling exploratory system for the Beaufort Sea.

Two drilling feasibility studies based on existing environmental data for the Beaufort Sea, resulted in different exploratory drilling systems. To assist in resolving a most suitable system, two experienced offshore operators reviewed the existing data and studies, and presented their recommended exploratory drilling system and associated costs.

Operator: Gulf Oil Canada Limited

Consultants: Global Marine Inc., Los Angeles, California
SEDCO Inc., Dallas, Texas

Reports:

1. "Beaufort Sea Exploratory Drilling System" Westburne - SEDCO, December, 1971.
2. "Study of Beaufort Sea Exploratory Drilling Systems", Global Marine Inc., December, 1971.
(Reports restricted to participants)

Cost: \$33,303.00

May 30, 1975

APCA Project No. 31

Title: Aerial Reconnaissance of Ice, Beaufort Sea 1971

Purpose and Method: To sample typical summer ice conditions in the Beaufort Sea by aerial reconnaissance.

The study consisted of three reconnaissance flights, two conducted in July and one in November, 1971. The first flight path was due north of Herschel Island to a turnaround point 88 miles out. In November, fog and cloud hampered the flight, but ice conditions were recorded north of Hooper Island and in Mackenzie Bay.

A Twin Otter was used for the flights during which a trained surveyor used an aerial camera to record ice floe sizes and concentration. Conventional photography was used to provide a descriptive record of the ice.

Operator: Imperial Oil Limited

Reports:

1. Ice Reconnaissance Flight from Herschel Island, July 17, 1971. L. G. Spedding. Imperial Oil Limited Laboratory Report.
2. Ice Reconnaissance Flight from Hooper Island, July 17, 1971. L. G. Spedding. Imperial Oil Limited Laboratory Report.
3. Ice Reconnaissance Flights from Herschel Island and Tuktoyaktuk, November 14, 1971. L. G. Spedding. Imperial Oil Limited Laboratory Report.

Cost: \$7,585.

August 1, 1973

APMA PROJECT NO. 32

Title: Beaufort Sea Scour Records - Phase II

Purpose

and Method: To study all aspects of sea bottom scouring in selected areas of the Beaufort Sea.

A mosaic of a control area surveyed by the Canadian Government in 1971 was constructed from Side Scan Sonar Records. An attempt was made to resurvey this area in 1972 using Side Scan and Echo Sounders and one additional area was similarly surveyed. Mosaics of these areas were constructed. During future projects they will be analyzed to determine the number of new scours added. All data recorded after 1970 was incorporated into a revised analysis to replace that done during APMA Project 19.

Operator: Gulf Oil Canada Limited

Consultant: Hunting Geology and Geophysics Limited, Boreham Wood, Herts England.

Report: "Investigation of Sea-Bed Scouring in the Beaufort Sea (Phase II) by Hunting, February 1973 (Report restricted to Participants)"

Cost: \$19,236

Table of Contents: Attached

July 1, 1974

152

APOA PROJECT NO. 11

Title: Land Fast Ice Movement - Beaufort Sea 1971-72

Purpose and Method: To measure movement of the fast ice at ten locations just north of Richards Island in the Mackenzie Delta.

Simple mechanical devices have been built which measure the distance between a point on the ice and the sea bed below. These devices can be read manually by visiting the sites or remotely via a telemetry system from Inuvik. The mechanical device consists of a spring loaded reel connected by a measuring tape to an anchor through a tube in the ice which contains a non-freezing fluid.

Of the ten sites installed, 5 are read manually and 5 are remotely interrogated via the V.H.F. matrix. The sites were installed in January. Some were removed at the end of April, the remainder were removed in late May. For most of the period the telemetered sites were interrogated once a day. In addition to ice movement other parameters measured include wind speed and direction, ice temperature, air temperature, cabinet temperature and battery voltage.

The water depth range for the sites is 7 to 10 feet.

Continuation of this work is proceeding as APOA Project No. 51.

Operator: Imperial Oil Limited

Report: Landfast Ice Movement - Mackenzie Delta 1972 by K. R. Crossdale and L. G. Spedding, IPRT-SME-72.

Cost: \$90,000 (Total). Maximum participation fee is \$7,000

March 15, 1973

APNA Project No. 34

Title: The Northern Resources Research Project

Purpose and Method: Study of the actual and potential economic benefits of oil, gas and minerals to northern settlements.

Systems analysis of the economics of resources in the north, the contribution they are making to northern livelihood and ways of increasing this contribution. Analysis of labour requirements and skills locally available. The study will be primarily based on the collection and interpretation of existing data.

Operator: APNA

Consultant: The Boreal Institute for Northern Studies
Dr. J. J. Lord - The University of Alberta

Reports: "Northern Oil and Gas Production Related Employment Opportunities: The Impact of Mackenzie Delta Production."

Cost: \$ 25,000

July 1, 1976

167

ADDA PROJECT NO. 15

Title: Environmental Study of the Baffin Bay - Davis Strait Region

Purpose and Method: To present existing environmental data of the Canadian portion of the Baffin Bay - Davis Strait Region in a format suitable for use in planning exploration and development activities in this frontier region.

All existing environmental data was studied by Maren and summarized in useful charts and diagrams. In addition, an observer was placed aboard a seismic vessel working in the area in the summer of 1972. This data added significantly to the limited amount of quantitative data available and forms an important part of the report.

Operator: Gulf Oil Limited

Consultant: Marine Exploration Limited, Cowes, Isle of Wight, England.
Marine Environmental Services Limited, Calgary, Alberta

Reports:

- 1) "Preliminary Report - Environment Conditions in Northern Baffin Bay", Marine Exploration Limited.
- 2) "Wind, Waves, Weather, and Icebergs in Baffin Bay and Davis Strait Summer 1972", Marine Environmental Services Limited.
- 3) "Environmental Conditions in Baffin Bay and Davis Strait Including Presentation of Data collected during summer 1972" Marine Environmental Services Limited.

Cost: \$42,459

Table of Contents: Attached for #1 and #2

July 1, 1974.

158

26
394

APOA Project No. 17

Title:

Arctic Environmental Research
Tundra and Ecological Studies on the Mackenzie Delta
and Devon Island

Purpose
and Method:

A. Mackenzie Delta Region Research

From 1970 through 1972 a series of studies was conducted to determine various impacts of petroleum development (gas and oil exploration and gas pipeline-lining) on vegetation and the ability to rehabilitate disturbed land surfaces.

The research was jointly funded by the Arctic Land Use program (ALUR) of the Department of Indian and Northern Affairs and member companies of the Arctic Petroleum Operators Association (APOA) in Calgary. The fire and oil spill studies were funded by industry and an NRC operating grant. Total costs of the project were \$207,300. \$67,400 provided by ALUR, \$122,900 provided by APOA member companies and \$17,100 from university monies.

Much of the research was co-ordinated by Dr. Ross W. Wein, then an NRC Post-Doctoral Fellow and he conducted several of the studies. Two Research Associates, one Ph.D., and 3 M.Sc. researchers were trained via the project.

B. Devon Island Research (High Arctic Productivity and Manipulation Study)

The major objectives:

1. To determine, through integrated, multidisciplinary research, the system's efficiency in capturing and utilizing energy.
2. To determine the environmental limiting factors on the growth and development of key animals and plants.
3. To develop predictive models of population numbers and standing crop for the major biological components of the Truelove Lowland.
4. To determine the limits of degrading and restoring plant-soil portions of the system by various manipulations.

APDA Project No. 38

Title: APDA - DIAND Transportation Study

Purpose and Method: To obtain an evaluation between track vehicles and wheeled vehicles during summer operations.

Operator: APDA (Environmental Committee)

Consultants: AILR

Reports:

1. "Immediate Effects of Wheeled Vehicle Traffic on Tundra During the Summer" by J. R. Radforth, IAND Publication No. QS-3033-000-EE-A1.
2. "Long Term Effects of Summer Traffic by Tracked Vehicles on Tundra" by J. R. Radforth, IAND Publication No. QS-1522-000-EE-A1.

Cost: Logistic support by companies participating in this study.

396
396
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July 1, 1974

APOA PROJECT NO. 39

Title: Arctic Offshore Pipeline Feasibility Study

Purpose

and Method:

To determine the technical feasibility of installing pipelines offshore Mackenzie Delta to the 15 ' water depth contour. Estimates of installation costs are to be provided in order to establish economic feasibility. Lay-barge, Pull, and Reel-barge pipelaying methods are to be considered; limits of technical applicability for each method are to be established and problems identified.

Thermal effects of the pipeline will be examined and adequate measures to prevent melting of any existing offshore permafrost will be considered. The study will analyze available scour information, evaluate risk and determine pipeline burial requirements and costs. Trenching techniques form an important aspect of the study.

The project is essentially a feasibility study of Arctic offshore pipelines and not a detailed design for a specific line and route. Although certain specific factors in a specific area are being considered, the range of conditions in which a specific recommendation might apply will be given. The sensitivity of any recommended pipeline installation technique to changes of conditions will be indicated.

Operator:

Imperial Oil Limited

Consultant:

K. J. BROWN & Associates (Rotterdam, Netherlands),
Pecan Services, Calgary, Alberta

Report:

Arctic Offshore Pipeline Feasibility Study in Mackenzie River Delta Area, by K. J. Brown & Associates, February 1973.

Cost:

\$75,000

APDA Project No. 40

Title: Evaluation of Mechanical Properties of Saline Model Ice

Purpose
and Method:

To examine how the mechanical properties (mainly modulus of elasticity and strength) of saline model ice can be adjusted by varying salinity and temperature. The repeatability of the properties is also to be examined.

A series of experiments has been designed to demonstrate the capability to produce proper model values of modulus, bending strength and the modulus to strength ratio.

During the course of the experiments elastic modulus, bending strength, compression strength and shear strength will be carefully measured. These properties will be obtained for various cases of ice salinity, air temperature and ice thickness.

The work is proceeding at ARCTEC'S model basin.

Operator: Imperial Oil Limited

Consultant: ARCTEC Inc., Columbia, Maryland

Reports:

1. Results of Model Ice Sheet Properties Research. ARCTEC Inc. July, 1972.
2. Addendum to Final Report for APDA Project 40 ARCTEC Inc. October, 1972.

Cost: \$19,800

August 14, 1974

APOA PROJECT NO. 41

Title: Evaluation of the Mechanical Properties of Michel's Model Ice and Preliminary Ice-Structure Interaction Experiment

Purpose: To systematically determine the important physical properties of a model ice material, determine if the properties may be improved by altering the composition of the material, and determine the effect on the properties by externally controllable variables.

Method:

- (1) To determine the Physical Properties of a Model Ice Material
 - (a) Variation of Material Composition - to determine the optimum composition of the model ice material.
 - (b) Variation of Temperature - to determine the effect temperature fluctuations will have on the model material's strength properties.]
 - (c) Variation of Plate Thickness - to determine if the thickness of the material effects the strength properties.
 - (d) Variation of Time to Failure - to determine the effect of loading rate on the strength properties of the material.
- (2) To determine, by model tests, the horizontal forces a uniform ice sheet can exert on cylindrical and conical shaped structures.

Operator: Amoco Canada Petroleum Company Ltd. - 10 participants.

Reports: "The Use of Model Ice to Simulate Ice Action on Offshore Structures" Dr. B. Michel

Cost: \$7,000

June 10, 1975

AIOA PROJECT NO. 42

Title: Mackenzie Delta Gravel Inventory

Purpose
and Method:

The proposed study includes a review of all available pertinent geological reports and maps, including relevant USC data to obtain:

1. Best estimates of probable quantities of materials in absence of field drilling and testing;
2. Appraisal of quality of materials from a commercial-use standpoint;
3. Discussion of problems of development along with alternate methods of development;
4. Location of places to field test and suggestions for procedures for field testing.

Operator: Imperial Oil Limited

Consultants: J. D. Mollard & Associates Limited,
Regina, Saskatchewan

Reports: Gravel Inventory Survey
Richards Island and adjacent areas

Cost: \$16,500

APOA PROJECT NO. 43

Title: Environmental Impact Assessment Program - Mackenzie Delta

Purpose and Method: To assess the impact, on the local ecosystems, of construction and operations of hydrocarbon development facilities in the Taglu - Richards Island Area.

Where necessary, the base inventories of the present elements of the environment will be made. The elements include: wild-life, fisheries, vegetation, soil, air, water and climate. Complementing this will be an estimate of current human utilization of the resources and an estimate of potential productivity of the study area.

A comprehensive projection of the type and extent of environmental impact, caused by petroleum development (as conceived by the operator), will be prepared at the conclusion of the study.

Operator: Imperial Oil Limited

Consultant: F. F. Slaney & Co. Ltd.
Vancouver, British Columbia

Reports: 1972 Environmental Field Program
Taglu - Richards Island, Mackenzie Delta
by F. F. Slaney & Co. Ltd.
(Report in 7 parts)

Cost: \$648,000

AFSA PROJECT NO. 45

Title: Arctic Clothing Study

Purpose
and Method:

This project is a continuation of Project No. 24. It is focussed on body protection, although some improvements on the army face masks have been tested at the same time.

Eight types of commercial parka and three types of military outfit have been tested in a laboratory for both behaviour and properties under Arctic conditions, and resistance to tearing.

From the laboratory tests, two types of commercial parka were chosen and tested in the field along with the military outfits. Field tests were conducted by having drilling and seismic crew personnel wear the clothes during their normal work and observing their behaviour and recording their comments.

Laboratory and field test results are included in the final report.

Operator: CIL Oil Exploration and Production Canada Ltd.

Consultant: Defence Research Establishment of Ottawa

Report: Final Report dated July 1973:
"A Study of Arctic Clothing for Oil Operating Crews."

Composite Report dated January 1974:
CIL CPEO Report No. 45
"A Study of Arctic Clothing for Oil Operating Crews."

1. CIL Technical Memorandum No. 134 (NBO)
Laboratory Testing of Commercial Arctic Clothing
Submitted to the Arctic Clothing Task Committee
1973

2. CIL Technical Memorandum No. 134
Arctic Clothing

Cost: \$19,350

APCA Project No. 46 (a)

Title: Photo Reconnaissance in Beaufort Sea

Purpose
and Method: On April 9, 1972, Northwest Survey Corporation in
Edmonton carried out continuous photographic work
in the Beaufort Sea as shown on attached map.

594 mi. at 10,000 ft.
photo scale: 1 inch = 1,667 ft.
123 mi. at 5,000 ft.
photo scale: 1 inch = 834 ft.

Operator: Sun Oil Company Limited

Consultant: Northwest Survey Corporation
Edmonton, Alberta

Report: Mosaic covering area outlined on map

Cost: \$12,600. + Photographs

APOA PROJECT NO. 46(b)

Title: Photo Reconnaissance in Arctic Islands

Purpose
and Method: On April 2, 1972, Northwest Survey Corporation of Edmonton carried out continuous photographic work in the Arctic Islands, as shown on attached map.

870 mi. at 10,000 ft.
photo scale: 1 inch = 1,667 ft.

47 mi. at 5,000 ft.
photo scale: 1 inch = 834 ft.

Operator: Sun Oil Company Limited

Consultant: Northwest Survey Corporation
Edmonton, Alberta

Report: Mosaic covering area outlined on map

Cost: \$21,103 + Photographs

July 1, 1975

APOA Project No. 47

Title: Ice Chipper Evaluation Test

Purpose
and Method:

The Conduct of conventional seismic operations on the ice of the Arctic marine areas is greatly impeded by the rough surface of ridged and rafted sea ice. An order of magnitude cost reduction should be possible in a large offshore ice seismic program by the development of an ice chipper. By reducing ice obstacles to chips or small pieces, the ice chipper will prepare a route for the more conventional tracked and wheeled seismic vehicles and equipment.

A prototype was tested near Edmonton and in the Arctic Islands. Design modifications and improvements have been suggested in the final Engineering Report.

Operator: Sun Oil Company Limited

Reports:

1. Progress Reports #1 and #2
2. "Ice Chipper for Road-Cutting on Sea Ice"
January, 1974 John D. Bennett, Sun Oil Company
Production Research Development

Cost: Shared Costs . . . \$42,000.

July 1, 1975

APDA PROJECT NO. 48

Title: Documentation of Vehicular Traffic on Mackenzie Delta
Tundra - 1972, Freeze-Up and 1973 Thaw

Purpose
and Method:

This Mackenzie Delta study evaluated the use of a Polligon vehicle and other vehicles for preparation of road surfaces and movement of equipment at the earliest date during freeze up and the latest date during the spring thaw with least disturbance of the tundra surface. The consultant (a) evaluated the suitability of ground conditions by commencement of traffic (b) observed traffic operations (c) prepared descriptions of the terrain conditions (d) kept records of the weather conditions, snow depths, and ground surface frost (e) observed and reported on two selected traffic operations in the Delta which could benefit from extension of operations into the thaw season (f) prepared illustrated reports on the various aspects of the operation and evaluated the effects of the vehicle traffic on the terrain surface.

Operator: Gulf Oil Canada Limited

Consultant: Muskeg Research Institute at the University of New Brunswick.

Reports:

- 1) "Inspection of Winter Roads, Mackenzie Delta, Following Spring thaw, 1973" by Muskeg Research Institute, August 1973.
- 2) "Winter Road Preparation and Commencement of Traffic in the Mackenzie Delta" by M. R. I., November 1972.
- 3) "Factors Affecting Use of Winter Roads During Spring Thaw" by M. R. I., May, 1973.

Cost: \$15,355

Table of
Contents: Attached

APOA PROJECT NO. 49

Title: Study of Arctic Transportation Equipment - Mackenzie Delta

Purpose and Method: The purpose of the study was to evaluate the effectiveness of the equipment being utilized for rig moves and logistic operations in the Mackenzie Delta.

In general, the report examines in some detail the type and mix of equipment being utilized in northern operations, studies the problems and failures of the equipment and discusses possible methods of resolving the problems including improved maintenance techniques and design improvements. In addition, the study reviews and discusses potential uses of new equipment and more effective uses of existing equipment.

Operator: Gulf Oil Canada Limited

Consultant: J. E. Rymes Engineering

Report: "Arctic Winter Evaluation Study of Transportation Equipment"
J. E. Rymes Engineering Limited, July, 1973.

Cost: \$10,034

Table of Contents: Attached

July 1, 1974

APCA Project No. 50

Title: Ice Thickness Measurement

Purpose and Method: To measure the thickness of sea ice under varying conditions of salinity, thickness, age, snow cover, and to measure the effect of the ice-slush-water interface beneath the ice. The depth of penetration, accuracy and resolution of the technique, and calibration requirements were determined. Ground truth was obtained by coring and by augering holes for calibration of the measurements.

Operator: Sun Oil Company Limited

Consultant: Geophysical Survey Systems Inc.

Report: "Sea Ice Thickness Determinations Using
Electromagnetic Subsurface Profiling"
April, 1973 A. Orange et al
Geophysical Survey Systems Inc.

Cost: \$27,900

July 1, 1975

ARPA Project No. 51

Title: Ice Movement in Beaufort Sea 1972-73

Purpose

and Method:

To measure the magnitude direction and rate of movement of the near shore ice in the Mackenzie Delta area of the South Beaufort Sea.

Simple mechanical devices have been built which measure the distance between a point on the ice and the sea bed below. The mechanical device consists of a spring loaded reel connected by a measuring tape to an anchor through a tube in the ice which contains a non-freezing fluid. These devices can be read manually by visiting the sites or via a telemetry and telex system from Calgary. Interrogation is automatically carried out every hour and the data stored on punched tape for processing. At several sites chart recorders are installed so that continuous movement characteristics are monitored.

In addition to ice movement the following measurements are also made: wind speed and direction, ice temperature, air temperature, and tidal state.

A total of 15 sites will be installed in the 10 to 80 ft. water depth range.

Operator: Imperial Oil Limited

Report: Land Fast Ice Movement - Mackenzie Delta 1972-73 L. G. Spedding
Imperial Oil Limited Laboratory Report

Cost: \$237,525 (Total): Maximum participation fee is \$20,000.

August 14, 1974

AP . Project No. 52

Title: Crushing Strength of Ice

Purpose
and Method:

- (1) To establish the effect of the size ratio (D/t) on the crushing strength of ice by means of field tests.
- (2) To correlate the field test results with the mechanical properties of ice determined from small scale ancillary tests.
- (3) To determine the effect of indenter shape on the crushing strength - flat and circular indenters will be tested.
- (4) To determine the effect of adhesion between the ice and the indenter on the crushing strength.
- (5) To determine the effect of strain rate on the crushing strength.

A portable hydraulic test device will be used to measure the crushing strength of ice. The tests will be performed on a lake near to Calgary. A rectangular hole will be cut into the ice, the device lowered into the hole and the load face will be forced into the edge of the ice sheet by the hydraulic cylinder(s). For each test the hydraulic pressure and load face displacement will be recorded continuously. The temperature distribution through the ice and the air temperature will also be recorded.

The test device is similar in principle to that used in the latter part of APOA Project 9, however this one is much bigger. Five loading face sizes will be used; 1 ft., 2 ft., 4 ft., 8 ft., and 12 ft. Two hydraulic cylinders are to be used and they can develop a total of about 2,000 tons. The tests commenced in January 1973 and were completed in April.

Operator: Imperial Oil Limited

Consultants:

1. FENCO
2. J. B. Nuttall and N. R. Morgenstern, University of Alberta, Edmonton.

Report:

1. Small Scale, In-situ Ice Strength Tests, March 1973. Foundation of Canada Engineering Corporation Limited.

- 2 -

Reports:

2. Ice Forces on Offshore Monopods and Piles, September 1973. Foundation of Canada Engineering Corporation Limited.
3. Ice Crushing Tests 1973 - July 1973. T. P. Taylor. Imperial Oil Limited Laboratory Report.
4. Compression Tests on Fresh Water Ice, 1973 - June 1973. J. B. Nuttall, University of Alberta

Cost:

\$145,873. (Total): Maximum participation fee is \$18,334.

August 1, 1975

411
~~776~~

APCA Project No. 22

Title: Count of Ice Islands - Beaufort Sea 1972

Purpose
and Method:

Better knowledge about the size and distribution of ice islands from year to year is needed to help in decisions concerning methods of exploration and development in the offshore provinces. The work covered in this report is a start in the process of collecting yearly counts of ice islands along the coast of the South Beaufort Sea.

In May 1972, an aerial reconnaissance flight was made along the shear zone between Cape Bathurst and Cape Melville. The object of the flight was to record the number and size distribution of the ice islands grounded or trapped in the fast ice of the South Beaufort Sea. A total of 477 aerial photos were taken, these have subsequently been scrutinized. The report presents ice island frequency versus water depth and size for individual legs of the flight.

Operator: Imperial Oil Limited

Report: Ice Island Count, South Beaufort Sea, 1972
by E. Burton, K. R. Croweale, H. Hestink and J. G. Smith.
Imperial Oil Report IPR-104-72.
(Report restricted to Participants)

Cost: \$11,370. (Total)

August 1, 1973

A.P.O.A. PROJECT #54

TITLE: Ice Geology of the Southern Beaufort Sea

PURPOSE: To conduct an air photo reconnaissance study of ice conditions in the Southern Beaufort Sea. The objective of the study is to secure essential information on field ice conditions in the winter, describing and, where possible, quantifying ice features relevant to the design of offshore drilling systems, both fixed and floating and to the problem of over the ice transportation and logistics.

A topographical mapping study by means of aerial photo reconnaissance will be undertaken to investigate statistical and spatial aspects of typical ice features, such as landfast ice, transition zone, shear zone (open leads), winter pack, pressure ridges, and ice islands, along a number of traverses running offshore to the pack ice in an area from Cape Dalhousie to Shallow Bay. Additional reconnaissance flights will be made from Cape Bathurst to Herschel Island. Satellite photographs will be used where applicable. Some ice movement calculations may be possible.

OPERATOR: Imperial Oil Limited

REPORT:

- (1) The Extent and Growth Pattern of Land Fast Ice in the Southern Beaufort Sea - Winter 1972-73, April, 1974. L. G. Spedding, Imperial Oil Limited Laboratory Report, IPRT 2-ME-74.
- (2) Ice Island Count-Southern Beaufort Sea - 1973. L. G. Spedding, Imperial Oil Limited Laboratory Report, IPRT 21-ME-74.
- (3) Statistical Analysis of Ice Pressure Ridge Distribution in the Southern Beaufort Sea - R. W. Gladwell, Imperial Oil Limited Laboratory Report, IPRT 13-ME-76.

COST: \$50,000

February 28, 1977

APOA Project No. 55

Title:

Arctic Environmental Research 1973 (Devon Island IBP Project)

Purpose and Method:

The main purpose of this project was to provide financial and in-kind assistance by APOA member companies to the Devon Island Research Project to complete field studies during 1973. The study was initiated in May 1970 with field work conducted each summer through 1973. In addition a group of six people overwintered in 1972-1973 to gather meteorological data and to study muskox activity. In 1971-72 Dr. R. R. Rieve, his wife, and small boy lived much of the winter with the native people at Crise Fiord, Ellesmere Island. They also spent the summer, and fall of 1972 with these people, learning from them their hunting, fishing, and handy craft ways. Dr. Rieve was basically studying how these people live off the land and the sea, and the economic costs and benefits derived from their livelihood.

Another related study was conducted in part in the Truelove Lowland but mostly elsewhere on the impact of northern development. This consisted of determining changes in depth of the active layer, soil temperature changes, and the general rates of plant reestablishment following the use of off-road vehicles and abandonment of well and camp sites. Research was also conducted on the use of fertilizer to stimulate plant growth and the effect of spilling diesel fuel on vegetation.

In total about 80 people worked on Devon over the four years. This amounted to 26 people and 52 man-months in 1970, 48 people and 105 man-months in 1971, 56 people and 118 man-months in 1972, and 38 people and 91 man-months in 1973. The latter figure includes the winter man-months for the 6 people. Of the supervisors of the research studies (17) 13 have spent time in the field either conducting their own research or working with their students. These completed or nearing completion include 3 MSc, 10 Ph.D, and 7 others have held Postdoctoral Fellowships.

The research has had direct costs of \$1,219,000 of which federal agencies (NSC-IEP, NSC-operating and equipment grants, Department of Environment, Department of Indian and Northern Affairs, and Energy Mines and Resources 0 (FCSP) have provided \$904,000, 22 oil and gas companies and consortia have provided \$228,000, Arctic Institute of North America \$43,000,

APOA Project No. 17

Title: Beaufort Sea Pressure Ridge and Ice Island Scouring

Purpose
and Method:

To investigate the geometry, composition, ice strength and other pertinent properties of four multi-year pressure ridges and one single year pressure ridge and to investigate the scouring effects of one ice island in the Beaufort Sea. It was necessary beforehand to confirm the feasibility of using an air cushion vehicle in connection with the study, and do aerial reconnaissance to locate suitable study areas.

Multi-year pressure ridges at four sites were investigated in detail using ice coring and sonar profiling. Divers also investigated the underwater portions of the ridges and obtained photographs and soil samples. Ice strengths, salinities and temperature profiles were determined on the site. The ice and soil samples were further investigated in laboratories. A grounded ice island was examined by sonar profiling and divers. The trenches were photographed and soil samples obtained.

Operator: Gulf Oil Canada Limited

Consultants: A. Kovacs, B.Sc., Civil Engineering, New England College.
M. Mellor, D.Sc., Melbourne University, Australia
J. B. Nuttall, University of Alberta

Reports:

1. "Sea Ice Pressure Ridges and Ice Islands" - CREARE, Inc., August 1971.
2. "Sea Ice Tests" - J. B. Nuttall, University of Alberta, October 1971.
3. "Micropaleontologic - Mineralogic Analysis of Recent Mud Samples from Ice-Scored Bottoms of Beaufort Shelf" - M. M. Borland, Gulf Oil Canada Limited, October 1971.
4. "Evaluation of Hovercraft and Ice Reconnaissance" - J. Hnatuk, Gulf Oil Canada Limited, March 1971.

Cost: \$102,472

May 15, 1972

APOA Project No. 19

Title: Analysis of Sea Bottom Iceberg Scouring Records

Purpose
and Method:

Copies of 1970 Beaufort Sea side scan sonar, echo sounding and shallow seismic records were purchased for detailed analysis. The results will indicate depth to which wellheads and pipelines must be buried to avoid damage.

Records were analyzed for scour free depth, width, azimuths and dependence on width.

Operator: Gulf Oil Canada Limited

Consultant: Hunting Geology and Geophysics Ltd., Boreham Wood, Herts, England.

Reports: "Investigation of Sea-Bed Scouring in the Beaufort Sea" - Hunting Geology and Geophysics Ltd., November 1971.

Cost: \$16,329

May 15, 1972

APDA Project No. 20

Title: APDA Recommendations to DIAND on Arctic Drilling Regulations and Preparation of Arctic Petroleum Operators Guide

Purpose and Method:

The major purpose of this project was to provide recommendations to DIAND regarding casing requirements, cementing techniques and blowout prevention, following a request from Dr. H. W. Woodward for such assistance. A second purpose was to provide funding for preparation and publishing of the "APDA Drilling Guide" undertaken by the APDA Drilling Committee.

A consultant was retained to assist with design and construction of a blowout prevention training facility near Devon, which is now operative. APDA helped obtain the necessary funding and reviewed the training program.

Expenses involved in preparation and publication of the Drilling Guide Bulletins were paid by this project.

Due to the fact that the costs for a permafrost cementing study were found to be prohibitive, it was decided that a more practical use of the funds in Project 20 would be to partially fund work being done by joint government industry groups working on developing guidelines for Disposal of Drilling Fluids.

Operator: APDA

Consultants: Representatives volunteered by member companies
V. H. Hunter & Associates

Reports: Bulletins published in Oilweek
"Arctic Drilling Operations Guide"

Cost: \$ 3,151.07
25,246.51 transferred to joint government industry groups working on Disposal of Drilling Fluids
228,500.00 Total funded by APDA Members on a pro-rata basis

July 1, 1974

113

ADDA Project No. 21

Title: Evaluation of Desert Type 6 x 6 Oilfield Truck in Arctic Conditions.

Purpose and Method:

A 6 x 6 oilfield truck with large low pressure tires was purchased for cross-country hauling in the Mackenzie Delta area during the winter. This project was designed to evaluate the vehicle's cross-country mobility, its overall performance as an oilfield truck in winter conditions, and the performance of various mechanical components. In particular, the behaviour of the tires in snow was observed and recommendations for tire design were made for work in unprepared terrain. A final report is expected in June, 1972.

Operator: Imperial Oil Limited

Consultant: J. E. Rymes Engineering Ltd.

Reports:

1. Arctic Winter Test and Evaluation, Initial Stage, Kenworth Truck Model 953A; January, 1972.
2. Arctic Winter Test and Evaluation, Mid-Winter Stage, Kenworth Truck Model 953A; March, 1972.
3. Arctic Winter Test and Evaluation, Late Winter Stage, Kenworth Truck Model 953A; May, 1972.
J. E. Rymes Engineering Ltd.

Cost: \$40,000

August 14, 1974

APOA Project No. 23

Title: Beaufort Sea Soil Sample Analysis

Purpose

and Method:

The purpose of this project was to obtain soil strength data on samples obtained by G.S.C. during the summer of 1971 and to obtain insitu shear strengths off the vessel. Soil strengths were obtained immediately upon sampling but insitu strengths could not be obtained. Twenty-seven soil samples covering a large area of the Beaufort Sea north of Richards Island were retained and shipped to Calgary. It is proposed that additional laboratory analysis be conducted to determine grain size, water content, shear strength, liquid limit and plastic limit. Although encouragement was received prior to underwriting the project, no participants have joined the project and further work has been deterred.

Operator: Gulf Oil Canada Limited

Consultant: Materials Testing Laboratories Ltd

Reports: -

Cost: \$3,000

May 15, 1972

APDA Project No. 24

Title: Arctic Clothing Study

Purpose and Method: To investigate the problems related to clothing and protective equipment which occur during oil operations in the Arctic environment. To find out if research studies should be conducted along this line, and if so, which articles should be improved first. To allow for well-being of the man and improve operational efficiency.

Observations of clothing ensembles were done on drilling locations, seismic lines and during transportation operations to obtain a better understanding on their degree of effectiveness. Canadian army outfits and a research model were also tested at the same time. Questionnaires were circulated which requested details on:

- (1) Working conditions;
- (2) Type of suit worn;
- (3) Arctic worker's recommendations regarding improvements on clothing.

Sixty completed questionnaires were collected which outlined more clearly the Arctic worker's feelings in areas for improvement in the clothing which was tested.

Operator: Elf Oil Exploration and Production Canada Ltd.

Consultant: Defence Research Establishment of Ottawa

Report: Final report dated February, 1973.
"Study of the Clothing Problems of the Oil Operating Crews in the Arctic."

Cost: \$18,240.00

April 22, 1975

APOA Project No. 23

Title: Model Tests to Simulate the Action of Ice on Fixed Structures

Purpose and

Method:

To assess the feasibility of using model ice to study the interaction between moving ice fields and fixed structures.

The evaluative experiments were conducted in the ARCTEC Ice Model Basin. This facility is patterned after a ship model towing basin with the added capacity to form layers of ice on the surface of the water in the basin.

The three major areas of investigation were (1) interaction of a conical shaped structure with a field of uniformly thick ice; (2) the interaction of a cylindrical shaped structure and uniformly thick ice; (3) the interaction of a conical shaped structure with an ice field containing multi year type pressure ridges.

During each test, load levels on the models were measured and recorded.

Wherever possible the experiments were preceded by the development of mathematical models of the expected interactions.

Operator: Imperial Oil Limited

Consultant: ARCTEC Inc., Columbia, Maryland, U.S.A.

Reports: Model Experiments to Determine the Forces Exerted on Structures by Moving Ice Fields.
ARCTEC Inc. Report 00571-5. Final Report March 1972.

Also Progress Reports: 00571-1, September 1971
00571-2, November 1971
00571-3, January 1972
00571-4, February 1972

Cost: \$45,855.

August 1, 1973

APOA Project No. 27

Title: Co-ordination of Arctic Environmental Research

Purpose

and Method:

A joint group representing government and the Petroleum Industry has been proposed for the purpose of co-ordinating Arctic environmental research. An advisory board with representatives from government, APOA, pipeline study groups, AINA, universities, northerners, CPA, IPAC, CARC and others has been suggested. Their function would be to periodically review research problems, priorities, responsibilities and progress. A central information agency should facilitate reviews of prior research. Duplication should be minimized and priorities made known. A permanent staff would be maintained for at least five years. The APOA and the pipeline study groups have committed to their share of the required funding. The federal government has been formally approached regarding the project.

Operator: APOA

Consultant: Not named

Reports: -

Cost: \$150,000 per year total (\$37,500 from APOA; \$37,500 from pipelines and \$75,000 from government)

May 15, 1972

and universities through teaching assistantships \$44,000. About 10% of the total budget was spent on logistics.

The major findings of the study are listed, but not in any order of priority.

1. The Truelove Lowland is representative of the few (less than 2%) oases in the Queen Elizabeth Islands that provide an adequate plant cover and food base for birds and mammals. These lands are much more like the Low Arctic in terms of their biological production. Most of the High Arctic lands north of 73° N are either Polar-Semi Desert (43%) or Polar Deserts and ice caps (55%).
2. A combination of available summer water because of the slower drainage of water (lakes, wet peats, raised beaches) and higher amounts of summer sunshine are the controlling factors. Most of the lands are barren or approach barrenness because of the lack of summer water and low temperatures.
3. Soils in these lands are about as well developed as the present climate permits. Thus low biological production is not a product of soils that are too youthful to permit a higher biological production.
4. Summer climate is very closely coupled to sun angle. The warmest days are in late June and early July. When spring comes early and the ice pack melts earlier, this depresses summer temperature because of more cloud and fog with more open water.
5. The summer climate was quite different in the 4-years (the large lakes were thawed from 50% in late August one year to 2 days and 6 weeks other years) yet total plant growth varied less than 10% year to year. Much of the plant and animal activity seems to be geared to an average number of days in the snow-free season and a good long growing season does not result in a significant increase in biological activity.
6. Numerous insects take longer to complete their life cycles than in temperate regions.
7. Permafrost temperatures are considerably lower at these latitudes than in the Low Arctic of the Mackenzie River Delta. Massive ice wedges and lenses occur in the Truelove Lowland, but they also are less common than in the Low Arctic.
8. The number of species utilized by other species is less than in other major ecosystems and thus the loss of single species or species groups would have a greater impact. For example there is only one species of fish

in the lakes and it feeds mostly on the larvae of one group of flies. Lemming are the major diet component of the carnivorous birds the jaeger and snowy owl and there is only one species of lemming and no voles. Muskox depend on one species of sedge though they also eat the one species of sedge but the latter is more limited in its extent. Arctic hare feed mostly on this one willow and the lemming feed mostly on two species of plants.

9. The ecosystem in terms of energy captured from the sun and utilized by plants and animals is mostly a system of Solar radiation—plants—soil decomposers (bacteria, fungi, soil invertebrates—worms, insects, etc.). The birds and mammals play a very minor role in terms of system energy use, yet they provide an important part of the food base for the Inuit. Snow Geese can change a sedge-moss meadow to a moss meadow by eating out the sedge and muskox add nutrients via feces to the drier raised beaches. The muskox consume a very small percent of the vegetation each year and probably do not influence the plant species or botanical composition of the meadows.
10. These ecosystems function on a very low level of nutrients in the soil or added by snow, rain or meltwater in spring. As a result the plants are quite efficient in reusing nutrients and in preventing them from being carried away in runoff waters or by the wind. When fertilizer is added plant growth and flowering are stimulated for at least the 3 following years.
11. The pattern of muskox movement into and throughout the Lowland is very similar each summer. Thus it seems that a rather clearcut feeding and behavior pattern is established. Each year the muskox have had a high percentage of calves and the cows must on the average have a calf every other year, in some cases each year. This was not known before. Also the population has nearly doubled in the 4 years indicating that animal stresses have been low during our study. Predation by wolves is minor in this herd though on Ellesmere and Lanks Islands it may be much higher.
12. Muskox are very dependent on these sedge meadows, but even more so in the winter. The animals can paw through about 2 feet of snow for winter food (they paw or dig snow craters). The sedges harden off each fall with a high protein content so the animals eat nutrient rich food in the winter, better quality food than caribou, moose, deer, bison and other animals get in more temperate climates.

13. Native people in the Arctic eat a protein rather than a carbohydrate diet. They are the only native people that have such a diet. In turn more of their food comes from the sea than from the land. They get only a minor component of food from plants. If attempts are made to increase biological production in the Arctic and Subarctic emphasis should be placed on animal (herbivores-caribou, moose, muskox) rather than plant production.
14. These arctic ecosystems have a very limited biological production and thus a very limited ability to support people. Except for Banks Island where fox production is high because of diverse vegetation (meadows of sedges, and low uplands of cushion plants and sedges-just as on the Truelove Lowland) and therefore a more diverse group of lemmings and birds on which they feed, there is a very limited ability for Inuit to have their own wage economy based upon wildlife. Monies from crafts and working for governments or industry are something separate.
15. In the Low Arctic the generally thick cover of sedges, low shrubs, lichens, and mosses with several inches of peat below provide an excellent insulative layer against permafrost melt. If this cover is removed ice melt, unstable slopes and thermokarst often result. In the High Arctic plant cover is much less and even where it is thick as in the sedge meadows, its removal does not lead to nearly as much meltout. There is also much less massive ice to melt, though such surface rutting result from the use of off road vehicles in the soft soils in summer. One of the greatest problems in the northern islands is controlling the normal rapid surface erosion that occurs when the spring snow melts. Drainage ditches and areas of greater snow (pushed off runways or around camps) lead to accelerated erosion in spring. These current and future related problems are far more important in the islands than on the mainland where water erosion is minor and thus seldom leads to deep ruts and massive ice melt.

Operator: APOA

Consultants: Dr. L. C. Eliss, Department of Botany, University of Alberta.

Reports: To be published in 1974.

Cost:

Devon Island Project Funding

	<u>1970/71</u>	<u>1971/72</u>	<u>1972/73</u>	<u>1973/74</u>	<u>Total</u>
<u>Government</u>					
Cash	\$127,928	\$227,792	\$236,657	\$175,500	\$767,877
In-Kind	\$ 16,850	\$ 44,302	\$ 53,020	\$ 22,000	\$136,172
<u>Industry</u>					
Cash	\$ 14,500	\$ 24,460	\$ 45,505	\$ 22,300	\$106,765
In-Kind	\$ 31,938	\$ 43,382	\$ 36,608	\$ 9,642	\$121,570
Arctic Institute	\$ 9,891	\$ 14,310	\$ 10,479	\$ 8,069	\$ 42,749
<u>Universities</u>	\$ 14,100	\$ 15,820	\$ 13,572	----	\$ 43,492
<u>Total</u>	<u>\$215,207</u>	<u>\$370,066</u>	<u>\$395,841</u>	<u>\$237,511</u>	<u>\$1,218,625</u>

In addition \$8,000 was provided from APOA General Funds in 1974 to assist in publication of this Research.

APOA Project No. 56

Title: Preparation of Specifications for Large Arctic Truck

Purpose and Method: To prepare a set of technical specifications for a large Arctic truck (Kenworth Model 953A), to ensure that recommended improvements were incorporated into any new units ordered by participants in this project. Discussions were held with various field operators to determine the most desirable features for optimum winter truck operations.

Operator: Imperial Oil Limited

Consultant: J. E. Rymes Engineering Ltd., Calgary, Alberta

Reports: Technical Specifications of A Large Arctic Truck for Imperial Oil Limited, Calgary, Alberta. September, 1973.

Cost: \$5,000

APCA Project No. 57

Title:

Adhesion Study

Purpose
and Method:

To study the effects of ice freezing to a conical structure on the forces encountered by the structure when surrounded by a moving ice sheet.

Small scale tests in wax model ice were carried out and a mathematical model of the observed failure sequence was developed.

Finite element models were developed to predict the behaviour of ice sheets and pressure ridges failing against the cone.

Operator:

Imperial Oil Limited

Consultants:

1. Arctec Canada Limited - Montreal, Que.
2. Acres Consultants Services Limited - Calgary, Alberta

Reports:

1. Mathematical Model to Describe the Behaviour of a Moving Ice Field Encountering a Conical Structure - Volumes I and II, Arctec Canada Limited.
2. Ice Adhesion Study - Acres Consulting Services Limited.

Cost:

\$68,000.

August 1, 1975

APOA PROJECT NO. 58

Title: Task Force on Training Natives

Purpose
and Method:

To define the future employment opportunities and the skills required for the future jobs with the Pipeline and Petroleum Industries, to provide a manpower inventory and the existing education levels, to define the training needs necessary for natives to effectively fill the jobs and to recommend a program to provide the necessary educational job training.

The 1973 training program placed 73 trainees in job sites with Alberta Gas Trunk Line, Canadian Arctic Gas Study Limited, Gulf Oil Canada Limited, Imperial Oil Limited, and Shell Oil Canada Limited.

Operator: APOA

Cost: \$200,000

APCA PROJECT NO. 80

Title: Beaufort Sea Summer Ice Testing Project

Purpose and Method: To study the summer ice properties and the physical parameters of the floe such as surface area, shape, thickness, specific gravity, salinity, temperature and drift velocity of the ice floes.

One set of measurements was carried out closely after breakup by July 15 to July 22 and a second set in the open water season from September 18 to September 21. Triangular plate tests, circular plate tests and bore hole jack tests were the in situ tests used to obtain strength parameters.

Operator: Gulf Oil Canada Limited

Consultant: FENCO

Reports: "Beaufort Sea Summer Ice Testing Project", Foundation of Canada Engineering Corporation Limited, November 1973
(Report restricted to Participants.)

Cost: \$88,326

Table of Contents: Attached

APOA PROJECT NO. 61

Title Environmental Impact Assessment Program,
Mackenzie Delta - Phase II

Purpose
and Method To assess the impact on the local ecology of
possible hydrocarbon development in the Mackenzie
Delta area.

The study will supply environmental advice and
services based primarily upon an assessment of
potential impact of the construction, operation
and maintenance of natural gas production, pro-
cessing and associated gathering facilities on the
local resources and important ecological systems.

A comprehensive projection of the type and extent
of environmental impact will be prepared at the
conclusion of the study.

Operator Imperial Oil Limited

Consultant F. F. Slaney and Company Ltd.
Vancouver, British Columbia

Reports 1972 - 1974 Environmental Program, Mackenzie
Delta, N.W.T., by F. F. Slaney and Company Ltd.
(Report in eight volumes)
(Reports restricted to participants)

Cost \$680,000.

APCA Project No. 63

Title: Arctic Institute of North America
Beaufort Sea Symposium

Purpose and
Method:

To provide financial support for a Symposium on the Beaufort Sea and Coastal Shelf Research sponsored by the Arctic Institute of North America held in San Francisco, January 7 - 9, 1974.

The purpose of the symposium was to outline the present state of knowledge of the area, to define still-existing problems, to interrelate the works of the various disciplines in a synthesis of this environment and its processes, and to provide a forum for discussion of the area environment in relation to the orderly development and utilization of its resources.

The total contribution through APCA was \$12,000.00 of which \$9,000.00 was contributed by the Beaufort Sea Group, \$2,000.00 from three individual member companies, and \$1,000.00 from APCA General Funds.

Operator: A.P.O.A.

Report: The Coast and Shelf of the Beaufort Sea - The Arctic Institute of North America.

Cost: \$12,000.00

APCA Project No. 64

Title: Ice Mechanics and Ice Strengthening 1973-74
Arctic Field Test Program, Resolute Bay, N.W.T.

Purpose
and Method:

The objective to determine the load bearing capacity of the sea ice cover, methods to increase load bearing capacity, measure engineering properties of sea ice, evaluate the technique for predicting safe loads, obtain the temperature gradient in the ice sheet and to determine the response of deteriorating ice to loads.

To determine load bearing capacity storage tanks of 1000 barrel to 4000 barrel capacity were filled with sufficient sea water to effect breakthrough. Data through various instrumentation was gathered on ice deflection, ice cracking, ice strain and ice temperature before, during and after the test. These tests were conducted to include single and multi-area loads on natural sea ice. Additional tests were conducted using tanks with and without rig mats on ice that had been reinforced on the bottom and allowed to freeze in. Data through various instrumentation was also gathered in the natural sea ice tests.

Engineering properties of sea ice were measured at each test site using old and new techniques to determine temperature gradients, salinity gradient, compressive strength, tensile strength, viscoelastic properties, density and characteristics of the ice fabric.

Magnitude of load, rate of loading and other factors were all varied as a function of time to evaluate the techniques for predicting safe loads and for development of new techniques.

The testing program at Resolute Bay, N.W.T. began in November 1973 and concluded in May 1974. Data was analyzed and reports were issued late 1974 and early 1975.

Operator: Sun Oil Company Limited

Reports:

1. Static Ice Loading Tests, Resolute Bay Winter 1973/74.
Report No. 7458-74-14, Sun Oil Company
2. Appendix No. 1.1
Ice Deflection and Water Level Data

Report:

1. Appendix No. 1.2
Reduced Deflection and Load Data Tabulation
2. Appendix No. 1.3
Reduced Deflection versus Load Graphs
3. Appendix No. 1.4
Reduced Deflection versus Time Graphs
4. Appendix No. 11.1
Raw Strain Gauge Data
5. Appendix No. 111.1
Ice Core Data Tabulation
6. Appendix No. 111.2
Ice Block Temperature, Core Salinity
and Core Density Graphs
7. Vibration Measurements made on an Ice Platform
in the Vicinity of Panarctic Hecla N-32 Well.
Technical report 74-4 for Sun Oil Company
by Tetra Tech Geotech

Cost:

\$796,735.

August 1, 1975

A.P.O.A. PROJECT #65

TITLE: Small Prototype Cone Test

PURPOSE: To test the performance of a small conical structure (about 1/8 full scale) under the influence of moving ice in shallow water. The tests should provide data to verify the mathematical and physical modelling techniques.

Tests will be made by pulling an ice sheet towards a fixed cone at constant speed and recording the loads exerted on the cone.

OPERATOR: Imperial Oil Limited

CONSULTANT: Arctec Canada Limited - Montreal, Quebec

REPORT: "Small Prototype Cone Tests - Winter 1973/74".
IPRT 8-ME-75. P. H. Verity, March 1975.

COST: \$238,269

February 28,

APOA PROJECT NO. 66

Title: Ice Crushing Tests 1973-74

Purpose
and Method:

1. To establish the effect of strain rate and ice temperature on the load applied to a cylinder penetrating an ice sheet at constant speed.
2. To establish the effect of the bond strength between ice and cylinder (i.e. cylinder roughness) on the cylinder indentation load.
3. To determine the effect of indenter shape for an aspect ratio of approximately four.
4. To investigate ice crushing strength at large aspect ratios.

The same testing equipment was used as in the 1972-73 ice crushing tests (APOA 54) with the addition of a device to cool the ice and control its temperature.

Basically, a four foot indenter (flat or cylindrical) and of controlled roughness) will be pushed against a one foot (approx.) thick ice sheet by a hydraulic ram at controlled speed. Tests with a twelve foot indenter will also be performed.

Operator: Imperial Oil Limited

Consultant: J. B. Nuttall, University of Alberta, Edmonton

- Reports:
1. Ice Crushing Tests-1974-T. Miller et al, IPRT-13 ME 74, Imperial Oil Limited Laboratory Report.
 2. Laboratory Tests on Fresh Water Ice 1974. September 1974 - Morgenstern, Nuttall and Segu, University of Alberta Civil Engineering Department.

Cost: - \$190,000

July 18, 1975

436

436
11/5

A.P.O.A. PROJECT #67

TITLE: Ice Movement in the Beaufort Sea, 1973/74

PURPOSE: To measure rate and magnitude of ice movement in 5 to 100-foot water depth range along with wind, tide, ice and ambient temperatures.

Ice movement will be measured at ten sites in the MacKenzie Delta area of the Beaufort Sea. The telemetry system will be employed at all sites allowing hourly interrogations to take place. Recorders will be installed at some sites to obtain a continuous record of ice movement. Information on winds, temperatures, and tides will also be collected.

OPERATOR: Imperial Oil Limited

REPORT: Landfast Ice Movement - MacKenzie Delta 1973-74.
IPRT 2-ME-75. G. Spedding, April 1975.

COST: \$178,500

February 28,

A.P.O.A. PROJECT #68

TITLE: Properties of Wax Model Ice Ridges

PURPOSE:

1. To establish the feasibility of modelling pressure ridge-ice sheet systems.
2. To demonstrate that ridges with realistic dimensions can be economically formed using wax.

In order to understand the interaction process so that maximum loads can be predicted and structures optimized, an analogue of the system is desirable. The analogue would be a small-scale physical model in which the structural properties of the ice are correctly scaled.

OPERATOR: Imperial Oil Limited

CONSULTANT: Arctec Canada Limited - Montreal, Quebec

REPORT: Investigations into Feasibility of Producing Pressure Ridge/
Ice Sheet Systems with Synthetic Ice. No. 4C-1, R. Edwards

COST: \$21,600

February 28, 1977

APOA Project No. 69

Title: An Analytical Study of Ice Scour

Purpose and Method: The primary objective is to develop one or more models for ice-soil interaction suitable for predicting the scour depth and forces that may be produced by a grounding ice feature of given geometry (ice islands, multi year floe, ice berg etc.) subject to given driving forces for a given set of bottom conditions.

Operator: Imperial Oil Limited

Consultant: FENCO Limited of Calgary

Reports: An Analytical study at Ice Scour on the Sea Bottom - April 1975, FENCO.

Cost: \$30,738

July 18, 1975

APQA PROJECT NO. 70

Title Wind/Wave Hindcast, Canadian Beaufort Sea

Purpose and Method Existing Beaufort Sea hindcast studies are not adequate to provide an accurate prediction of the effects of weather on offshore operations or for the development of design criteria for offshore structures. This study describes the surface environmental events with substantial accuracy so that a high degree of confidence may be placed in the results. Specifically, the consultant will (a) evaluate all available wind data associated with recorded wave data to correlate wind velocity, duration and fetch with wave height; (b) use the fetch and wind data to make a wave hindcast; (c) compare the hindcast results with the wave-rider data in order to select the best hindcast method; (d) make a search of past severe storm wind reports; (e) prepare a hindcast model for the locations of interest.

Operator Imperial Oil Limited

Consultant Intersca Research Corporation
La Jolla, California

Report Normal and Extreme Winds and Waves in the Canadian Southern Beaufort Sea, by Intersca Research Corporation.

(Report restricted to participants)

Cost \$49,800.

APOA Project No. 71

Title: Task Force on Training Natives 1974 (Extension of APOA Project No. 58)

Purpose and Method: To continue the training of 1974 enrollees, and to make additions to existing training and employment opportunities. As of April 30, 1975, there were a total of 105 current training positions as follows:
The Alberta Gas Trunk Line Company Limited 25,
Canadian Arctic Gas Study Limited 5,
Gulf Oil Canada Limited 22,
Imperial Oil Limited 22,
Shell Canada Limited 23, and
TransCanada Pipelines Limited 8.

In addition industry supervisors seminars were held at Fort Smith in conjunction with Canada Manpower, N.W.T. Government and Native Political organizations.

Also, trainee orientations were held at the AVTF, Fort Smith in conjunction with Canada Manpower and N.W.T. Government to assist Northerners in their social and physical adaptation to a southern wage economy.

Operator: A.P.O.A.

Cost: \$310,000.00

May 30, 1975

A.P.O.A. PROJECT #72

TITLE: Beaufort Sea Environmental Program

PURPOSE: Member Companies of APOA have provided \$4.6 million to support the environmental studies required by DOE before considering a drilling authority for the Beaufort Sea. These funds include \$4.1 million paid to the Federal Government in direct support of the studies and the remainder for Industry co-ordination, administration and publicity. The studies have been co-ordinated by government in co-operation with the Industry Project Manager and Co-ordinators. In turn, contractors or consultants have been retained where necessary.

The results were reviewed at the end of 1974, but it was concluded that insufficient data had been obtained to consider a drilling authority. Additional field work was undertaken in 1975 to obtain the data which could not be obtained in 1974, due to the adverse ice year. Most of the studies and reports were completed by the end of 1975 and are now being published and distributed.

The studies are designed to provide baseline and operating data preparatory to exploratory drilling in the Beaufort Sea. The program included studies of birds, marine mammals, wildlife, physical and chemical oceanography, meteorology, sea bottom investigations and the effects of possible oil spills in ice-covered waters.

OPERATOR: Gulf Oil of Canada Limited

CONSULTANT: Department of Environment and contractors, as required.

REPORT: Investigator's Conference held in Calgary January 1975 and January 1976. Interim reports published and distributed in 1975. Final Technical and Overview Reports are presently being published and distributed.

COST: \$4,600,000

TABLE OF CONTENTS: List of Studies and Costs.

February 28, 1977

<u>STUDY NO.</u>	<u>TITLE</u>	<u>REVISED INDUSTRY COST</u>
A3	Sea Bird Population in Coastal Beaufort Sea	\$389,400
A5	Effects of Oil Pollution on Marine Mammals	\$ 79,000
B4	Nitrogen Fixation by Bacteria Affected by Oil	\$ 29,700
B5	Effects of Oil on Marine Micro-Organisms and Invertebrates	\$ 63,400
B6	Baseline Information on Biological Productivity	\$ 76,500
C1	Mackenzie River Input to Beaufort Sea	\$ 91,500
D2	Near Bottom Currents and Offshore Tides	\$478,500
D3	Open Water Surface Currents	\$182,000
D4	Oceanography from Historical Data	\$ 42,000
D5	Storm Surges Related to Local Topography	\$ 44,800
E1	Environmental Prediction System Design	\$630,000
E2	Synoptic Study of Wave Climatology	\$ 20,000
F2	Bottom Scour by Sea Ice in Southern Beaufort Sea	\$170,000
F3	Geological Aspects of Susceptibility of Coasts to Oil Spills	\$100,000
F4	Sediment Dispersal in Southern Beaufort Sea	\$ 20,000
G1	Ice Climatology of Beaufort Sea From Historical Data	\$ 37,000
G2	Behavior of Oil in An Ice-Covered Area	\$450,000

<u>STUDY NO.</u>	<u>TITLE</u>	<u>REVISED INDUSTRY COST</u>
G3	Distribution of Ice Thickness In Beaufort Sea	\$ 45,700
H1	Oil Disposal, Detection and Quantification, Oil Spill Countermeasure System	<u>\$ 265,000</u>
	- Cost of Studies	3,314,500
	- Government Management & Logistical Support (Ship Charter and Decca Navigation)	<u>785,500</u>
	- Total Government Costs	4,100,000
	- Industry Cost - Co-ordinators Salaries and Expenses, Public Interface	<u>500,000</u>
	- TOTAL COST OF STUDIES	<u><u>\$4,600,000</u></u>

APOA PROJECT NO. 73

Title Research Program on Pollution from Drilling Fluids.

Purpose and Method To develop effluent standards by July 1975, for the disposal of sump fluids from onshore and offshore drilling operations in the North. Two working groups are established to undertake the studies. Working Group A will investigate into the extent of the pollution problem associated with current methods of handling sump fluids in order to develop effluent standards for the disposal of sump fluids by April 1975. Working Group B will develop guidelines for the location, design, construction and restoration of drill sumps and pits.

Operator Imperial Oil Limited

Consultants 1) T. W. Beak Consultants Limited
Calgary, Alberta
2) Environmental Protection Service
Edmonton, Alberta

Reports Disposal of Waste Drilling Fluids in the Canadian Arctic by Beak Consultants Ltd.
(Report restricted to participants)

Cost \$130,700.

APCA PROJECT NO. 74

Title: Banks Island Development Environmental Considerations

Purpose and Method: This study was designed to evaluate the impact of summer petroleum exploration activity on Banks Island, N.W.T. Specific emphasis was placed on the potential impact that year round drilling operations might have on the terrain and wildlife of the Island. The project included:

- a) permafrost active layer measurements, and
- b) studies of bird, white fox, muskoxen, caribou, and other wildlife populations, and their habitats;

in order to determine what effect summer drilling activities would have on same.

Operator: Panarctic Oils

Consultant: Beak Consultants Limited, Calgary, Alberta

Report: Banks Island Development, Environmental Considerations, 1974 - Volumes I, II, and III - Beak Consultants Limited.

Cost: \$334,007.61 to December 31, 1974.

Table of Contents: Attached

May 5, 1975

A.P.O.A. PROJECT #75

TITLE: Field Study of First-Year Ice Pressure Ridges

PURPOSE: The proposed series of measurements will provide information on the size and structural integrity of a first-year ridge; and the ice strength parameters of temperature, density and salinity. Drilling will reveal the extent of consolidation that can take place in one season.

The measurements of several profiles could establish a relationship between the sail and the submerged keel. This would enable estimates of total ridge size to be made by surface observation alone.

The accuracy of ridge appraisal using aerial photographs can be checked by comparing the detailed field data with aerial photographs of the profiled ridges.

By investigating ridges at successively greater depths, the effect of water depth on ridge structure will also be determined. Eight ridges were investigated.

OPERATOR: Imperial Oil Limited

REPORT: Field Studies of Eight, First-Year Sea-Ice Pressure Ridges in the Southern Beaufort Sea. IPRT 8-ME-75. R. W. Gladwell, July, 1976.

COST: Estimated Cost, \$80,000

February 28, 1977

AIWA PROJECT NO. 76

Title

Summer Environmental Studies - East Mackenzie Bay - Mackenzie Delta.

Purpose and Method

To assess the impact on the local ecosystems of construction and operations of hydrocarbon development facilities in the East Mackenzie Bay area.

Specifically, the consultant will provide an assessment of the environmental effects arising from summer construction of offshore islands upon the following elements:

- 1) Whale movements, distribution and activities.
- 2) Abundance and distribution of fish and plankton at island sites.
- 3) Water quality.
- 4) Summer use and significance of these barrier islands to birds and wildlife.

A comprehensive projection of the type and extent of environmental impact will be prepared at the conclusion of the study.

Operator

Imperial Oil Limited

Consultant

F. F. Slaney and Company Ltd.
Vancouver, British Columbia.

Report

Summer Environmental Study - 1975
Vol. I, II and III.

Cost

\$451,000.

Date to be made public - Dec. 31, 1978

APOA Project No. 77

Title: Modelling of Small Cone Prototype Tests

Purpose and Method: To establish the validity of using the synthetic ice developed by Arctec Canada Limited as a suitable modelling medium for ice being failed in bending.

The test program will attempt to model the small prototype cone tests, APQA 65, completed last year in Imperials test basin.

In principle, the model tests will be performed in a similar way to the small prototype tests where an ice sheet was moved against a stationary conical structure.

Operator: Imperial Oil Limited

Consultant: Arctec Canada Limited

Report: "Model Experiments To Determine The Forces Exerted On Structures By Moving Ice Fields" - R. Edwards et al - Arctec Canada Limited, June 4, 1975.

Cost: \$60,854

July 18, 1975

A.P.O.A. PROJECT 978

TITLE: Environmental Data Gathering Program - Baffin Bay,
Davis Strait and Arctic Islands

PURPOSE: The purpose of this project was to obtain meteorological,
oceanographic and ice data in the study region.

A trained meteorological, oceanographic and ice observer
was placed aboard the MV Arctic Explorer while it was con-
ducting seismic surveys in Baffin Bay and the eastern
Arctic Islands during the 1974 open water season. The
data collected has been processed and summarized into an
environmental data report.

OPERATOR: Gulf Oil of Canada Limited

CONSULTANT: Marine Exploration Limited

REPORT: "Arctic Environmental Observations - M/V Arctic Explorer,
1974". Marine Environmental Services Limited.

COST: \$12,646

February 28, 197

A.P.O.A. PROJECT #79

TITLE: Arctic Island Ice Movement Study, 1974-1975

PURPOSE: To measure the extent of horizontal ice movement and ocean currents in Hazen Strait, Maclean Strait, and Desbarats Strait in the Sverdrup Basin area of the Canadian Arctic Islands.

Savonius rotor current meters, combined with Acoustic Ice Movement Systems, which measure two dimensional ice movement using an acoustic signal, were installed at three separate locations.

The data collected is necessary to determine the feasibility of offshore drilling in the straits, from an artificially strengthened ice platform or an air cushion barge. The locations of the measurements were as follows:

Station #2	Latitude 77°00'	Longitude 110°30' W
Station #3	Latitude 76°50'	Longitude 106°00' W
Station #4	Latitude 77°20'	Longitude 102°30' W

OPERATOR: Panarctic Oils Ltd.

CONSULTANT: Innovative Ventures Limited

REPORT: Published on completion of study. (Reports restricted to participants).

FINAL COST: \$ 207,177.72

RELEASE DATE: Information can be released by October 31, 1979.

PARTICIPANTS:

<u>Name</u>	<u>Amount</u>
Canadian Superior	\$ 18,834.33
Dome Petroleum	18,834.33
Global Arctic Islands	18,834.33
Global Marine Arctic	18,834.33
Gulf Oil	18,834.33
Imperial Oil	18,834.33
Petro-Canada	18,834.33
Phillips Petroleum	18,834.33
Shell Canada	18,834.33
Panarctic Oils	18,834.33
Total	<u>\$207,177.72</u>

APOA Project 80

Title: Development of a Semisubmersible Drilling System for the Arctic Offshore Area - Phase I

Purpose and Method:

The objectives of this project are to establish a preliminary design for the basic Arctic semi-submersible drilling vessel and to obtain engineering data concerning ice cutting which can be used in designing a full-sized ice cutter system for the drilling vessel.

A number of systems including ice breaker drillships, ice strengthened drilling barges, ice platforms and air cushioned drilling barges, etc., have been considered for drilling offshore area of the Arctic Islands. All of these systems possess some deficiencies such as: the length of the drilling period and as a result, the depth of the well that may be drilled; limited ability to cope with moving ice; deficiencies associated with logistics, resupply, safety and other factors.

Recognizing the deficiencies of the above drilling systems, nine Calgary-based oil companies entered into a program with Sedco, Inc., a major offshore drilling contractor, and Snaresing, the developer and patentee of a unique ice cutting principle, to investigate the possibility of developing a drilling unit with year-round Arctic offshore drilling capability.

This project has been divided into four major tasks:

- Task A: Preliminary Design and Analysis involves conducting a preliminary design study of the drilling vessel and primary systems to demonstrate practicability, establish design parameters, and arrive at preliminary cost estimates.
- Task B: Hydrodynamic Model Testing involves building and testing a 1/40th scale model of the drilling vessel to determine operating capabilities in the open sea and while under the influence of severe environmental and operating forces.
- Task C: Aerodynamic Model Testing involves building and testing an aerodynamic model of the drilling vessel (monopod column and superstructure) to obtain data on wind loads.

Task D: Arctic Ice Cutting Tests involves designing and constructing a scale-ice cutting unit and subjecting the unit and scale cutters to a rigorous Arctic test program to:

1. Establish feasibility of cutting ice using Sea-Log patented technique under actual arctic conditions.
2. Obtain engineering data on ice forces, power requirements, wear etc. and to compare these data to analytical predictions and extrapolations obtained from prior smaller-scale tests making adjustments to the theory of ice cutting where required.
3. Establish engineering factors which may be used in assessing the practicability of scaling up to a full-size ice cutter consistent with technical, economic and related criteria.

Tasks A, B, and D have been completed. Task C has been deferred to a later date. Report on Task D (APOA 80) has been completed.

Operator: Sun Oil Company Limited

Reports:

1. Preliminary Design Study - Phase I prepared by Earl & Wright, Consulting Engineers
2. Report of the Arctic Tests of the Ice Cutter/Removal System Scale Test Unit, Phase I - Task D prepared by Sedco and Sea-Log

Cost: \$1,500,000.

A.P.O.A. PROJECT #81

TITLE: Small Prototype Cone Test - Phase II

PURPOSE: The proposed series of measurements will provide information on:

1. Failure mechanism and failure loads of beam at naturally grown ice, impinging on a small prototype cone.
2. Adfreeze strength of an ice sheet naturally frozen to a small conical structure.
3. Adfreeze strength of broken fragments of naturally grown ice to the surface of a small prototype cone.
4. Ice sheet failure against a conical structure.
5. The ratio between the initial break-out crushing strength of naturally grown ice sheet and the secondary failure loads as moving continues.

OPERATOR: Imperial Oil Limited

REPORT: "Small Prototype Cone Tests, Winter 1974/75". IPRT 39-ME-75.
P. H. Verity, November 1975.

COST: Estimated Cost, \$300,000

February 28, 1977

A.P.O.A. PROJECT #83

TITLE: Landfast Movement in the Beaufort Sea - 1974/75

PURPOSE:

1. To measure the rate and magnitude of ice movement in 7 to 100-foot water depth range at selected locations.
2. To measure wind speed, tidal fluctuations, ambient temperature and ice temperature at selected locations.

OPERATOR: Imperial Oil Limited

REPORT: "Landfast Ice Movement MacKenzie Delta 1974/75"
IPRT 26-ME-75, L. G. Spedding, November 1975.

COST: Estimated Cost, \$118,000

February 28, 1977

A.P.O.A. PROJECT #84

TITLE: In-Situ Ice Property Measurement in the Beaufort Sea

PURPOSE:

1. To measure Young's Modulus and flexural strength on cantilever beams cut in first year ice.
2. To determine variations of Young's Modulus with loading rates.
3. To measure salinity, temperature, and crystal fabric variation through the thickness of the ice.

OPERATOR: Imperial Oil Limited

REPORT: "The Flexural Strength and Young's Modulus of Landfast Ice By The MacKenzie River Delta". IPRT 41-ME-75, P. R. Kry, November 1975.

COST: Estimated Cost, \$56,000

February 28, 1976

A.P.O.A. PROJECT #85

TITLE: Adfreeze On Conical Structures

PURPOSE: To perform preliminary dislodging tests on small rectangular samples of laboratory grown ice adfrozen to flat steel plates to determine the dependence of adfreeze strength on:

- Ice Salinity
- Bond Type
- Temperature
- Surface Roughness
- Ice Geometry
- Urethane Coating
- Loading Configuration

OPERATOR: Imperial Oil Limited

CONSULTANT: Arctec Canada Limited - Montreal, Quebec

- REPORT:
1. "Preliminary Assessment of the Adhesion Shear Strength of Ice-Steel and Ice-Frozen Sand Bonds". No. 61C - R. Edwards, February 1975.
 2. "Adhesion Shear Strength and Friction Tests Ice-Urethane Coated Steel & Ice Gravel/Bag/Sand". No. 61C1 - R. Edwards, May 1975.
 3. "Photoelastic Determination of the Shear Stress Distribution in Adfrozen Ice Blocks". IPRT 40-ME-75, A. Semenluk, October 1975.
 4. "Finite Element Analysis of the Dislodging of an Ice Block Adfrozen to a Surface". IPRT 32-ME-75, P. N. Trofimenkoff, October 1975.

COST: Estimated Cost, \$55,000

APOA Project No. 86

Title: Study of Pressure Ridge/Cone Interaction

Purpose:

1. To obtain experimental data to verify the math model at APOA Project 87.
2. To obtain loads for failing an ice sheet against a downward breaking cone and compare these with loads for an equivalent upward breaking cone.
3. To use artificial ice to obtain vertical deflection of ridges during fracture.
4. To obtain the load required to fail a ridge on a cone covered with a rubble pile constructed from sheet fragments.
5. To obtain ridge failure loads when the ridge is ad-frozen to the cone.
6. To obtain loads to fail a ridge with a downdrag breaking cone.

Operator: Imperial Oil Limited

Consultant: Arctec Canada Limited - Montreal, Que.

Report: "Preliminary Modelling of The Process of Penetration at Pressure Ridges By Conical Structures" R. Edwards & R. Abdelnour, Arctec Canada Limited, May 24, 1975.

Estimated Cost \$70,000

July 18, 1975

A.P.O.A. PROJECT #87

TITLE: Computerize a Mathematical Model Of Ice/Cone Interaction

PURPOSE: Computerize the best analytical math models presented by Arctic Canada Limited and Acres in A.P.O.A. Project #57.

OPERATOR: Imperial Oil Limited

REPORT: "Computer Program To Evaluate The Forces Generated By A Moving Ice Field Encountering A Conical Structure".
IPRT 21-ME-75-A. Semenluk, June 1975.

COST: \$3,250

February 28,

APOA PROJECT No. 28

Title Ya Ya Lake Gravel Testing Program, 1975

Purpose and Method To accurately estimate the amount and quality of gravel in the lake presently being mined by drilling a series of core holes.

Operator Imperial Oil Limited.

Consultants EBA Engineering Consultants Ltd.

Report Ya Ya Lake Gravel Testing, Vol. I and II.

Cost \$165,000.

August 1, 1975

A.P.O.A. PROJECT #89

TITLE: Study of the Thickness of Multi-Year Pressure Ridges

PURPOSE: The purpose of the study was to obtain more information on multi-year pressure ridges in the Beaufort Sea; their size and their configuration, with a view to the effect of these ridges on exploratory drilling and bottom founded structures.

The study involved locating approximately twenty-five of the more severe multi-year pressure ridges in the area. By augering, sonar and levelling, the thickness and approximate geometry of the ridges were determined. Several shoreline pile-ups were also investigated.

OPERATOR: Gulf Oil of Canada Limited

CONSULTANT: NORCOR Engineering & Research Limited

REPORT: "An Investigation of Multi-Year Pressure Ridges & Shore Pile-Ups, October 1975". NORCOR Engineering & Research Limited.

COST: \$59,600

February 28, 1977

APOA Project No. 90

Title: Mobile Arctic Ice Chipper

Purpose
and Method:

The objective is to develop an efficient, lightweight ice chipper to prepare routes for conventional tracked and wheeled seismic vehicles operating on Arctic ice. The mobile ice chipper can be mounted on a D6 or D7 tractor and is transportable by air.

Specifically, the mobile ice chipper will be able to:

1. traverse 40 miles of Arctic ice per day
2. operate at 1 m.p.h. cutting packed or drifted snow up to three feet high x 12 feet wide
3. move at comparable speed of a D6 tractor without cutting snow or ice

The unit will provide good operator visibility, be self-contained with 24 hours of diesel fuel, and will have minimal controls to allow the operator to handle the tractor and chipper simultaneously.

The unit will be tested at an Arctic site deemed representative of typical seismic operations.

All final phase reports and drawings prepared by the consultants have been provided to the participants, including the analysis and final report.

Operator: Sun Oil Company Limited

Consultants: Centurion Engineering Ltd.
Innovative Ventures Ltd.

Reports:

1. Feasibility and conceptual design, Phase IA, Volumes I and II, by consultants
2. Detailed Engineering Design, Phase IB, by consultants
3. Analysis and Report, by consultants

Cost: \$163,700.

August 1, 1975

APDA Project No. 91

TITLE: Strength of Multi-Year Pressure Ridges

PURPOSE:

1. To determine the flexural strength of selected multi-year sea ice pressure ridges in the Southern Beaufort Sea.
2. To profile all the easily accessible multi-year pressure ridges within the study area, and determine the thickness of the slush layer present at the water/ridge interface.
3. To determine salinity, temperature, density, and crystallography profiles of selected ridges.
4. To measure water current velocity near selected ice pressure ridges.

OPERATOR: Imperial Oil Limited

REPORT: "Field Studies of the strength and Physical Properties of a Multi-Year Ice Pressure Ridge in the Southern Beaufort Sea" - [PRT-3ME-77. R.W. Gladwell Imperial Oil Ltd.

Structural Analysis of the Ice Encountered in Ridge Group - Arctic

COST: estimated cost: \$125,000.00 max/pert \$25,000

PARTICIPANTS: Amoco, IOL, Shell, Sun, Gulf, Chevron, Petrocan.

CONFIDENTIALITY: Mar 1980.

October 19, 1978

A.P.O.A. PROJECT #17

TITLE:

Arctic Islands Sea Ice Movement Analysis from Ice
Reconnaissance and Satellite Imagery Data

PURPOSE AND
METHOD:

This study was designed to assemble pertinent data relating to sea ice movement and to provide an overview of specific aspects of the ice regime in the central part of the Queen Elizabeth Islands, including movement, roughness, pattern of break-up and freeze-up, and the development of leads.

The data included in this report is mainly restricted to the years from 1961 through and including 1974. When it is pertinent, information from early years is also presented. The report is comprised of 273 maps showing the various factors. The majority of these maps shows the actual observations of mean and extreme conditions for each of the main factors studied and are presented under the heading of Map Summaries. There are approximately 100 of these maps.

The written report is restricted solely to a description of the sources of information and the methods of data collection, reduction (if any) and interpretation. Occasionally, comments relating to trends and variations are included.

OPERATOR:

Panarctic Oils Ltd.

REPORT:

Arctic Islands Sea Ice Movement Analysis from Ice
Reconnaissance and Satellite Imagery Data, January 1976,
D. G. Lindsay, Northice Consultants.

FINAL COST:

\$43,916.53

RELEASE DATE:

Information can be released July 1, 1981.

PARTICIPANTS:

<u>Name</u>	<u>Amount</u>
Imperial Oil	\$ 3,659.71
Aquitaine Company	3,659.71
Norcen Energy Resources	3,659.71
Canadian Superior	3,659.71
Global Arctic Islands	3,659.71
Global Marine Arctic	3,659.71
Hudson's Bay Oil & Gas	3,659.71
Gulf Oil Canada	3,659.71
Petro Canada	3,659.71
Phillips Petroleum	3,659.71
Sun Oil Company	3,659.71
Panarctic Oils	3,659.72

\$ 43,916.53

APOA Project No. 93

TITLE: High Aspect Ratio Ice Crushing Tests

PURPOSE:

1. To determine the relationship between crushing strength, ice thickness and indenter width for high aspect ratio (indenter diameter to ice thickness).
2. To investigate the possibility of non-simultaneous failure of an ice sheet loaded with a wide indenter.

OPERATOR: Imperial Oil Limited

REPORT: To be published later.

COST: Estimated cost: \$55,000 - Max participant \$8,000.

PARTICIPANTS: Gulf, Imperial

CONFIDENTIALITY: July 1980

October 19, 1978

A.P.O.A. PROJECT #94

TITLE: Development of a Semi-Submersible Drilling System for the Arctic Offshore Area - Phase II.

PURPOSE
AND METHOD:

To conduct an engineering study to define engineering data relating to ice disaggregation, which would constitute a sufficient engineering basis for a 1/5 model as the target scale or for single full scale teeth of various designs will be considered if deemed necessary. The study will include a definition of the range, accuracy and trends of parameters to be recorded as well as a test plan and the performance capabilities of the required instrumentation for a field test in Resolute Bay, N.W.T. or other suitable location at a future date.

The study will identify those ICSDV items requiring further test effort, based upon: (a) ICSDV engineering design requirements related to ice disaggregation (b) results of the Resolute test program conducted as a part of the A.P.O.A. Project #80. Within the study, we will determine the ice disaggregation parameters, their relationship, test requirements, results required, and candidate tooth design to be tested. We will also prepare a test plan including the specific tests, objectives, general procedures, desired test conditions, duration and accuracy, and description of test set-up including instrumentation and data acquisition.

OPERATOR: Sun Oil Company Limited

CONSULTANTS: Fonco Consultants Limited
George M. Morgan, Consulting Engineer

REPORTS: (1) "Ice-Related Technology as Required for Final Design of Full-Scale ICSDV"
Report 7601-76-42 - Sontach Inc.
George M. Morgan - December, 1976

REPORTS:
(Cont'd)

- (2) Development of a Semi-Submersible Drilling
System for the Arctic Offshore Area -
Phase II, Task II

Fenco Consultants Limited:

Volume 1 - "Theoretical Investigation and Field
Test Program on Disaggregation"
November, 1978

Volume 2 - "Hydraulic Clearing and Laboratory
Tests"
December, 1978

COST: \$133,567.30

April 10, 1979

A.P.O.A. PROJECT #95

TITLE: Arctic Islands Ice Movement Study, 1975-1976

PURPOSE AND
METHOD:

Project #95 is a continuation of ice movement measurement at the three locations monitored during the 1974-75 winter season under A.P.O.A. Project #79.

A fourth station, Station #1 in Prince Gustaf Adolf Sea was added to the original Stations 2, 3 and 4. Current measurements and CDT profiles were obtained at Stations 1 and 2. Weather recording equipment was installed at Station #2. The location of the measurements was as follows:

Station #1	Latitude 78°10'N	Longitude 107°00'W
Station #2	Latitude 77°00'N	Longitude 110°30'W
Station #3	Latitude 76°50'N	Longitude 106°00'W
Station #4	Latitude 77°20'N	Longitude 102°30'W

OPERATOR: Panarctic Oils Ltd.

REPORT: "Data Report" Innovative Ventures Ltd., August 1976
5 Volumes.

FINAL COST: \$ 293,967.23

RELEASE DATE: Information can be released August 28, 1980

PARTICIPANTS:

<u>Name</u>	<u>Amount</u>
Canadian Superior	\$ 36,745.90
Dome Petroleum	36,745.90
Global Marine Arctic	36,745.90
Gulf Oil Canada	36,745.90
Petro-Canada	36,745.90
Phillips Petroleum	36,745.90
Sun Oil Company	36,745.90
Panarctic Oils	36,745.90
Total	<u>\$293,967.23</u>

A.P.O.A. PROJECT #95

TITLE:

Statistical Study of Late Winter Ice Thickness
Distribution in the Arctic Islands from Seismic
Data, 1971 - 1975.

PURPOSE AND
METHOD:

To provide information on ice thickness distribution
in the Arctic Islands to assist in the design and
evaluation of various drilling and re-supply schemes
for the Arctic Islands.

The thickness of the ice at various locations was
determined by drilling through the ice and measuring
the thickness. This data was then analyzed by com-
puter to obtain a statistical frequency of occurrence
of an ice thickness above a given value. Computer
plots were made of ice thickness along each line.
These plots are keyed to reference maps showing the
geographic location of the lines.

OPERATOR:

Panarctic Oils Ltd.

REPORT:

Data published in 11 volumes. (Reports restricted
to participants).

FINAL COST:

\$ 54,258.16

RELEASE DATE:

Information can be released February 10, 1981.

PARTICIPANTS:

<u>Name</u>	<u>Amount</u>
Canadian Superior	\$ 5,425.82
Dome Petroleum	5,425.82
Global Marine Arctic	5,425.82
Gulf Oil Canada	5,425.82
Hudson's Bay Oil & Gas	5,425.82
Imperial Oil	5,425.82
Petro-Canada	5,425.82
Phillips Petroleum	5,425.82
Sun Oil Company	5,425.82
Panarctic Oils Ltd.	5,425.82
Total	<u>\$54,258.16</u>

A.P.O.A. PROJECT 497

TITLE : Tests of the Arctic Boat Configuration of the Lockheed Clean Sweep System in a Broken Ice Field.

PURPOSE AND METHOD : To make a comparison between the performance of a standard clean sweep and one modified for use in ice infested waters.

The tests were done with a full-scale unit being operated in the test tank at Arctec's facility in Columbia, Maryland. The building housing the tank was refrigerated and the tank itself had about 9/10 ice cover in the form of large broken lumps of fresh water ice. Crude oil at varying stages of weathering was poured on to the surface and the two versions of the Lockheed device were tested by picking up this oil at different forward speeds as well as different drum speeds. The recovered oil was collected and measured after each run.

OPERATOR :

Canadian Marine Drilling

REPORT WRITTEN :

"Report on Tests of the Arctic Boat Configuration of the Lockheed Clean Sweep Oil Recovery System in Broken Ice Field"

COST : \$14,000

APQA No. 98 - Arctic Science and Technology
Information System

This project is being conducted by the Arctic Institute of North America. Its purpose is to implement a computerized cataloging and information retrieval system for research related to arctic regions. The components of the project are:

- 1) Programming and development of subject geographic title list.

Duration: October 1977 - March 1978.

Cost: \$15,000 - librarian to produce title list.

(\$23,000 remaining from last year's funding will cover the programming cost)

- 2) Operation:

Continuous current cataloging will be done by computer, including back to the beginning of 1977. Almost all material catalogued will be abstracted. Output in the form of a monthly current awareness bulletin, an annual cumulative bibliography and microfiche, and on-line access to the data base will be operational early in 1978. These services will be available to the APQA and other users by early 1978.

Duration: November 1977 - November 1980.

Cost: \$50,000 per year for 3 years.

Funding of \$30,000 was provided in 1976 by APQA for the first phase of the project. The present phase has a total commitment of \$165,000 from APQA over three years.

The funding is being distributed as follows:

- (i) \$7,500 on October 1, 1977.
- (ii) \$7,500 on October 1, 1978.
- (iii) \$25,000 on first day of every sixth month from November 1, 1977 to May 1, 1980, inclusive.

There is no release date for the information generated by this project. All listings produced are available to both APOA participants and outside users on a user-fee basis.

The participants are:

Canadian Superior Oil Ltd.
Dome Petroleum Limited
Gulf Oil Canada Limited
Esso Resources Canada Limited
Panarctic Oils Ltd.
Petro-Canada Exploration Inc.
Shell Canada Resources Limited
Sun Oil Company Limited

To the present, programming and implementation has been completed for the following functions:

- Inputting current and past abstracts and references.
- proofreading.
- production of current awareness bulletin.
- production of reference labels for AIMA library.
- on line searches (users manual still to be written).

Two current awareness bulletins have been produced and sent out. One free copy is being sent and will continue to be sent to participating APOA member companies (to the attention of the APOA representative). The subscription fee for the current awareness bulletin is:

	Regular User	APOA Participants (additional copies)
1978	\$25/year	\$12.50/year
1979 and on	\$45/year	\$22.50/year

There are at present 95 users on the mailing list. The present work has resulted in only 1978 titles having been input to the system. Current titles will be continually added, and back listing will take place slowly. A program is being produced to print a catalogue of all AIMA holdings, again with only 1978 acquisitions listed.

George Greene

A.P.O.A. PROJECT #99

TITLE: Ice Island Count - Southern Beaufort Sea 1974, 1975 and 1976

PURPOSE: To record the invasion of ice islands and ice fragments into the coastal waters of the Southern Beaufort Sea. Because of their large size and thickness, they could present severe problems to offshore operations. Collection of this type of data on a yearly basis is considered necessary to a meaningful risk analysis of the collision of ice islands with fixed structures.

OPERATOR: Imperial Oil Limited

REPORT:

1. "Ice-Island Count 1974" L.G. Spedding
Imperial Oil Limited IPRT-18ME-75
2. "Ice-Island Count Southern Beaufort - 1975
L.G. Spedding, Imperial Oil Limited IPRT-14ME-76
October 1976

COST: Estimated Cost \$30,000

February 28, 1977

A.P.O.A. PROJECT #1001

TITLE : Evaluation of the Bennett Canmar Oil Containment Boom

PURPOSE AND METHOD : To evaluate a test section of a radical boom design under development. Two short sections were built to verify the theoretical performance of the new design by subjecting them to sea trials. The tests included the following :

1. Towing at different speeds
2. Response time to wave action
3. Ultimate strength tests

Of particular interest were tests of the boom's anticipated ability to release objects trapped inside by sliding over the top of such obstructions and then righting itself.

OPERATOR :

Canadian Marine Drilling Ltd.

REPORT :

"Evaluation of the Bennett Canmar Oil Containment Boom
Arctec Canada Ltd.

COST : \$28,000

APCA Project No. 101

Title: Field Testing of The Mobile Ice Chipper II

Purpose and Method: The objective of these tests is to demonstrate the capabilities of a skid supported ice chipper. Results of the tests will be used to prepare operational specifications for use on seismic exploration crews.

Operator: Sun Oil Company Limited

Report: "A Report on The Field Testing of The Mobile Arctic Ice Chipper as Modified and Tested in March, 1976" by Sun Oil Company Limited

Cost: Equal share of costs at \$30,000 (maximum of \$10,000)

415
October 13, 1976

A.P.O.A. PROJECT #102

TITLE: Multi-Year Pressure Ridge Study, Queen Elizabeth Islands.

PURPOSE AND METHOD: The objective of this study is to obtain as much information on multi-year pressure ridges and their size and configuration, as they exist within the channels of the Queen Elizabeth Islands, N.W.T.

Data from overflights by Polar Continental Shelf and Atmospheric Environment, along with maps as published by the Ice Forecasting Central and ERTS photos were used to determine areas for specific overflights to determine ridges made from April 2nd through 7th, 1976 to locate desired ice features and to position the camp.

For approximately three weeks during the latter part of May and the first part of June, 1976 the thickness and geometry of various pressure ridges was recorded by using standard survey leveling techniques, direct measurement through holes augered through the ridges and side looking sonar. Density calculations and compressive strengths were also obtained from selected ridges.

OPERATOR: Sun Oil Company Limited

CONSULTANT: NORCOR Engineering and Research Limited

REPORT:

- (1) Progress Report #1
April 28, 1976 - Sun Oil
- (2) Reconnaissance Flight
Queen Elizabeth Islands of April 2-7
May 15, 1976 - NORCOR
- (3) "Multi-Year Pressure Ridge Study
Queen Elizabeth Islands"
October, 1976 - NORCOR

COST: \$179,884.00

April 10, 1979

APQA Project No. 103

TITLE:

Interaction Between Ice Sheets and Wide Structures

PURPOSE:

1. To determine if ice of typical thickness will ride-up or pile-up on Netserk type artificial islands.
2. For the cases in which ride-up occurs, investigate techniques to induce pile-up.
3. For those cases in which pile-up occurs but tends to encroach on the island, investigate techniques which will limit or eliminate the encroachment.
4. In all the above cases, measure the horizontal load on the island and observe and record the mechanisms by which the ice sheet fails.
5. Investigate the horizontal loads generated and the failure mechanisms of an ice sheet impinging on a pile-up.

OPERATOR:

Imperial Oil Limited

REPORT:

Large scale ice interaction tests with artificial island and with a caisson retained island winter 1975-76 - A. Semeniuk Imperial Oil Limited IPRT-9ME-76, November 1976.

COST:

Estimated Cost \$245,000 - Max participant \$40,000

PARTICIPANTS:

Gulf, Shell, Imperial

CONFIDENTIALITY:

June 1981

October 19, 1978

APMA Project No. 104

TITLE: Measurement of Ice Pressure on Artificial Islands - Phase 1.

PURPOSE:

1. To measure the in-situ pressure on an artificial island, Imperial Oil Limited's Adgo P-28, during the winter of 1973 - 1974 with sensors supplied by the University of Alaska.
2. To develop a large area in-situ ice pressure sensor.
3. To measure the in-situ ice pressure on the artificial islands Netserk B-44 and Adgo P-25 during the winter of 1974-1975; the former with both the U. of Alaska and large area pressure sensors and the latter with the U. of Alaska sensor only.
4. To analytically investigate the stress field adjacent to an in-situ sensor.

OPERATOR: Imperial Oil Limited

REPORT:

- Ice Pressure Measurements Netserk B44 1974/75, A.R. Savilchuk, (to be published)
- Finite Element Analysis of PR & TS In-situ Ice Pressure Sensors, IPRT-30ME-75, Sept 1975, P.N. Trofimenkoff, Imperial Oil Limited.
- Landfast Ice Movement - Mackenzie Delta 1973-74, IPRT-2ME-75, (pp.30-33 plus associated figures only) L.G. Spedding.
- Ice Conditions and Ice Deformation at Netserk B-44 and Adgo P-25 During the winter of 1974-75, IPRT-4ME-76, July 1976, M. Metge, Imperial Oil Limited.
- Ice Stress Measurement at Adgo Island, R.D. Nelson and W.M. Sackinger, Penco Canada Ltd. for Imperial Oil Ltd., Oct. 1974.
- Ice Stress Measurements at Adgo and Netserk Islands, 1974-75, R.D. Nelson and W.M. Sackinger, U. of Alaska for Imperial Oil Ltd.
- Landfast Ice Movement Mackenzie Delta 1974/75, IPRT-26ME-75, L.G. Spedding, Imperial Oil Ltd. (only pp. 19-22 incl., plus associated tables and figures)

COSTS:

Estimated Costs \$547,000
Fixed Fee per participant \$49,000

PARTICIPANTS:

Gulf Oil Canada Ltd., Shell Canada Resources Ltd.,
Imperial Oil Ltd.

CONFIDENTIALITY:

March 2, 1981

October 19, 1978

708

APQA Project No. 105

TITLE: In-Situ Ice Pressure Measurements Around Artificial Islands in Northern Beaufort Sea - Phase II.

PURPOSE:

1. To measure the in-situ pressure around two artificial islands; Imperial Oil Limited's Ikattok J-17 and Netserk F-40; during the winter of 1975-1976 using the Imperial Oil large area pressure sensor.
2. Monitor ice movements around Ikattok J-21 and Netserk F-40 relative to the sea bottom and the islands themselves.
3. Monitor the strain field around Ikattok J-21 and Netserk F-40.
4. Analyze using Finite Elements, the effect of ice creep on the pressures recorded by the in-situ ice pressure sensors.

OPERATOR: Imperial Oil Limited

REPORT:

- Ice Pressure Measurements Netserk F-40 1975-76, IPRT-14ME-77, 1977, A.B. Sevilchuk, Imperial Oil Ltd.
- Landfast Ice Movement Mackenzie Delta 1975/76, IPRT-14ME-77, June 1977, L.G. Spedding, Imperial Oil Ltd. (Sections 1 and 2 of the report only)
- Ice Pressure Sensor calibrations 1976, IPRT-11ME-77 Sept. 1977, P.K. Trofimenkoff, Imperial Oil Ltd.
- Ice conditions around Artificial Islands, 1975/76, IPRT-21ME-77, R.W. Gladwell, Imperial Oil Ltd.

COSTS: Estimated Costs \$468,000
Fixed Fee per participant \$46,000

PARTICIPANTS: Gulf Oil Canada Ltd., Sun Oil Co. Ltd., Shell Canada Resources Ltd., Imperial Oil Ltd.

CONFIDENTIALITY: March 3, 1981

October 19, 1978

ARPA Project No. 106

TITLE: Continuous Crushing of an Ice Sheet by a Circular Indenter

PURPOSE:

1. To identify failure mechanisms as a function of strain rate during continuous crushing of a circular indenter into an ice sheet.
2. To determine maximum secondary failure loads as a function of strain rate during continuous crushing and relate these to initial break-out loads from a frozen-in condition.
3. To determine the influence of indenter diameter and thickness on secondary failure loads and failure mechanisms.

OPERATOR: Imperial Oil Limited

REPORT: To be published later

COSTS: Estimated Costs \$157,000 Max/part \$31,000

PARTICIPANTS: Gulf Oil Canada Ltd., Imperial Oil Ltd.

CONFIDENTIALITY: March 1981

October 19, 1978

A.P.O.A. PROJECT #107

TITLE : Some Aspects of Weathering and Burning of Crude Oil in Water
and Ice Environment

PURPOSE AND METHOD : To establish how much oil can be burned when floating
free on icy water. Also, to test various methods of igniting such
oil. The Method - two types of crude oil, light and heavy, were
poured into large specially made trays with one week intervals and
let stand to weather naturally. At the time of the tests a carefully
measured quantity of oil would be poured onto icy water in special
burning trays and ignited by various means, including self combusting
chemicals. After each burn the residue was carefully collected and
measured.

OPERATOR : Canadian Marine Drilling

REPORT : "Some Aspects of Weathering and Burning of Crude Oil in Water
and Ice Environment"

COST :

APQA PROJECT NO. 108

TITLE: In-Situ Burning of the Products of a Subsea Blowout

PURPOSE
AND METHOD:

To determine if it is possible to burn the oil and gas issued from an offshore blowout, which, if possible, would greatly reduce the pollution resulting from such an event.

Gas was injected through an orifice at the bottom of a tank of water and ignited on the surface. Four different gases were used and several different flow rates. The effects of wind, waves and ice floes on the burning gas was investigated.

Oil was also injected and attempts made to ignite it on the surface. The generation and effects of the wave rising (as proposed by Topham) was investigated.

Theory was developed to study the scaling from model to full scale (model scale ratio 30 to 50 to 1)

Model tests were conducted by Arctec, theoretical modelling of burning by University of Waterloo (D.T. Brustowski) and analysis by Dr. K. Azzis, University of Calgary

OPERATOR: Dome Petroleum

REPORT: In-Situ Burning of the Products of a Subsea Blowout (report released)

COST:

AP/IA Project No. 109

TITLE: Model Ice Pile-up and Ride-up on Islands

PURPOSE:

1. To observe the interaction (pile-up or ride-up) when a large ice flow with practically infinite kinetic energy collides with an island under two conditions.
(a) Island slope frozen, ice thin and strong (freeze-up)
(b) Island slope thawed, ice thick and weak (break-up)
2. To determine the amount of ice encroachment on the island under same conditions.
3. To identify the key parameters of the ride-up and pile-up phenomena.
4. To test defense systems that will initiate pile-up at the water line in the cases where ride-up is a possibility

OPERATOR: Imperial Oil Limited

CONSULTANT: Arctec Canada Limited

REPORT: Model Experiment to examine the Behavior of an Ice Field Impinging on a Man-made Island, Arctec Canada Ltd. Final Report 124 C. AP/IA-76-2 + 16 mm film.

COST: Estimated Cost \$42,000 Max/part \$7,000

PARTICIPANTS: Gulf Oil Canada Ltd., Imperial Oil, Sun Oil

CONFIDENTIAL: March 1981

October 19, 1978

A.P.O.A. PROJECT P 110

TITLE: Conical and Cylindrical Gravity Structures for Southern Beaufort Sea

PURPOSE: 1. To design exploratory gravity-founded platforms for exploratory drilling in the Beaufort Sea.

OPERATOR: Imperial Oil Limited

CONSULTANT: Swan-Mooster
Cook, Pickering and Doyle

REPORT: (A) Monopod - Steel

1. Conceptual Design by Swan-Mooster - July 1973
"Beaufort Sea Monopod Conceptual Design".
2. "Soils Engineering Report Beaufort Sea" - Foundation Study by Cook, Pickering and Doyle - July 1973.
3. Imperial's submission to Canadian Government -- September 1973.

Note: Data obtained from other APOA projects (2, 9, 12, 13, 14, 16, 31, 52, 53) will be removed from this submission in order to require no pre-requisites for this project. Participants in these projects may obtain sections which have been removed.

4. Design Study - Earl and Wright
 - (a) "Monopod Drilling Unit for the Beaufort Sea - Design Criteria" - Revised October 15/73.
 - (b) "Monopod Drilling Unit for the Beaufort Sea - Cost Estimate" - November 25, 1973.
 - (c) "Monopod Drilling Unit for the Beaufort Sea - Cost Estimate" - Revised February 11, 1974.
 - (d) "Monopod Drilling Unit for the Beaufort Sea - Construction and Outfitting" - January 11, 1974.
 - (e) "Monopod Drilling Unit for the Beaufort Sea - Construction and Outfitting" - Addendum No. 1 May 22, 1974.

A.P.Q.A. PROJECT #110

REPORT:

(continued)

5. Model Tests - Earl Wright
 - (a) "Model Tests of Imperial's Monopod Drilling Unit - UTC 73-40, November 1973.
 - (b) "Model Tests of Imperial's Monopod Drilling Unit - Supplement to UTC 73-40.
6. Beaufort Sea Monopod Shear Key Test Program, Swan Wooster, April 1974.
7. Set of Drawings for Monopod Drilling Unit.
- (B) Monopod Concrete - Swan Wooster
 - "Beaufort Sea Monopod - A Preliminary Report on a Concrete Monopod Concept" - March 22, 1974.
- (C) Monocone and Fixed Cone - Swan Wooster
 - (a) "Beaufort Sea Monocone - Conceptual Design" Vol. 1, November 1974.
 - (b) "Beaufort Sea Monocone Conceptual Design" Vol. 2, November 1974.
 - (c) Model Tests for Set Down and Towing at National Research Council.
"Monocone Model Tests" - LTR-SH-174-May 1978.
 - (d) "Beaufort Drilling Structure - Preliminary Report on a Fixed Concrete Cone" - November 29, 1974.

COST:

\$939,532

February 28, 1977

APDA Project No. 111

TITLE: Evaluation of Ice Defence Systems for Artificial Islands

PURPOSE:

1. To determine the failure characteristics of an ice sheet with slots cut into it to produce weakened ice. This constitutes one type of defence system for artificial islands.
2. To determine the behavior during failure under pressure of an ice sheet with a simulated wide thermal crack.
3. To study the buckling characteristics of various thicknesses of ice columns.

OPERATOR: Imperial Oil Limited

REPORT: Island Defense System Tests - P. Trofimukoff, Imperial Oil Limited Laboratory Report 19ME-76, October 1976.

COST: Estimated Cost \$44,000 Max/part \$7,500

PARTICIPANTS: Imperial Oil Limited, Amoco

CONFIDENTIAL: April 1981

October 19, 1978

APOA Project No. 113

TITLE: Passage Into Beaufort Sea Via Point Barrow

PURPOSE:

1. To determine the probabilities of successfully passing from the Pacific Ocean to the Mackenzie River Delta area of the Beaufort Sea or return - given different starting dates, drafts and assumptions about the progress of the passage, specifically speed as a function of ice conditions.
2. To determine the time spent on these passages.

OPERATOR: Imperial Oil Limited

REPORT: Statistical Study of Passage into the Beaufort Sea via Point Barrow, IPRT-22ME-77, Dec 1977, S.E.G. Wilson, Imperial Oil Ltd.

COST: Estimated Cost \$6,000 \$1,000 per participant fixed

PARTICIPANTS: Gulf Oil Canada Ltd., Imperial Oil, Dome Petroleum Ltd., Shell Development Co. Ltd. Amoco Canada Petroleum Co. Ltd.

CONFIDENTIAL: March 15, 1981

October 19, 1978

APOA PROJECT NO. 114

TITLE:

Preliminary Tests of Bird Scare
Devices on the Beaufort Sea Coast.

PURPOSE AND METHOD:

In the event of a major blowout in the Beaufort Sea, large numbers of waterfowl could be affected by an oil spill. Bird deterrent experiments have been conducted at airports, inland lakes and in fields, however deterrents have not been tested in marine arctic areas.

In the summer of 1977, one month of fieldwork was carried out at Atkinson Point (Tuktoyaktuk Peninsula) to test the effectiveness (i.e. time, area, distances) of three devices to deter and/or disperse water birds from a coastal bay. The devices used were: a propane cannon, an electronic AV-alarm and a helicopter.

OPERATOR:

Canadian Marine Drilling Ltd.

REPORT:

Preliminary Test of Bird Scare
Devices on the Beaufort Sea Coast.

COST:

\$11,000.00

A.P.O.A. PROJECT #115

TITLE: Polar Bear Research

PURPOSE: 1. To support a basic and applied research program on polar bear ecology as a laboratory in Churchill, Manitoba.

OPERATOR: Imperial Oil Limited

CONSULTANT: University of Guelph Dr. Keith Ronald

REPORT: To be published later.

COST: Total Cost is unknown, but cost per participant - \$1,000

February 28, 1977

A.P.O.A. PROJECT #117

TITLE: Statistical Study of Late Winter Ice Thickness Distribution
in the Arctic Islands from Seismic Data (1976).

PURPOSE AND
METHOD: To provide information on ice thickness distribution in the
Arctic Islands to assist in the design and evaluation of
various drilling and re-supply schemes for the Arctic Islands.
The thickness of the ice at various locations will be deter-
mined by drilling through the ice and measuring the thickness.
This data will then be analysed by computer to obtain a
statistical frequency of occurrence of an ice thickness above
a given value. A computer plot will be made of ice thickness
along each line. These plots will be keyed to reference maps
showing the geographic location of the lines.

OPERATOR: Sun Oil Company Limited

REPORT: Completed June, 1977:
Volume 1 - General Information
Volume 2 - Statistics
Volume 3 - Profiles

COST: \$22,527.49

April 9, 1979

A.P.O.A. PROJECT #118

TITLE: Arctic Islands Winter Ice Movement Study, 1976-1977.

PURPOSE AND METHOD:

A.P.O.A. Project #118 is a continuation of projects #79 and #95, however these projects are not pre-requisites. Ice Motion was measured utilizing the Doppler Satellite Survey Technique for the first time in this application at Stations 1, 2, 3 and 4A. Ice Motion was also measured at Stations 2 and 4A by the acoustic bottom reference system utilized in the previous projects for a comparison of the two methods. Ocean currents and weather instrumentation was deployed at Station #2 and #4A.

RAMS transmitters were deployed on the ice at Stations #2 and #4A in early July and were used to track the movement of the ice throughout the summer and fall and subsequent early winter periods. C-CORE obtained measurements of ice strain at Station #2 during portions of April, May and June and reported on the correlation between ice strain measurements and ice movement measurements.

The location of the stations were as follows:

Station #1	Lat. 78°30'55.921"	Long. 107°06'02.116"
Station #2	Lat. 76°58'02.513"	Long. 110°40'25.900"
Station #3	Lat. 76°49'11.048"	Long. 106°03'34.728"
Station #4	Lat. 77°37'33.638"	Long. 99°27'26.103"

Panarctic Oils Ltd.

OPERATOR:

CONSULTANTS:

Innovative Ventures Ltd.,
H.G. Falkenberg & Associates Ltd.,
Centre for Cold Ocean Resources Engineering.

REPORTS:

Published on completion of study. Reports distributed to participants.

FINAL COST:

\$ 532,858.33 Total
\$ 88,809.72 Per Participant

RELEASE DATE:

Information can be released November 26, 1981.

PARTICIPANTS:

<u>Name</u>	<u>Amount</u>
Sun Oil Company	\$ 88,809.72
Phillips Petroleum	88,809.72
Petro-Canada	88,809.72
Gulf Oil Canada	88,809.72
Dome Petroleum	88,809.72
Panarctic Oils Ltd.	88,809.72
Total	<u>\$532,858.33</u>

A.P.O.A. PROJECT 119

TITLE: Remote Detection of Oil In/Under Ice

PURPOSE: Under certain conditions, oil while migrating from an oil spill source will become trapped in and under ice floes or an ice sheet. Subsequent recovery of this oil will be through holes drilled to the pools of oil in the ice or the oil will be allowed to migrate to the surface of the ice through brine channels and be burnt on the next pass in Spring.

In both cases, a knowledge of the locations and the volumes of the packets of oil trapped in the ice will be of considerable benefit in developing an effective clean-up program. At present, systematic drilling of the ice is the only effective method of locating oil in and under ice. This is a time-consuming and costly method and there is an obvious need for a remote sensing technique.

An impulse radar system has been developed for remotely measuring ice thickness and the feasibility of applying this technique for the detection of oil in and under ice needs to be investigated.

OPERATOR: Esso Resources Canada Limited

CONSULTANTS: Geophysical Survey Systems Inc.
U.S. Army Cold Regions Research and Engineering Laboratory

REPORT: To be published

COSTS: Estimated cost: \$51,000
Maximum per participant: \$12,750

PARTICIPANTS: Esso Resources Canada Limited
Gulf Oil Canada Ltd.
Polarctic Oils Ltd.
Dome Petroleum Ltd.
Shell Canada Resources Ltd.

CONFIDENTIALITY: November 17, 1981

A.P.O.A. PROJECT #120

TITLE:

Safe Ice Detector

PURPOSE:

To develop a simple and economical fail safe device, for mounting on the front of a vehicle when travelling on ice covered waters to warn the vehicle operator that he is approaching an unsafe ice condition. The detector would utilize the basic radar, ice profiling technology developed by GSSI. The device would be developed for use by unskilled operators.

OPERATOR:

Panarctic Oils Ltd.

CONSULTANT:

Geophysical Survey Systems Inc.

PARTICIPANTS:

The project proposal required six participants to proceed and was cancelled when this level of participation was not achieved.

APQA PROJECT NO. 122

TITLE: In-Situ Ice Pressure Measurements 1976/77

PURPOSE:

1. To increase the data bank on actual in-situ ice pressures in order to provide additional information for design data for artificial islands.
2. To use the sensors as a warning device to alert operating personnel of any excessive pressure build-up in the surrounding ice sheet.
3. To relate the ice pressure measurements to forces on the island.
4. To relate the pressure measurements to events, i.e. storms, ridge formation, etc. which will aid in providing an explanation for the high or low pressures recorded.

OPERATOR: Imperial Oil Limited

REPORT:

- Ice Pressure Measurements at Arnak L-30 and Kemmerik G-42, 1976/77, IPKT-15ME-77, A. Semenluk, Imperial Oil Ltd.
- Ice Conditions around Artificial Islands 1976/77, IPKT-33ME-78, D. Favrat, Imperial Oil Ltd.

COST: Estimated Cost \$790,000 Max cost/participant \$116,200

PARTICIPANTS: Imperial Oil Ltd., Gulf Oil Ltd.

CONFIDENTIALITY: December 1981

October 19, 1978

APCA Project No. 121

TITLE: Continuous Crushing of Ice: 1976/77

PURPOSE:

1. To determine the effective ice stresses for very low strain rate penetration of an ice sheet by an indenter.
2. To determine the rate of decrease of the median stress for continuous crushing with increasing ice sheet thickness.
3. To determine the effect on continuous crushing stresses of indenter shape, temperatures and geometric scale.

OPERATOR: Imperial Oil Limited

REPORT: To be published later.

COST: Estimated Cost \$196,000 max/participant \$39,000

PARTICIPANTS: Imperial Oil, Gulf Oil Ltd.

CONFIDENTIAL: Dec. 1981

October 19, 1978

APOA Project No. 124

TITLE: Experimental Study of Ice Pile-Up

PURPOSE:

1. To induce pile-up conditions by the two mechanisms of instability identified to date.
2. To record the pile-up conditions and the physical parameters associated with the pile-up.
3. To determine the effects on the failure mode of variations in beach slope and configuration and ice thickness.

OPERATOR: Imperial Oil Limited

REPORT: To be published later.

COST: Estimated Cost \$130,000 max/participant \$20,000

PARTICIPANTS: Imperial Oil, Gulf Oil Ltd.

CONFIDENTIAL: Oct. 1982

October 19, 1978

APCA PROJECT NO. 123

TITLE: Experimental Ridge CRI Interaction 1976/77

PURPOSE:

1. To determine the mode of failure of a pressure ridge impinging against the CRI structure and against a consolidated pile-up ahead of the structure.
2. To measure the total force exerted on the structure during such ice movements.

OPERATOR: Imperial Oil Limited

REPORT: Experimental Ridge CRI Interaction, IPRT-17ME-77,
L. W. Rosenegger, Imperial Oil Ltd.

COST: Estimated Cost \$137,000, max/participant \$20,000

PARTICIPANTS: Imperial Oil Ltd., Gulf Oil Ltd.

CONFIDENTIALITY: September 1982

October 19, 1978

APCA NO. 126

Title Biological Literature Review of Davis Strait

Purpose and Method Conduct a literature review of existing biological data in the Davis Strait region of Canada from 60°N to 70°N including Hudson Strait. Investigation to include identification of data gaps in the biological information particularly insofar as these data deficiencies pertain to the environmental study guidelines for Davis Strait issued by the Department of Indian Affairs and Northern Development.

Operator Imperial Oil Limited

Consultant MacLaren Atlantic Limited
Engineers, planners and environmental consultants
Halifax, Nova Scotia

Report Biological Literature Review of the Davis Strait Regi
(MacLaren Atlantic)

Cost \$28,463

Confidential
Date to be made public (5 year secrecy)

APQA NO. 127

Title Winter Environmental Investigations in Davis Strait - 1977.

Purpose and Method To obtain winter biological information in relation to ice conditions adequate for the preparation of environmental assessment to support an application for exploratory drilling in Davis Strait. Winter biological information has been identified a major data gap for the Davis Strait region. This information is essential in the preparation of an environmental impact assessment required by the Department of Indian and Northern Affairs before approval of exploration drilling application.

Operator Imperial Oil Limited

Consultant MacLaren Atlantic Limited
Engineers, planners and environmental consultants,
Halifax, Nova Scotia

Report Report on the Davis Strait Aerial Survey 77-1
(MacLaren Atlantic)

Report on Cruise 77-1, February 1977
Environmental Aspects of the Cruise to Davis Strait
and the Labrador Coast
(MacLaren Atlantic)

Cost \$154,000

Date to be made public - Dec. 31, 1979

APNA Project No. 128

TITLE: "Davis Strait Ice and Oceanographic Investigations Winter 1976-77"

PURPOSE: 1. To observe sea ice conditions and measure flow characteristics and movement and surface current profiles near the ice edge in the Davis Strait area and off the coast of Labrador (December 1976 and February 1977)

OPERATOR: Imperial Oil Limited

REPORT: "Davis Strait Ice and Oceanographic Investigations Winter 1976-77"
Fenco Consultants Ltd.
Calgary

COST: Estimated Cost \$175,000.00

PARTICIPANTS: Aquitaine Company of Canada Ltd., BP Exploration Canada Limited, Canada-Cities Service Ltd., Hudson's Bay Oil and Gas Co. Ltd., Imperial Oil Limited, Shell Canada Resources Limited.

CONFIDENTIAL: March 1982

October 19, 1978

3-78

501

APDA Project No. 129

TITLE: Ocean Current Studies in the Vicinity of the Hudson Strait/Davis Strait Area, 1976

PURPOSE:

1. To gain an understanding of the ocean currents in the Davis and Hudson Straits region, from the surface to the sea floor, and an understanding of how these currents vary with location and time.
2. To determine current profiles for use as design criteria.

OPERATOR: Imperial Oil Limited

REPORT:

- Field Report on the Oceanographic Cruises During April July-Aug, Oct-Nov, 1976, MacLaren Atlantic Ltd., Feb 1977 for Imperial Oil Ltd.
- Imperial Oil East Coast Mooring Program Analytical Phase Volume I, and II Martec Ltd. 1976 for Imperial Oil Ltd.

COST: Estimated Total \$270,000.00
Participants (270,000 + 10%) = No. of participants
(max \$45,000)

PARTICIPANTS: Aquitaine Company of Canada Ltd., Canada Cities Services Limited, Shell Canada Resources Ltd., BP Exploration Canada Ltd., Hudson Bay Oil & Gas Co. Ltd., Imperial Oil Ltd.

CONFIDENTIAL: Dec. 1981

October 19, 1978

APOA Project No. 130

Title: Preliminary Design Studies for Production Structures for the Beaufort Sea.

Description: The objective of this project was to develop design concepts for oil and gas production platforms to be installed in water depths of 95 feet and 180 feet in the Beaufort Sea.

Operator: Dome Petroleum Limited

Reports: The project includes the following reports (Table of Contents attached)

- (i) A Preliminary Analysis of Requirements for Development and Operation of Oil Fields in Beaufort Sea - Phase II Survey of Potential Structures (Crest Engineering Inc.)
- (ii) Engineering Properties of Ice in the Beaufort Sea (F.C. Bercha and Associates Limited)
- (iii) Preliminary Investigation of Potential Concept for a Gas Production Platform for the Timgbi Well Location in the Beaufort Sea (Crest Engineering Inc.)
(Reports restricted to participants)

Cost: \$81,000

A.P.O.A. Project #131

Title: Feasibility (Phase I) and Development
(Phase II) of a Bottom Mounted Under
Ice Profiling System

Purpose
and Method: The purpose of this phase I study is to investigate the
feasibility of developing an electronic system capable
of under ice profiling and velocity measurement for
zones of highly mobile ice.

The work analyzes alternative methods of obtaining
significant under ice and ridge profile data and re-
commends an optimum system based upon reliability and
costs.

The data collection priorities that were used in this
consideration are:

1. Keel depth/ice thickness versus time
2. Absolute Ice Velocity versus time
3. Ice Velocity components relative to arbitrary
reference
4. Water pressure (used to determine instrument
depth)
5. Temperature.

Operator: Gulf Oil Canada Limited

Consultant: Hermes Electronics Ltd.
Dartmouth, Nova Scotia

Report: Study Report A Bottom Mounted Under Ice
Profiling System.

Cost: \$12,200.

Confidentiality: 5 years from May 30, 1977.

A.P.O.A. Project #133

Title: Investigation of Sea-Bed Scouring in the Beaufort Sea (Phase III).

Purpose and Method: The purpose of this study was to analyze approximately 2100 line miles of Beaufort Sea echo sounder data recorded in 1974, 1975 and 1976 for scour depth and frequency.

Maps were generated for the study area showing echo sounder tracks, mean scour depth, maximum scour depth, frequency of scouring, unusual features, and scour return period. The data from APAO projects 19 and 32 has been incorporated into these maps.

Regression analyses of scour frequency and depth versus water depth has been included along with the methodology of scour return period computations based upon sedimentation assumptions.

Operator: Gulf Oil Canada Limited

Consultant: McLaren Atlantic Limited
Halifax, Nova Scotia

Report: Investigation of Sea-Bed Scouring in the Beaufort Sea (Phase III).

Cost: \$14,700.00

Confidentiality: 5 years from March 3, 1977.

APOA NO. 134

Title Late Winter and Spring Investigations in
Davis Strait - 1977.

Purpose
and Method To obtain spring biological information in relation
to ice conditions and shorelines adequate for the
preparation of an environmental assessment to support
an application for exploratory drilling in Davis
Strait. This to be carried out by both ship cruise
and aerial survey.

Operator Imperial Oil Limited

Consultant MacLaren Atlantic Limited
Engineers, planners and environmental consultants
Halifax, Nova Scotia

Report Report on Cruise 77.2 and 77.3 Davis Strait Biologic
Program April-May (MacLaren Atlantic)

Cost \$341,000

Date to be released to the public - Dec. 31, 1979

APQA NO. 135

Title Biological Studies in the Vicinity of Hudson Strait,
Davis Strait and Labrador Sea Area - 1976.

Purpose and Methods To obtain biological information adequate for the
preparation of environmental assessment to support
an application for exploratory drilling in Davis
Strait. The field investigations to be conducted
on three separate ship cruises.

Operator Imperial Oil Limited

Consultant MacLaren Atlantic Limited
Engineers, planners and environmental consultants
Halifax, Nova Scotia

Report Report on Cruise II, July 1976
Environment of the Imperial Oil Limited Cruise to
Flemish Pass and Davis Strait (MacLaren Atlantic)

Field Report on the Oceanographic Cruises during
July-August, October-November, 1976.

Report on Cruise III, October-November, 1976 and
Cruise IV November-December, 1976. Environmental
Aspects of the Davis Strait, Hudson Strait and
Flemish Pass (MacLaren Atlantic)

Cost \$74,800

APCA PROJECT NO. 136

TITLE:

Beaufort Sea Shoreline Study: Kotzebue Beach to Baillie Islands.

PURPOSE AND METHOD:

If there were a major oil spill in the Beaufort Sea and shoreline contamination was imminent, the On-Scene Commander and his colleagues must selectively appoint resources to important coastal stretches in order to minimize environmental damage. The final report aids spill response planning by:

- 1) establishing the relative importance of all sensitive coastal regions between the Alaska-Yukon border (141° W) and the Baillie Islands (128° W).
- 2) recommending oil spill protection and cleanup strategies for the identified, important stretches of coastline.

The study began in 1976 with the preparation of a Beaufort Sea Atlas which was based on literature review and interviews with key scientists. Two summers of fieldwork supplemented the atlas in order to collect site specific and operational information pertinent to oil spill response. The result of this work is the shoreline oil spill manual. Before the manual could be completed, a ranking system had to be developed to establish the relative importance of all sensitive coastal regions in the study area.

Traditional environmental impact assessment methodologies have been used to develop the ranking scheme. The ranking system has been reviewed by a panel of government and industry scientists, as well as other government officials. Staff from the Environmental Protection Service, the Arctic Marine Oilspill Program (AMOP) worked with the APCA in reviewing the manual and ensuring that government scientists familiar with the Beaufort Sea area has the opportunity to comment on its contents.

APCA PROJECT NO. 116 (cont'd)

OPERATOR:

Canadian Marine Drilling Ltd.

REPORTS:

- 1) "Coastline of the Beaufort Sea; An Atlas of Environmental Factors Pertaining to Onshore Oil Spill Counter-measures" (Canmar 1976).
- 2) "Shoreline Protection and Cleanup Manual for the Southern Beaufort Sea" (to be printed March 1979).

COST:

\$51,060.00

A.P.D.A. PROJECT 4174

TITLE: ENVIRONMENTAL Investigations and Analysis in Davis Strait
- Second half 1977.

PURPOSE AND METHOD: To obtain information on the physical oceanography and biological environment in the sea and shorelines adequate for the preparation of an environmental assessment to support an application for exploratory drilling in Davis Strait.

OPERATOR: Imperial Oil Limited (Now Esso Resources Canada Limited)
Associate Operators:
Aquitaine Company of Canada Ltd.
Canada-Cities Service Ltd.

REPORTS: (see attached list)

COST: Estimated total Project Cost: 32,310,000.

Project costs shared by Esso Resources, Aquitaine and Canada-Cities Service

Participation costs:

Associate participant	10%
Contributory participant	5%

PARTICIPANTS: Esso Resources Canada Limited
Aquitaine Company of Canada Ltd.
Canada-Cities Service Ltd.
B.P. Exploration Canada Ltd.
Hudson Bay Oil and Gas Co. Ltd.
Shell Canada Resources Ltd.

CONFIDENTIALITY: Jan 1 1979

A.P.O.A. PROJECT FILES

- Aerial Surveys 77-2, 77-3, 77-4, Studies of Seabirds & Marine Mammals in Davis Strait, Hudson Strait & Ungava Bay, MacLaren Atlantic Ltd., Dartmouth, February 1978, APOA Projects 134 & 138-20.
- Analysis of Ocean Currents, Davis Strait - 1977, 2 vols, T.R. Osborn, et al, Seaconsult Marine Research Ltd., Calgary, March 1978, APOA Project 138-10.
- Biological Literature Review of Ungava Bay & Hudson Strait, MacLaren Atlantic Ltd., Dartmouth, November 1977, APOA Project 138-2, MacLaren 77-4.
- Biological Literature Review of the Labrador Sea Region, MacLaren Atlantic Ltd., Dartmouth, November 1977, APOA Project 138-1, MacLaren 77-5.
- Coastal Environment of Southern Baffin Island & Northern Labrador - Ungava, R.G. Barry, et al, Institute of Arctic & Alpine Research, for APOA, December 1977, APOA Project 138-6.
- Davis Strait Surface Drifter Buys Program 1977, M. Hetge, Imperial Oil Limited, Production Research Division, Calgary, March 1978, IPRT-3ME-78, APOA Project 138-22.
- Davis Strait Wave Climate Study, 1970-77 Meteorological & Oceanographic Centre Synoptic Significant Wave Charts, Sites 1 & 2, W.H. McKay, Imperial Oil Limited, Production Research Division, Calgary, March 1978, IPRT-10ME-78, APOA Project 138-24.
- Environmental Conditions Off the East Coast of Canada: Sites 1 & 2, M. Dannard, Atmospheric Dynamics Corp., Imperial Oil Limited, Production Research Division, Calgary, October 1977, APOA Project 138-3.
- Environmental Conditions Off the East Coast of Canada: Godthaab, Greenland - 64 deg. 10 mins. N, 51 deg. 45 mins. W, Addendum, M. Dannard, Atmospheric Dynamics Corp., April 1978, APOA Project 138-3 Addendum.
- Final Report - 1977 Ocean Current Study, Innovative Venture Ltd., Calgary, January 1978, APOA Project 138-13.
- Inuit Natural Resources Use in South East Baffin Region, MacLaren Atlantic Ltd. for APOA, Dartmouth, March 1978, APOA Project 138-25.
- Preliminary Nearshore Environmental Studies on Southeast Baffin Island, MacLaren Atlantic Ltd., Dartmouth, December 1977, APOA Project 138-18.
- Preliminary Study of the Fate of Oil from a Subsea Blowout on the East Coast, A.S. Telford, M. Hetge, Imperial Oil Limited, Production Research Division, Calgary, April 1977, APOA Project 138, IPRT-2ME-77.
- Primary Data Collected for the 1977 Davis Strait Biological Programme & Analysed Prior to December 1977, MacLaren Atlantic Ltd., Dartmouth, December 1977, APOA Project 138-17.

Report on Biological Studies, Offshore Cruise 77-4 - 77-7, July - December 1977, Davis Strait, MacLaren Atlantic Ltd., for APOA, Dartmouth, 1978, Appendix Included, APOA Project 138-14.

Report on Ice & Meteorological Observations in the Davis Strait During April, May & June, 1977, MacLaren Atlantic Ltd., for APOA, Calgary, December 1977, APOA Project 138-4.

Report on Laboratory Testing of Seabed Samples from Davis Strait, R.M. Hardy & Associates Ltd., Calgary, December 1977, Hardy 77-1, APOA Project 138-15.

Report on Marine Benthic Invertebrates of Southern Davis Strait & Ingsava Bay, MacLaren Marine Inc., Calgary, July 1978, APOA Project 138-23.

Report on Sediment Analysis of Cores from Davis Strait & Flemish Pass, MacLaren Atlantic Ltd., Halifax, December 1976, APOA Project 138-7.

Report on Strength & Deformation Characteristics of Seabed Samples from Davis Strait, R.M. Hardy & Associates Ltd., January 1978, APOA Project 138-9, Hardy 78-2.

Revised Biological Literature Review of the Davis Strait Region, MacLaren Atlantic Ltd., Dartmouth, January 1978, APOA Project 138-19.

Some Sea Ice Cover Statistics for the Canadian East Coast, J. E. Fraser, Imperial Oil Limited, IPRT-37ME-75, October 1975.

NOTE: Project-Report Numbers for 138 that follow are those used in the "APOA REVIEW", and differ from the above list provided from Esso Resources Limited.

A.P.Q.A. Project #139

Title:

Development of High Resolution Ice Tracking System for the Southern Beaufort Sea.
Phase I: Test Prototype NAVSAT/NIMBUS-RAMS Subsystem.

Purpose

and Method:

The purpose of this phase I study is to investigate the feasibility and develop a test-prototype high resolution ice movement buoy.

The basic requirements of the system are that it be self-sustaining for up to 6 months on the ice, that it provide position fixes with an accuracy in the order of 50-100 meters at intervals of 3 hours, and that it be deployable from a Twin Otter or a helicopter.

The development integrates a number of modules into a certain configuration which allows computation of a NAVSAT fix in situ and transmission of that information via the NIMBUS 6 satellite.

Operator:

Gulf Oil Canada Limited.

Consultant:

polar Research Laboratory, Inc.
Santa Barbara, California.

Report:

Development of a High Resolution Ice Tracking System for the Southern Beaufort Sea - Phase I

Cost:

\$22,000.00

Confidentiality: 5 years from January 1, 1978.

APOA Project No. 140

TITLE: "Davis Strait Ice Survey (November-December 1977)"

PURPOSE: To measure ice movement and concomitant meteorological and oceanographic conditions and to define ice conditions prior to and during the incursion of pack ice in southern Davis Strait.

To deploy data buoys to measure flow movement due to wind-driven surface and residual ocean currents.

OPERATOR: Imperial Oil Limited

REPORT: "Davis Strait Ice Survey (November-December 1977)"
Innovative Ventures Ltd.
Calgary

COST: Estimated Cost \$250,000.00

PARTICIPANTS: Aquitaine Company of Canada Ltd., Imperial Oil Limited,

CONFIDENTIAL: December 1982

APCA Project No. 741

Title: Ignition and Burning of Crude Oil on Water Pools Under Arctic Springtime Conditions, May 1977

Purpose and Method: Previous studies had investigated the possibilities for in-situ burning of crude oil on a water surface under Arctic spring condition. This study examines some of the important parameters such as limiting crude oil thickness, minimum crude oil thickness which will support stable burning, ignitor requirements, natural wind herding abilities, etc. related to the in-situ burning of crude oil on water.

An experimental program was undertaken to determine the limiting crude oil film thickness of various crude oils and oil/water temperatures. The possibility of natural wind herding of crude oil films was experimentally and theoretically investigated. Also the use of chemical herding agents for the containment and/or the thickening of crude oil was explored. The ignition and burning of crude oil films on water under wind conditions was experimentally investigated. Some aspects of incident solar radiation on a crude oil film on water were examined. Based on a review of available ignitors, a test program was performed to determine a minimum crude oil film thickness that could be ignited and would support combustion on a water surface, for different crude oils. A solid fuel type ignitor was developed and tested.

Operator: Dome Petroleum Ltd.

Report: Ignition and Burning of Crude Oil on Water Pools Under Arctic Springtime Conditions - May 1977, Energetex Engineering, Waterloo, Ontario

Cost: \$33,747.22

A.P.O.A. PROJECT #142

TITLE: Statistical Study of Late Winter Ice Thickness Distribution
in the Arctic Islands from Siesmic Data (1977).

PURPOSE AND METHOD: To provide information on ice thickness distribution in the
Arctic Islands to assist in the design and evaluation of
various drilling and re-supply schemes for the Arctic Islands.
The thickness of the ice at various locations will be deter-
mined by drilling through the ice and measuring the thickness.
This data will then be analysed by computer to obtain a
statistical frequency of occurrence of an ice thickness above
a given value. A computer plot will be made of ice thickness
along each line. These plots will be keyed to reference maps
showing the geographic location of the lines.

OPERATOR: Sun Oil Company Limited

REPORT: Completed May, 1978:
Volume 1 - General Information
Volume 2 - Statistics
Volume 3 - Profiles

COST: \$74,314.65

APOA Project No. 143

TITLE: Model Experiment to Determine the Forces and Behaviour of Moving Ice Fields against a Concrete Drilling Caisson.

PURPOSE:

1. To determine if pile-up against a CDC occurs
2. To determine freeboard requirements for CDC
3. To measure forces against CDC for interaction with several ice sheet thicknesses.

OPERATOR: Imperial Oil Limited
Consultant Arctic Canada Limited

REPORT: Model Experiments to Determine the Forces and Behaviour of Moving Ice Fields against a Concrete Drilling Caisson. Final Report 105C., Arctic Canada Limited.

COST: Estimated cost: \$43,000 - max/participant \$11,000

PARTICIPANTS: Imperial Oil Limited, Gulf Oil Limited

CONFIDENTIAL: Dec. 1981

APOA Project No. 144

TITLE:

Criticism Retained Island and Ice Ridge Interaction Studies
1977/78

PURPOSE:

1. To reduce the uncertainty of estimated loads imposed
on a CIR by the failure of a multi-year ridge.

OPERATOR:

Imperial Oil Limited

REPORT:

Not completed or titled

COST:

Estimated Cost \$262,000

PARTICIPANTS:

Imperial Oil, Gulf Oil Ltd.

CONFIDENTIAL:

September 1982

APDA NO. 145

Title Caisson Retained Island Design

Purpose and Method To design a drilling platform for Arctic waters using caissons to retain island fill

Operator Imperial Oil Limited

Consultants Albery, Pullerits, Dickson & Associates Ltd.
Robert Allan Ltd
Swan Wooster Engineering Co. Ltd.
E.B.A. Engineering Consultants Ltd.
Hydronamic B. V.
Kingston University
National Research Council
Delft Hydraulic Laboratory

Report Caisson Retained Island Report
vol 1 Design report
vol 2 Design Calculations
vol 3 Internal Reports and General Correspondence
vol 4 Supporting Technical Reports
Complete set of Design Drawings
Executive Summary

Cost \$ 800,000.

Confidential -- 5 years (1933)

APCA NO. 145

Title Biological Environmental Investigations and
Analyses in Davis Strait - 1978.

Purpose
and Method To obtain additional information on the biological
environment in the sea and shorelines in compliance
with government requirements for environmental
assessments in support of offshore exploratory
drilling proposals in Davis Strait. These will be
conducted by government and industry, but industry
funded. The actual field work will involve both
aerial surveys and ship cruises.

Operator Imperial Oil Limited

Consultants Government of Canada (EAMES)
MacLaren Atlantic
Aquatic Environment

Report To be published upon completion of project.

Cost \$1,260,000

TITLE:

Ice Keel Profiling in the Beaufort Sea

PURPOSE
AND METHODS:

To develop and implement a system, capable of remaining on the seabed below the ice in the Beaufort Sea for an entire winter, which will profile the undersurface of the ice by acoustic sonar. The data will be useful for statistical studies of pressure ridge frequencies and keel depth, as well as providing valuable information about the form of pressure ridge keels.

A 3 point sampling system, with transducers positioned 60 metres apart at the vertices of an equilateral triangle, was developed. The system is capable of sampling at each transducer, the depth of the ice below mean sea level, and recording the data on magnetic tape. A pre-storage processing technique reduces the amount of tape storage necessary without any significant loss of meaningful data.

The system was installed in the Beaufort Sea in 30 m of water at a position north of Tuktoyaktuk. Due to logistics problems, only one of the 3 possible transducers was deployed. The system will be recovered in July or August of 1979.

The data should be fully analysed by October 1979 and a report issued soon thereafter. The complete system will be reinstalled in the fall of 1979.

OPERATOR:

Dome Petroleum Ltd.

REPORT:

No formal report issued as of March 1, 1979.

COST:

\$64,000

APQA PROJECT NO. 148

TITLE: Regmented Indenter

PURPOSE:

- To measure stress distribution across a wide indenter.
- To measure continuous crushing stresses for saline ice.
- To evaluate unconfined compressive strength of 12 ice with /flexure platens.

OPERATOR: Esso Resources Canada Ltd.

REPORTS: To be published

COST: \$43,000 \$12,000/participant

PARTICIPANTS: Esso Resources Canada Ltd.

CONFIDENTIALITY: October 1983

AOA Project No. 149

TITLE: Oil Spill and Iceberg Studies Conducted for Preparation of an Environmental Impact Statement for Davis Strait

PURPOSE:

1. To obtain information on the risk of oil spills, behavior of such spills and countermeasure strategy adequate for the preparation of an environmental impact assessment for the Davis Strait region.
2. To gain an understanding of the iceberg regime off the Canadian East Coast.

OPERATOR: Imperial Oil Limited

REPORT:

- Slicktrak Simulations - East Coast, IPRT-10ME-77, Dec 1977, D. Bradfield, M. Metge and A.S. Telford. Imperial Oil Ltd.
- Oil in Pack Ice Cold Room Tests, IPRT-16ME-78, Apr. 1978, M. Metge, Imperial Oil Ltd.
- Deep Sea Dispersion Analysis, NORDDCO Limited for Imperial Oil Ltd., Oct. 1977
- Some Iceberg Statistics for the Davis Strait, IPRT-22ME-78, March 1978, P.M. Trofimenkoff, Imperial Oil Ltd.

COST: Total Project \$155,000, AOA chargeout \$125,500

Costs sharing:	Imperial	52%
	Aquitaine	30%
	Canada Cities	18%
	Assoc. Part.	10%
	Contributory Part.	5%

PARTICIPANTS: Aquitaine, Canada Cities, Imperial Oil Ltd.

CONFIDENTIAL: Jan 07, 1979

APCA Project #150

Title: Laboratory Model Tests of Sea-floor Scouring by Ice Features.

Purpose

The primary objective of this laboratory study is to obtain a better understanding of the processes taking place when different soils (simulated sea bottom) fail under dynamic loads imposed by laterally moving indentors (simulated pressure ridges, icebergs, ice islands, etc.) under modelled environmental conditions such as the speed of ice-mass, sea-bed slope, soil strength, etc. The indentors will be tested at 2 scales in order to draw scale relationships between the model and in-situ ice features.

The parameters that will be monitored include soil reaction at the base, frontal resistance, skin friction, soil strength before and after the loading (in the trench), mode of soil failure, variation of total soil pressure and pore water pressure in front of the indenting face and farther ahead at several locations, stability of the trench e.g. sluffing, dilation of trench sides, and the behaviour of the scouring ice feature.

These parameters will be used to study the following:

- trench characteristics including scour dimensions, surcharge behaviour, liquefaction phenomenon, passive resistance, soil reaction at the bottom, resisting forces on the sides of the indentor, development of soil failure planes and the extent of stress transmission, in three dimensions, in the soil; zones of elastic and plastic failures; the behaviour of the indentor and scale effects; etc.

The following applications are envisioned from the results of this study:

- 1) Estimating for a given location, the maximum scour depth as well as recurrence intervals for a range of scour depths.
- 2) Predicting the effectiveness of natural and artificial underwater barriers (topographic highs, dams, berms, etc.) in stopping the movement of deep draft ice features and consequently determining the depth of burial of pipelines or establishing the depth of a glory hole for the installation of a sub-sea facility.

iii) Verifying the theoretical model of APOA #69 and if necessary updating and/or modifying the assumptions used in this model.

iv) Defining the parameters needed for scour prediction and incorporating these requirements into future offshore ice and geotechnical surveys.

v) Planning full scale field tests, if necessary.

The study is divided into 4 phases as follows:

Phase I - Test Plan Preparation and Model Design

Dates: Initiation - Jan. 15, 1979

End - Mar. 15, 1979

Cost: \$12,000

Phase II - Test Preparation

Dates: Initiation - March 16, 1979

End - April 7, 1979

Cost: \$31,000

Phase III - Test Program

Dates: Initiation - April 8, 1979

End - July 9, 1979

Cost: \$71,500

Phase IV - Data Reduction and Reporting

Dates: Initiation - July 10, 1979

End - July 30, 1979

Cost: \$21,000

OPERATOR: Petro-Canada

Reports: 1: Proposed Test Plan - March, 1979

2: Interim Report - May, 1979

3: Final Report - Aug., 1979

TOTAL PROJECT COST: \$137,500

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Appendix E

Selected Additional Artic Offshore Bibliography

- Section 1. Sea Ice
- Section 2. Icebreakers
- Section 3. Arctic Seafloor Conditions
- Section 4. Ice-Structure Interaction
- Section 5. Frost Heave
- Section 6. Structure Icing

Section 1. Sea Ice

GLACIOLOGICAL DATA

REPORT GD-2

this issue:

ARCTIC SEA ICE **Part 1**

1978

Published by:

WORLD DATA CENTER A FOR GLACIOLOGY
[SNOW AND ICE]

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Glaciological Data, which supercedes Glaciological Notes, is published three to four times per year by the World Data Center A: Glaciology [Snow and Ice]. It is distributed without charge to interested individuals and institutions. Copies of most of the back issues of Glaciological Notes are available without charge upon request.

Direct all communications to:

Marilyn J. Shartran, Editor
Glaciological Data
World Data Center A: Glaciology [Snow and Ice]
Institute of Arctic and Alpine Research
University of Colorado
Boulder, Colorado 80309 U.S.A.

ARCTIC SEA ICE: A SELECTED BIBLIOGRAPHY, 1965-77

Because of the large body of literature on arctic sea ice, we found it necessary to limit the citations included in this bibliography by the date of publication (1965 to 1977), geographic area, and subject scope. Our definition of "arctic" for the purposes of this bibliography is illustrated by the shaded areas in figure 1. The following areas have been excluded unless they were included in more general studies: Bering Sea, Canadian Arctic Archipelago, Baffin Bay (including North Water), Davis Strait, Hudson Bay, Labrador Sea and the Gulf of St. Lawrence.

Figure 1. Shaded areas are included in the bibliography.

The citations have been divided into the ten sections described below:

A. GENERAL

Includes entire works on sea ice, terminology, bibliographies, conference proceedings, and textbooks which contain sections on sea ice.

B. MICROSCALE ICE CHARACTERISTICS

Salinity, electrical properties, dielectric permittivity, engineering aspects, ice chemistry, stress in ice, crystalline structure, ice structure, ice temperature, and some aspects of supercooling.

C. MASS BUDGETS

Mass and heat budgets of arctic ice cover, radiation budgets and albedo of ice types, and transmissivity of ice. Some articles on transfers at the air-water-ice interface are cross-referenced with Category H.

D. MESOSCALE AND MACROSCALE ICE CHARACTERISTICS

Ice surface and underside characteristics, including ridging, hummocking, surface forces, and associated ice dynamics; multiyear ice, ice islands; ice morphology; Ellesmere ice shelf.

E. ICE DRIFT

Ice drift, water drag, ice velocity, ice deformation, ocean circulation and tidal exchange, ice redistribution, air stress by winds, planetary boundary layer, and wind profiles related to ice drift, drifting stations and ice island stations.

F. FREEZEUP, ICE GROWTH, AND THICKNESS

Includes articles on the above and on the refreezing of leads (which are cross-indexed with Category G).

G. BREAKUP, LEADS, POLYNAS

Breakup of sea ice, leads, polynas; plus articles on ice decay and river outflow onto the sea ice cover.

H. THE ICE-OCEAN-ATMOSPHERE SYSTEM

Interrelationships in the ice-ocean-atmosphere system including climate-ice relationships, past climates and ice covers of the arctic. Includes many studies on ice distribution and limits, seasonal and longer term fluctuations of sea ice.

I. REMOTE-SENSING

Data obtained from satellites, sonar and aircraft overflights, and ice measurements made by devices on the ice. Articles are cross-referenced with other categories if useful results are included.

J. ICE FORECASTING

Forecasting of freezeup, breakup, and other ice characteristics and limits.

Note: Modelling studies are listed in their appropriate category. References where modelling is discussed in general, with no specific research results, are placed in Category A.

Except where the citation deals mainly with one of the above subjects, the following topics have been excluded: icebergs; ice engineering; ice breakers; vehicles on ice; navigation, except where ice conditions are reported; organisms in ice; underwater sound; oil spills; action of ice on structures; ice as a geological agent; artificial growth of sea ice.

The decision to exclude particular geographic areas and subjects was made arbitrarily in order to limit the overall magnitude of the undertaking. We propose to include such topics in future bibliographies.

The bibliography has been compiled from several different sources, including the automated and manual indexing and abstracting services listed below. Many of the citations were found uniquely in one source, indicating the need for this more comprehensive literature survey.

Cold Regions Bibliography, 1965-77.

Meteorological and Geostrophysical Abstracts, 1965-76.

Oceanic Abstracts, 1965-77.

NTIS (National Technical Information Service), 1965-77.

Polar Record, 1965-72.

Recent Polar Literature, 1973-77.

Catalog of the Scott Polar Research Institute Library, 1976; monthly accessions lists, 1977.

Journal of Glaciology ["Glaciological Literature"], 1965-77.

Arctic Bibliography, 1965-75.

Georef, 1967-July 77.

Bibliography of Geology, 1965-66.

Bibliography of Geology Exclusive of North America, 1965-66.

Scisearch (Science Citation Index), 1974-77.

Dissertation Abstracts, 1965-77.

Libcon (U.S. Library of Congress), 1968-77.

Monthly Catalog of U.S. Government Publications, 1965-77.

Books in Print, 1977.

Catalog of the Scripps Institution Library, 1970, 1973.

Miscellaneous bibliographies.

In the bibliography, we assume that the language of publication is English unless otherwise stated. Because we do not have all of the original material in hand, we cannot be certain of the completeness of each citation, although every effort possible has been made to ensure accuracy. Where keywords or phrases were provided by the sources, we have included them as guides to subject content. Since we realize that the maximum value of a bibliography lies in the availability of the original documents, we have marked each item owned by the World Data Center with an "*". Photocopies of any of these documents can be provided upon request at \$0.10/page (\$1.00 min.) to institutions and individuals. Lengthy publications are available on interlibrary loan to other libraries. Publications with an NTIS number are available in microfiche or photocopy form from: National Technical Information Service, 5285 Port Royal Road, Springfield, Virginia, 22161, U.S.A. Prices vary according to length of the publication.

We urge you to acquire items not owned by the WDC through your regular library channels or from the publishing agency or author. However, if these methods are unsuccessful, please feel free to call or write the WDC for assistance.

If any individuals or institutions see their publications in this list without an "*", the WDC would gratefully appreciate receiving copies of the ones which are still available.

Since we plan to update the bibliography in the future, we greatly appreciate your notifying us of any errors or omissions.

Marilyn J. Shartran
Assistant Director
World Data Center A for Glaciology [Snow and Ice]

A. GENERAL

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Aagaard, Knut; Coachman, L.K. (1973)
ARCTIC OCEANOGRAPHY. Oceans, v. 6(2), March/April 1973, p. 24-31. [review of the scientific and practical importance of research in arctic oceanography, of the methods used in such research and of some results of arctic oceanographic studies; oceanographic investigation methods involving the method of drifting ships, drifting ice stations or ice islands, aircraft surveys, observations from submarines, ice breakers, and automatic sensing and transmittal]

A-2

Aagaard, Knut (1975)
OCEANOGRAPHY OF THE ARCTIC SEAS. Reviews of Geophysics and Space Physics, v. 13(3), July 1975, p. 614-15. [U.S. research activities in the arctic seas briefly reviewed]

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Abrahamson, Kurt V. (1966)
ARCTIC ENVIRONMENTAL CHANGES. Arctic Institute of North America. Research Paper no. 39, 1966. 79p. Maps, tables.

A-4

Adey, A.W. (1970)
SURVEY OF SEA-ICE-THICKNESS MEASURING TECHNIQUES. Canada. Dept. of Communications. Communications Research Centre. Report CRC-1214, 1970. 28p. NTIS: N71-14827. [ice formation, ocean surface, thickness]

A-5

ADRIFT ON ARCTIC SEAS. ESSA World, v. 4(4), Oct. 1969, p. 9-11. Map. [historical review of drift of floating ice island T-3 and outline of Weather Bureau program on T-3 since 1966]

A-6

Adrov, M.M. (1970)
K GIDROLOGII KANDALAKSHSKOI VPADINY (Hydrology of the Kandalaksha Deep). Poliarnyi Nauchno-Issledovatel'skii i Proektnyi Institut Morskogo Rybnogo Khoziaistva i Okeanografii. Trudy, v. 27, 1970, p. 101-213. 19 ref. In Russian. [ocean currents, sea ice distribution, ice formation, water transport, ice cover thickness]

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AIDJEX BULLETIN, no. 1-37, Sept. 1970-Sept. 1977. Individual papers appear under author throughout this bibliography. Following is a list of the issues devoted to a single topic:

No. 1 (Sept. 1970). Status Report.

NTIS: AD-713 986.

No. 2 (Oct. 1970). Theoretical Discussions.

NTIS: PB-195 636.

No. 3 (Nov. 1970). Selected Soviet Research.

NTIS: PB-196 063.

No. 4 (Jan. 1971). Water Stress Studies.

NTIS: PB-220 357.

No. 5 (Feb. 1971). Remote Sensing and Ice Morphology.

No. 6 (March 1971). Ice Dynamics.

NTIS: PB-220 358.

No. 7 (April 1971). Arctic Data Buoy and Positioning Systems.

No. 8 (May 1971). 1971 Pilot Study Narratives.

NTIS: PB-231 009.

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NTIS: PB-204 333

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NTIS: PB-220 859.

No. 15 (Aug. 1972). AIDJEX Scientific Plan.

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No. 16 (Oct. 1972). Translation of Arkticheskii i Antarkticheskii Nauchno-Issledovatel'skii Institut. Trudy, v. 303 (first half).

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No. 24 (May 1974). Numerical Modeling Report.

NTIS: PB-232 231.

No. 32 (June 1976). First Data Report.

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Akifieva, K.V. et al (1973)
PIATYI OBSCHESOIUZNYI GLIATSIOLOGICHESKII SIMPOZIUM (Fifth All-Union Glaciological Symposium). Akademiya Nauk SSSR. Institut Geografii. Materialy Glyatsiologicheskikh Issledovaniy. Khronika, Obsuzhdeniya, no. 21, 1973, p. 5-24. In Russian. [meetings, research projects, glaciology, snow cover, avalanches, sea ice, river ice]

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Alaska. Univ. Arctic Research Laboratory (1966)
ICE STATION POSITIONS. Barrow, Alaska, Univ. of Alaska, 1966. 49p., mimeo.

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Alaska. Univ. Arctic Research Laboratory (1966)
PROGRESS REPORT FOR THE MONTH OF AUGUST 1966. Barrow, Alaska, Univ. of Alaska, 1966. 51p., mimeo.

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PROGRESS REPORT FOR THE MONTH OF JANUARY 1966. Barrow, Alaska, Univ. of Alaska, 1966. 17p., mimeo.

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ANNUAL REPORT, 1975-76. Fairbanks, Alaska, Univ. of Alaska, 1977. 184p.

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ANNUAL REPORT, 1973-74: 25th YEAR. Fairbanks, Alaska, Univ. of Alaska, 1975. 169p. Fig.

958

A-14 *

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ANNUAL REPORT, 1972-73. Fairbanks, Alaska, Univ.
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Wash., Boeing Co., Aerospace Group, 1969. 275p.
NTIS: AD-860 389. [sea ice, infrared radiation,
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1971 PILOT STUDY SUMMARIES. AIDJEX Bulletin, no. 5,
Feb. 1971, p. 37-45. [sea ice, remote sensing,
strain measuring instruments, meteorological data,
hydrography, subglacial observations]

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Arctic Ice Dynamics Joint Experiment (1977)
PRELIMINARY AIDJEX MODEL SIMULATION WITH 1972 DATA.
AIDJEX Bulletin, no. 37, Sept. 1977, p. 1-23. 2
ref.

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SCIENTIFIC OPERATIONS OF THE 1972 AIDJEX PILOT
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[tabulated data on the 23 projects and their
investigators, institutions and funding agencies]

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THIRD WORKING SESSION HELD ON NOV. 13-14, 1970, AT
THE UNIV. OF WASHINGTON. AIDJEX Bulletin, no. 5,
1971, p. 55-58. [air stress from pressure maps,
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processing remote sensing data, interaction of ice
strain and heat balance, mass balance equation,
ice as a continuum or not, space and time scales on
which strain measurements should be made, finding
a constitutive law and interpretation of stress
and strain data]

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THE ALASKAN ARCTIC COAST: A BACKGROUND STUDY OF
AVAILABLE KNOWLEDGE. Prepared for the Dept. of the
Army, Alaska District, Corps of Engineers. Contract
no. DACW85-74-C-0029, June 1974. 551p. 49 fig.,
56 tables, ref.

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Arctic Institute of North America
ANNUAL REPORT. Montreal, Arctic Institute of
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NAVAL ARCTIC MANUAL ATP-17(A) (PRELIMINARY),
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SEA ICE TERMINOLOGY. Polar Record, v. 12(81),
1965, p. 723.

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Armstrong, Terence Edward; Roberts, Brian;
Swithinbank, Charles (1966)
ILLUSTRATED GLOSSARY OF SNOW AND ICE. Cambridge,
Scott Polar Research Institute, Special Publication
no. 4, 1966. 60p.

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Armstrong, Terence Edward (1972)
REVIEW: WMO SEA-ICE NOMENCLATURE, BY THE WORLD
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Glaciology, v. 11(61), 1972, p. 148-149. [book
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the Arctic). Arkticheskii i Antarkticheskii
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sea water, chemical composition, water temperature,
climatic factors, ocean currents, bibliographies,
boundaries]

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Issledovatel'skii Institut. Trudy, v. 318, 1973,
p. 6-12. 22 ref. In Russian. [water temperature,
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techniques, nuclear techniques, and miscellaneous
techniques]

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3 ref. NTIS: TT72-50089.) (Translated from
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laboratoriya VMF S.Sh.A. na Aliaske," Problemy
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reconnaissance]

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LIST OF TRANSLATIONS. Washington, D.C., U.S. Naval
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1 July 1968 to 1 Nov. 1970]

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1966, p. 1-4. 5 fig.

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Smith, Willard J. (1968)
INTERNATIONAL ICE PATROL. Oceanology International,
v. 3(4), June 1968, p. 37. 1 fig.

A-245

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ARCTIC JOURNEY. Explorers Journal, v. 44(3), 1966,
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sledge, which ended at Arlis II in 1964]

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AIDJEX DATA BANK. Presented at Symposium on Sea
Ice Processes and Models, Seattle, Univ. of
Washington, 6-9 Sept. 1977, sponsored by ICSI and
AIDJEX.

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Statenman, Murray J. (1977)
DATA AVAILABLE FROM AIDJEX AS OF 1 MAY 1977.
AIDJEX Bulletin, no. 36, 1977, p. 203-10. [lists
data files and explains how data may be obtained]

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ERTS-1 IMAGERY ACQUIRED BY THE AIDJEX BANK.
AIDJEX Bulletin, no. 25, 1974, p. 29-48. 10 fig.
[set of 628 photographs of Beaufort Sea, March-
Sept. 1973; describes method of cataloging,
indexing, displaying and analyzing these to study
ice concentration and movement]

A-249 *

STATION POSITIONS, AZIMUTHS, WEATHER 1972 AIDJEX
PILOT STUDY-PRELIMINARY DATA. AIDJEX Bulletin,
no. 14, 1972, p. 63-69.

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sea level, mapping, communication, satellites]

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Map. [defines first-year and multiyear ice]

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124.

A-253

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ENVIRONMENT, PROCEEDINGS. Washington, D.C.,
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A-254 *

SYMPOSIUM ON DRIFT ICE AND CLIMATE, REYKJAVIK 1969:
LECTURES AND DISCUSSION. Jökull, v. 19, 1969.
160p. Graphs, maps, tables. [presents an abridged
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at the symposium, 27 Jan.-17 Feb. 1969]

A-255

SYMPOSIUM ON REMOTE SENSING IN THE POLAR REGIONS.
Held at Easton, Md., 6-8 March 1968. Washington,
D.C., Arctic Institute of North America, 1968.
70p. NTIS: AD-682 240. [symposium was designed
to foster an exchange of ideas between the users
and potential users of remote sensing, and instru-
mentation and interpretation specialists]

A-256

SYMPOSIUM ON SEA ICE PROCESSES AND MODELS. Held
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Ice (ICSI) and Arctic Ice Dynamics Joint Experiment
(AIDJEX). In press.

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MARITIM METEOROLOGI OG FYSISK OCEANOGRAPHI. (In:
Denmark. Dansk Meteorologisk Institut.
Meteorologisk Institut Gennem Hundrede År, 1872-
1972. København, 1972, p. 165-98.) In Danish
with English summary. [meteorological and oceano-
graphical work in the North Atlantic since 1879,
including ice observations in Greenland waters]

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Volkov, N.A. et al (1973)
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Amerind, 1973, p. 9-18. 20 ref.
NTIS: TT72-52007.) (Also in: AIDJEX Bulletin,
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eksperiment po izucheniyu dinamiki arkticheskikh
l'dov," Problemy Arktiki i Antarktiki, v. 38,
1971, p. 14-21.)

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DVENADTSAT' PODVIGOV (Twelve exploits).
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1965. 321p. Ref. In Russian. [Soviet drifting
station accounts from 1937]

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IZUCHENIE SOVETSKOY ARKTIKI (Study of Soviet
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i Gidrologiya za 50 Let Sovetskoy Vlasti, Sbornik
Statei. Leningrad, Gidrometeoizdat, 1967, p. 173-
186. Photo.) In Russian. [history of Soviet
research on the Arctic since 1918 in the fields
of hydrography, meteorology, hydrology, and
oceanography]

8/16 548

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Treshnikov, A.F. (1966)
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ANTARCTIC DURING THE SOVIET REGIME. Oceanology,
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lations, 1970. 536p. NTIS: TT70-50017.
(Translated from Problemy Arktiki i Antarktiki,
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ice navigation, polar regions]
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(Translated from Problemy Arktiki i Antarktiki,
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ref. NTIS: TT72-52006. (Translated from
Problemy Arktiki i Antarktiki, v. 36-37, 1970.)
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Treshnikov, A.F., ed. (1973)
PROBLEMS OF THE ARCTIC AND ANTARCTIC, V. 38.
New Delhi, Amerind, 1973. 187p. NTIS: TT72-52007.
(Translated from Problemy Arktiki i Antarktiki,
v. 38, 1971.) [climate, sea ice, meteorology]
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PROBLEMS OF THE ARCTIC AND ANTARCTIC, V. 41.
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ref. NTIS: TT74-52009. (Translated from
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Treshnikov, A.F., ed. (1976)
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New Delhi, Amerind, 1976. 138p. NTIS: TT75-52018
and PB-261 149T. (Translated from Problemy
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Treshnikov, A.F. (1976)
RECENT SOVIET RESEARCH IN THE ARCTIC. Alaska.
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Publication no. 4, 1976, p. 55-59. 1 ref.
[ice breaking, meteorology]
- A-273
Treshnikov, A.F. (1972)
SOVETSKIYE ISSLEDOVANIYA V ARKTIKE (Soviet inves-
tigations in the Arctic). Akademiya Nauk SSSR.
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May/June 1972, p. 26-37. In Russian. [History of
Soviet investigations in the Arctic, which began
on July 2, 1918]
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v. 14(1), 1965, p. 15-18. [summary of meteoro-
logical and oceanographical work in recent years,
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studies of ice cover and ice movement]
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THE ARCTIC ICE DYNAMICS JOINT EXPERIMENT (AIDJEX).
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[describes development and aims of experiment]
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K VOPROSU O MEZHÐUNARODNOY LEDOVOY NOMENKLATURE
(On an international ice nomenclature).
Okeanologiya, v. 6(2), 1966, p. 372-78. In Russian.
[discussion of Canadian proposals to amend WMO
sea ice nomenclature]
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MORSKIYE L'DY (Sea ice). Itogi Nauki. Geofizika.
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In Russian. [methods of observation of sea ice,
its seasonal distribution and its properties]
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Society for the Promotion of Science, Dec. 1971.
562p. [ice formation, pack ice]
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NAVAL ARCTIC RESEARCH LABORATORY. Arctic Bulletin,
v. 1(5), 1975, p. 197-199. Ref.
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INTERNATIONAL ICE PATROL, 1966. Marine Observer,
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NTIS: AD-774 511.
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SEASON OF 1969, Bulletin no. 55, 1969. 51p.
NTIS: AD-718 504.
SEASON OF 1970, Bulletin no. 56, 1971. 96p.
NTIS: AD-736 981.
SEASON OF 1971, Bulletin no. 57, 1974. 43p.
NTIS: AD-778 013.
SEASON OF 1972, Bulletin no. 58, 1974. 60p.
NTIS: AD-780 537.
SEASON OF 1973, Bulletin no. 59, 1975. 75p.
NTIS: AD-A020 336.

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QUARTERLY PROGRESS REPORT. Issued quarterly.

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PART 1: POLEX-CARP (NORTH). Washington, D.C.,
National Academy of Sciences, 1974. 119p. [Ice-
air interface, air-water interactions, sea ice,
remote sensing, spaceborne photography, mathe-
matical models, heat balance]

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NENTAL SHELF, v. 2. Boulder, Colo., Environ-
mental Research Laboratories, 1975. 493p.
V. 8: SEA ICE, 1975. 112p. NTIS: PB-248 939.
V. 2, 1976. 873p. NTIS: PB-263 065.
V. 4: GEOLOGY, ICE, DATA MANAGEMENT, 1976.
596p. NTIS: PB-264 058.
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V. 3, 1977. 824p.
V. 4, 1977. 546p.

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tration (1977)
NOAA PROGRAM DEVELOPMENT PLAN FOR SEASAT-A
RESEARCH AND APPLICATIONS. Washington, D.C., 1977.
88p.

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ICE OBSERVATIONS. U.S. Naval Oceanographic Office.
Publication no. 606-D, revised ed., 1966. 28p.
NTIS: AD-705 034. [revised oceanographic office
observers manual]

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THE SEA ICE AND PHYSICAL OCEANOGRAPHY OF THE
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Oceanographic Office. Informal Report no. 70-61,
1970. 35p. [includes Berents, Kara, Laptev,
East Siberian, Chukchi and Bering seas, and Bering
Straits]

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Alan S. (1970)
AIDJEX. ARCTIC ICE DYNAMICS JOINT EXPERIMENT,
PART 1: SCIENTIFIC PLAN (SECOND DRAFT). Seattle.
Univ. of Washington, Division of Marine Resources,
Dept. of Atmospheric Sciences, Dept. of Ocean-
ography, 1970. 58p. 32 ref. [describes program
of observations to be made from drifting stations
(one manned and 4 unmanned) in Arctic Ocean]

A-292

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Held 16-19 Aug. 1970, College, Alaska, [1970],
p. 22.) [abstract only]

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ARCTIC ICE DYNAMICS JOINT EXPERIMENT. Arctic
Bulletin, v. 1(4), Spring 1974, p. 145-59. (Also
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Fig., 19 ref. NTIS: AD-690 628.

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POLAR METEOROLOGY, American Geophysical Union,
Transactions, v. 48(2), June 1967, p. 490-94.
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Dept. of Atmospheric Sciences. Technical Report
no. 28.) [primarily a literature review of
material published between 1963-66 dealing with
various facets of arctic and antarctic meteorology]

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Untersteiner, Norbert (1972)
PROGRESS REPORT ON PROJECT AIDJEX. EOS, v. 53(3),
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EOS, v. 53(11), 1972, p. 1018. [abstract only]

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EXPERIMENT (AIDJEX). (In: Karlsson, T., ed.
Sea Ice: Proceedings of an International Confer-
ence. Held 10-13 May 1971, Reykjavik. National
Research Council, 1972, p. 57-58.) [abstract only]

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Sciences. Technical Report TR-26 and its
Contribution no. 129, 1966. 7p. NTIS: AD-657 924.
(Also in: Fairbridge, R.W., ed. Encyclopedia
of Oceanography. N.Y., Reinhold, 1966, p. 777-
81.) [salinity, heat flux, surface temperatures,
physical properties, density]

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SOME ELEMENTS OF A SCIENTIFIC PLAN FOR POLEX.
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of Alaska, 1975, p. 430-36. 17 ref.)

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DYNAMICS JOINT EXPERIMENT (AIDJEX). Polar Record,
v. 15(98), May 1971, p. 725-27. [sea ice studies
in Arctic Basin]

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ISCENTRALEN HARSSARSSUAQ. Grønland, no. 4, 1965,
p. 139-46. Map. In Danish. [note on work at
Narsarssuaq ice reconnaissance station, south-
west Greenland]

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Symbols for ice maps). Leningrad, Gidrometizdat,
1974. 86p. Fig., tables, maps. In Russian.
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(In: Treshnikov, A.F., ed. Problems of the
Arctic and Antarctic, v. 29-32. Jerusalem, Israel
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35. NTIS: TT70-50017.) (Translated from "O
novoy mezhdunarodnoy nomenklature morskikh l'dov,"
Problemy Arktiki i Antarktiki, v. 32, 1969, p. 132-
43.)

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ICELAND 1971. Polar Record, v. 15(99), Sept. 1971,
p. 933-34. [summary of proceedings of conference]

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DISCUSSIONS. International Assn. of Scientific
Hydrology, Publication no. 79, Jan. 1968. 458p.
In English or French, with English and French
summaries. [snow physics, ice crystals]

A-309*

Washington. Univ. Dept. of Atmospheric Sciences
ANNUAL REPORT. Published annually. [summarizes
research performed during previous year; includes
sea ice dynamics, optical properties of sea ice,
desalination of sea ice, thickness distribution of
sea ice, generation of internal waves in the ocean
by pressure ridge keels] Many available from
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FINAL REPORT, 30 SEPT. 1958-30 SEPT. 1968. Seattle,
Wash., Univ. of Washington, Dec. 1969. 36p.
NTIS: AD-698 305. Cheat and mass budget of arctic
sea ice, sea ice drift]

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World Meteorological Organization. Technical Note
no. 87, 1967, p. 530-40. 48 ref.) [meteorology,
sea ice, drift, ice crystals]

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ARCTIC ICE DYNAMICS JOINT EXPERIMENT (AIDJEX).
Ice, no. 35, April 1971, p. 16-18. [description
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Weeks, Wilford F.; Campbell, William J. (1971)
THE CRREL-USGS PROGRAM AT CAMP 200; A POST-
OPERATIONS SUMMARY. AIDJEX Bulletin, no. 8, 1971,
p. 1-8. [narrates the activities of the "most
intensive airborne remote sensing and ground truth
investigations ever made from sea ice" during the
March 1971 AIDJEX pilot study on the ice floe
Camp 200 at 74°N 131°W in Beaufort Sea; study of
a multiyear pressure ridge and strain]

A-314 *

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CLIMATE OF THE ARCTIC: ALASKA SCIENCE CONFERENCE,
24TH, PROCEEDINGS. Held 15-17 Aug. 1973, Fair-
banks, Alaska. Geophysical Institute, Univ. of
Alaska, 1975. 436p. Ref. [56 papers presented
at the 24th Alaska Science Conference]

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Institute. Proceedings, v. 92(10), Oct. 1966,
p. 79-85. 4 fig.

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ENVIRONMENT OF THE CAPE THOMPSON REGION, ALASKA.
U.S. Committee on Environmental Studies for Project
Chariot. Oak Ridge, Tennessee, U.S. Atomic Energy
Commission, Division of Technical Information,
1966. 1250p. [bioenvironment, engineering
geology, patterned ground, drill core analysis,
slope processes, frost heave, soil classification,
sea ice, oceanography, radioactivity]

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Williams, G.P. (1972)
SUMMARY OF CURRENT RESEARCH ON SNOW AND ICE IN
CANADA. Canada. National Research Council.
Associate Committee on Geotechnical Research.
Technical Memorandum no. 106, 1972. 30p.

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Wittmann, Walter I. (1972)
NAVOCEANO FIELD PARTICIPATION. AIDJEX Bulletin,
no. 14, 1972, p. 22-23.

A-320

WMO ISNOMENKLATUR. DANSK UDGAVE (The WMO sea ice
nomenclature. Danish edition). Dansk
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29p. NTIS: NTIS: NT1-22544. In Danish with English
summary.

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ON SEA ICE OF THE COMMISSION FOR MARITIME
METEOROLOGY. Geneva, World Meteorological
Organization, 1967. 62p. [proposals for ice
nomenclature, symbols, and codes, made at meeting,
18-23 Sept. 1967, Geneva]

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WMO-SCAR-ICDM SYMPOSIUM ON POLAR METEOROLOGY.
World Meteorological Organization, 1967.

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WMO SEA ICE NOMENCLATURE. World Meteorological
Organization. Technical Publication no. 145, 1970.
152p.

A-324 *

Yakovlev, G.N., ed. (1973)
STUDIES IN ICE PHYSICS AND ICE ENGINEERING, v. 300.
Jerusalem, Israel Program for Scientific Trans-
lations, 1973. 192p. NTIS: TT72-50005.
(Translated from Arkticheskii i Antarkticheskii
Nauchno-Issledovatel'skii Institut. Trudy, v. 300,
1971.) [ice physics, ice navigation, ice reporting,
ice forecasting, ice cover thickness, ice cover
strength, snow cover effect]

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Zavatti, Silvio (1966)
LA NOMENCLATURA ITALIANA PER I GHIACCI DI MARE.
Il Polo, v. 12(1-4), Jan.-Dec. 1966, p. 1-5. In
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D-40, D-46, D-120, D-152

E-1, E-62, E-102, E-210

H-1, H-45, H-66, H-76, H-80, H-86, H-159

I-7, I-12, I-19, I-22, I-115, I-116, I-183, I-275,
I-343, I-386.

B. MICROSCALE ICE CHARACTERISTICS

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ELECTRICAL PROPERTIES OF SALINE ICE. Journal of Applied Physics, v. 40(8), 1969, p. 3105-14.
NTIS: AD-704 269. [study of complex dielectric permittivity of artificial sea ice as a function of frequency, temperature and salinity]

B-2

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ELECTRICAL PROPERTIES OF SALINE ICE. Montreal, McGill Univ., 1967. Ph.D. thesis.

B-3 *

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THE ELECTRICAL PROPERTIES OF SALINE ICE. (In: Oura, Hirobumi, ed. Physics of Snow and Ice: Proceedings of the International Conference on Low Temperature Science, v. 1, part 1. Sapporo, Institute of Low Temperature Science, Hokkaido Univ., 1967, p. 649-60. NTIS: AD-704 268.) [measurements of dielectric constant and resistivity of laboratory-grown saline ice from 20 Hz to 10 KHz and various salinities].

B-4

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ELECTRICAL PROPERTIES OF SALINE ICE AT 1 KHZ, DOWN TO -150 C. Journal of Applied Physics, v. 46, 1975, p. 513-22.

B-5

Addison, J.R. (1970)
ELECTRICAL RELAXATION IN SALINE ICE. Journal of Applied Physics, v. 41(1), 1970, p. 54-63.
NTIS: AD-705 788. [frequency dispersion of dielectric coefficient used to determine spectrum of relaxation times which is interpreted in terms of properties of ice and brine]

B-6 *

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IMPURITY CONCENTRATIONS IN SEA ICE. Journal of Glaciology, v. 18(78), 1977, p. 117-27. 26 ref. In English with French and German summaries. [impurities, ice composition, ion density (concentration)]

B-7

Addison, J.R.; Stalinski, P.; Pounder, Elton R. (1974)
STUDIES ON THE ELECTRICAL PROPERTIES OF SALINE ICE: FINAL REPORT. Montreal, McGill Univ. Macdonald Physics Laboratory, Ice Research Project, 1974. 69p. 47 ref. NTIS: AD-780 463/6. [presents results of measurements of electrical properties at 1 KHz at temperatures down to -150°C and at UHF and microwave frequencies]

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DIMENSIONAL FACTOR AND ITS INFLUENCE UPON DETERMINATION OF THE COMPRESSIVE STRENGTH OF ICE. Hydrotechnical Construction, no. 11, 1971, p. 1046-49. 3 ref. (Translated from Gidrotekhnicheskoe Stroitel'stvo, Nov. 1970.) [compressive strength, tests, laboratory techniques]

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WIRE STRAINMETERS ON ICE. Nature, v. 255(5503), May 1975, p. 45-46. [creep processes, wire strainmeter, glaciers, ice forces, measuring instruments]

B-10 *

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B-11

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O SILAKH SZHATIIA I VNUTRENNEGO SOPROTIIVLENIIA V LEDIANOM POKROVE PRI NAZHIMNOM DREIFE (Compression strength and internal resistance in ice cover during pressure drift). Arkticheskii i Antarkticheskii Nauchno-Issledovatel'skii Institut. Trudy, v. 320, 1976, p. 153-60. 12 ref. In Russian. [ice cover strength, compressive strength, ice deformation, drift, rheology]

B-12

ARCTIC BASIN. Washington, D.C., Arctic Institute of North America, revised edition, 1969. 337p. Ref. [ice physics, sea ice, permafrost distribution, permafrost structure, cold weather construction]

B-13

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SOLENOT' I TEPLOVOE SOSTOIANIE BERINGOVOMORSKIKH VOD KAK POKAZATELI STEPENI RAZVITIIA CHUKOTSKOI ZAPRIPAINOI PROGALINY V IIUNE (Salinity and thermal state of Bering Sea water as indicators of the extent of ice-free beaches in the Chukchi Sea in June). Problemy Arktiki i Antarktiki, v. 48, 1976, p. 64-69. 16 ref. In Russian. [polynyas, sea ice distribution, ice forecasting, water temperature, sea water, salinity]

B-14

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HYDRAULIC ROUGHNESS OF ICE COVERS. American Society of Civil Engineers. Proceedings. Journal of the Hydraulics Division, v. 100(HY2), Feb. 1974, p. 321-23. 2 ref. [ice water interface, heat transfer, ice bottom surface, ice structure, floating ice, ice friction]

B-15 *

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FLEXURAL AND OTHER PROPERTIES OF SEA ICE SHEETS.
(In: Oura, Hirobumi, ed. Physics of Snow and Ice: Proceedings of the International Conference on Low Temperature Science, v. 1, Part 1. Sapporo, Institute of Low Temperature Science, 1967, p. 557-67. 5 ref.) [outlines mathematical treatment of composite properties of sea ice to permit computer or nomogram methods of predicting properties to be developed]

B-16 *

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ICE ENGINEERING IN THE AMERICAN EXPERIENCE. (In: I.A.H.R. Symposium on Ice and Its Action on Hydraulic Structures. 2nd, Proceedings, v. 1. Held in Leningrad 26-29 Sept. 1972. Leningrad, International Assn. for Hydraulic Research, 1972, p. 81-82.) [brief outline of current studies on floating ice (fresh and sea)]

B-17 *

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SEA ICE ENGINEERING. (In: International Conference on Port and Ocean Engineering under Arctic Conditions, 3rd, Proceedings. Held 11-15 Aug. 1975, Fairbanks, Alaska. Institute of Marine Science, Univ. of Alaska, 1976, p. 231-34.) [vertical and horizontal forces, icebreaking ships, pressure ridges, ice erosion and scouring, icebergs, ice islands, modeling]

B-18

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GIDROMEKHANICHESKIYE OSOBENNOSTI PODLEDNOGO SLOYA (PO EKSPERIMENTAL'NYM DANNYM) (Hydromechanical features of the sub-ice layer (from experimental data)). Problemy Arktiki i Antarktiki, v. 43-44, 1974, p. 147-52. In Russian.

B-19

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SOLEVOY SOSTAV VOD V ARKTICHESKOM BASSEYNE I YEGO VLIYANIYE NA SOLENIYU MORSKOGO L'DA (Salt content of water in the Arctic Basin and its influence on salinity of sea ice). Arkticheskii i Antarkticheskii Nauchno-Issledovatel'skii Institut. Trudy, v. 331, 1976, p. 157-65. 5 ref. In Russian. [ice salinity, ice formation, ion density (concentration)]

B-20 *

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CRYSTAL AND BRINE RELATIONSHIPS IN SEA ICE. (In: Sater, J.E., ed. Arctic Drifting Stations: A Report on Activities Supported by the Office of Naval Research. Proceedings of a symposium held 12-15 April 1966 in Warrenton, Va. Washington, D.C., Arctic Institute of North America, 1968, p. 181-87. 11 ref. NTIS: AD-685 573.) (Also Washington Univ. Dept. of Atmospheric Sciences. Contribution no. 142 and its Technical Report no. 39, 1969.)

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DESALINATION FEATURES IN NATURAL SEA ICE. Journal of Glaciology, v. 6(43), 1967, p. 345-57. NTIS: AD-663 611. (Also Washington Univ. Dept. of Atmospheric Sciences. Technical Report no. 30 and its Contribution no. 146, 1967.)

B-22 *

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HOLOGRAPHIC TECHNIQUE FOR MEASUREMENTS OF STRAIN. CRREL Special Report no. 227, 1975. 325p. NTIS: AD-A011 247.

B-23

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PENETRATION STUDIES OF ICE WITH APPLICATION TO ARCTIC AND SUBARCTIC WARFARE. Stanford Research Institute. Report, Nov. 1965. 41p. 9 ref. NTIS: AD-630 122. [floating ice, ice cover thickness, ice temperature]

B-24

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ICE MODEL TESTING. (In: Offshore Technology Conference, 5th, Papers, v. 1. Held in Houston, Texas, 30 April-2 May 1973, p. I/757-62. 8 ref. OTC Paper no. 1812.) [ice models, sea ice, ice mechanics, ice elasticity]

B-25

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VOLUME SCATTERING FROM ICE AND WATER IN INHOMOGENEOUS TERRAIN. (In: AGARD Conference Proceedings, no. 144. Neuilly sur Seine, North Atlantic Treaty Organization, Advisory Group for Aerospace Research and Development, 1975, p. 16-1 to 16-13.)

B-26

Biggs, Albert W. (1970)
VOLUME SCATTERING FROM SEA ICE AND GLACIER SNOW. Kansas Univ. Technical Report no. 137-2, 1970. 46p. NTIS: AD-A021 393. [physical properties of sea ice and dielectric properties of glacier snow described in terms of dielectric mixtures and the relaxation spectra of water at microwave frequencies]

B-27

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SALT CONTENT OF SEAWATER AND ICE. U.S. Naval Oceanographic Office. Translation no. 370, 1968. 66p. (Also Marine Hydrochemistry. Hanover, N.H., CRREL, 1970. NTIS: AD-711 925.) (Translated from Gosudarstvennyi Okeanograficheskii Institut. Trudy, v. 83, 1965, p. 5-55.) [discusses the salt composition of ocean waters, salinity in sea ice in relation to processes of phase transitions; formation of ice from sea water as a complex solution]

B-28

Bogorodskii, V.V.; Smirnov, G.E.; Smirnov, S.A. (1975)
ACOUSTICAL PROPERTIES OF SEA ICE IN ULTRASONIC FREQUENCY RANGE. (In: Ocean '74: IEEE International Conference on Engineering in the Ocean Environment, Record, v. 1. Held 21-23 Aug. 1974, in Halifax, Nova Scotia. New York, Institute of Electrical and Electronic Engineers, 1975, p. 121-24. 5 ref.) [ice acoustics, sea ice, ultrasonic tests, elastic waves, absorption]

- B-29
Bogorodskii, V.V.; Gavrilov, V.P.; Gusev, A.V. (1974)
AKUSTICHESKII EFFEKTY PRI TRENII L'DA (Acoustic effects of ice friction). Arkticheskii i Antarkticheskii Nauchno-Issledovatel'skii Institut. Trudy, v. 324, 1974, p. 97-103. 12 ref. In Russian. [sea ice, drift, ice floes, ice friction, ice breakup, noise (sound), acoustic measuring instruments]
- B-30
Bogorodskii, V.V.; Gusev, A.V. (1968)
AMBIENT NOISE UNDER ICE. REVIEW. Akusticheskii Zhurnal, v. 14(2), April-June 1968, p. 153-62. 9 fig., 16 ref. In Russian.
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Bogorodskii, V.V.; Smirnov, G.E.; Smirnov, S.A. (1976)
ATTENUATION AND SCATTERING OF SOUND WAVES BY SEA ICE. CRREL Translation no. 539, Aug. 1976, p. 126-32. 4 ref. NTIS: AD-A030 818.
- B-32
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- B-33
Bogorodskii, V.V.; Tripol'nikov, V.P. (1974)
O KONTRASTE ELEKTROMAGNITNYKH KHKARAKTERISTIK NA GRANITSE MORSKOY LED-VODA (Contrast of electromagnetic characteristics of the sea-ice-water boundary). Zhurnal Tekhnicheskoy Fiziki, v. 44(4), 1974, p. 835-38. In Russian. [observations on pack ice and one-year ice]
- B-34
Bogorodskii, V.V.; Khokhlov, G.P. (1969)
ELEKTRICHESKIE KHKARAKTERISTIKI DREIFUIUSHCHEGO ARKTICHESKOGO L'DA V DIAPAZONE CHASTOT 100 GTS-1 MGTS. (Electrical properties of drifting arctic ice in the frequency range of 100-1 MHz). Akademiya Nauk SSSR. Doklady. Seriya Matematika, Fizika, v. 189(1/6), 1969, p. 1230-32. Ref. In Russian.
- B-35
Bogorodskii, V.V.; Tripol'nikov, V.P. (1973)
ELEKTROMAGNITNYE KHKARAKTERISTIKI MORSKOGO L'DA V DIAPAZONE 30-400 MGTS (Electromagnetic characteristics of sea ice in the 30-400 MHz range). Akademiya Nauk SSSR. Doklady. Seriya Matematika, Fizika, v. 213(1/3), 1973, p. 577-79. In Russian.
- B-36
Bogorodskii, V.V.; Gaitskhoki, B.Ia.; Tripol'nikov, V.I. (1973)
ELECTROMAGNETIC AND OPTIC CHARACTERISTICS OF SEA ICE. (In: Orvig, Svenn, ed. Energy Fluxes over Polar Surfaces. Proceedings of the IAMP/IAPSO/SCAR/WMO symposium held in Moscow, 3-5 Aug. 1971. Geneva, World Meteorological Organization, 1973, p. 281-99.) [discusses remote methods of measuring thickness of drifting sea ice]
- B-37*
Bogorodskii, V.V.; Koslov, A.I.; Tuchkov, L.T. (1976)
EMISSION OF ICE, TERRESTRIAL, AND SEA SURFACES MODELED BY STRATIFIED HETEROGENEOUS STRUCTURES. CRREL Translation no. 539, Aug. 1976, p. 29-35. 14 ref. NTIS: AD-A030 818. (Translated from "Izluchatel'naia sposobnost' ledian'nykh, zemnykh i morskikh poverkhnostei, modeliruemykh sloistoneodnorodnymi strukturami," Arkticheskii i Antarkticheskii Nauchno-Issledovatel'skii Institut. Trudy, v. 326, 1975, p. 32-38.)
- B-38
Bogorodskii, V.V.; Gavrilov, V.P. (1974)
FIZICHESKIE METODY ISSLEDOVANIYA NAPRIAZHENNOGO SOSTOYANIYA LEDIANOGO POKROVA (Physical methods of studying stresses in pack ice). Arkticheskii i Antarkticheskii Nauchno-Issledovatel'skii Institut. Trudy, v. 316, 1974, p. 59-69. 26 ref. In Russian.
- B-39
Bogorodskii, V.V.; Khokhlov, G.P. (1971)
INTERLAYER POLARIZATION IN ICE WITH NaCl INCLUSIONS. Arkticheskii i Antarkticheskii Nauchno-Issledovatel'skii Institut. Transactions, v. 295, 1971, p. 88-91. 5 ref. NTIS: TT70-50158. (Translated from "Mezhdusloinaya polarizatsiya vo l'du soderzhaschem vklucheniya NaCl," Arkticheskii i Antarkticheskii Nauchno-Issledovatel'skii Institut. Trudy, v. 295, 1970, p. 103-07.)
- B-40
Bogorodskii, V.V.; Khokhlov, G.P. (1974)
INTERPRETATSIYA EKSPERIMENTAL'NYKH DANNYKH PRI IZMERENII NEODNORODNYKH OBRAZTSOV MORSKOGO L'DA V SANTIMETROVOM DIAPAZONE (Experimental data interpretation in measuring inhomogeneous samples of sea ice in the microwave range). Arkticheskii i Antarkticheskii Nauchno-Issledovatel'skii Institut. Trudy, v. 324, 1974, p. 28-32. In Russian.
- B-41
Bogorodskii, V.V.; Galkin, E.I. (1966)
INVESTIGATION OF THE INTERNAL FRICTION OF ICE SLABS WITH A LAYER OF SNOW DURING FLEXURAL VIBRATIONS. Soviet Physics. Acoustics, v. 12(4), 1967, p. 360-63. (Translated from "Issledovaniye vnutrennego tremya plastin l'da so sloym pri izgibnykh kolebaniyakh," Akusticheskii Zhurnal, v. 12(4), 1966, p. 411-15.) [investigations on slabs frozen in a tank of water in the laboratory]
- B-42
Bogorodskii, V.V.; Khokhlov, G.P. (1974)
ISSLEDOVANIYE ELEKTRICHESKIKH SVOISTV MORSKOGO L'DA SETCHATYMI KONDENSATORAMI (Grid capacitors for studying electrical properties of sea ice). Arkticheskii i Antarkticheskii Nauchno-Issledovatel'skii Institut. Trudy, v. 324, 1974, p. 46-49. 6 ref. In Russian.

B-43

Bogorodskii, V.V.; Khokhlov, G.P. (1971)
MEASUREMENTS OF THE PERMITTIVITY AND CONDUCTIVITY
OF SEA ICE WITHOUT CONTACT ELECTRODES.
Arkticheskii i Antarkticheskii Nauchno-
Issledovatel'skii Institut. Transactions, v. 295,
1971, p. 71-75. 4 ref. NTIS: TT70-50158.
(Translated from "Analiz beskontaktnogo metoda
izmereniia dielektricheskoi pronitsaemosti i
provodimosti morskogo l'da," Arkticheskii i
Antarkticheskii Nauchno-Issledovatel'skii Institut.
Trudy, v. 295, 1970, p. 83-88.)

B-44

Bogorodskii, V.V.; Gavrilov, V.P.; Gusev, A.V.
(1971)
NONLINEAR EFFECTS ACCOMPANYING ICE BREAKING IN A
LIQUID. Arkticheskii i Antarkticheskii Nauchno-
Issledovatel'skii Institut. Transactions, v. 295,
1971, p. 133-138. 6 ref. NTIS: TT70-50158.
(Translated from "O nelineinykh effektakh pri
razrushenii l'da v zhidkosti," Arkticheskii i
Antarkticheskii Nauchno-Issledovatel'skii Institut.
Trudy, v. 295, 1970, p. 159-65.)

B-45 *

Bogorodskii, V.V. (1976)
PHYSICAL METHODS OF STUDYING ICE AND SNOW. CRREL
Translation no. 539, Aug. 1976. 248p. Ref.
NTIS: AD-8030 818. (Translated from "Fizicheskie
metody issledovaniia l'da i snega," Arkticheskii i
Antarkticheskii Nauchno-Issledovatel'skii Institut.
Trudy, v. 326, 1975. 228p.) [proceedings of a
scientific symposium which was held in Leningrad
on 1-5 Oct. 1973]

B-46

Bogorodskii, V.V. (1971)
THE PHYSICS OF ICE. Jerusalem, Israel Program for
Scientific Translations, 1971. 157p.
NTIS: TT70-50158. (Translated from Arkticheskii
i Antarkticheskii Nauchno-Issledovatel'skii
Institut. Trudy, v. 295, 1970.) [ice physics,
glacier ice, sea ice, ice crystals]

B-47

Bogorodskii, V.V.; Smirnov, G.E.; Smirnov, S.A.
(1975)
POGLOSHCHENIE I RASSEIANIE ZVUKOVYKH VOLN MORSKIM
L'DOM (Absorption and scattering of acoustic
waves in sea ice). Arkticheskii i Antarkticheskii
Nauchno-Issledovatel'skii Institut. Trudy, v. 326,
1975, p. 128-34. 4 ref. In Russian.

B-48 *

Bogorodskii, V.V.; Gavrilov, V.P.; Gusev, A.V.
et al (1972)
STRESSED ICE COVER STATE DUE TO THERMAL WAVE AND
RELATED UNDERWATER NOISE IN THE OCEAN. (In:
I.A.N.R. Symposium on Ice and Its Action on
Hydraulic Structures, 2nd, Proceedings, v. 2.
Held in Leningrad 26-29 Sept. 1972. Leningrad,
International Assn. for Hydraulic Research, 1972,
p. 28-33.) [physical-statistical relationships
of underwater noise, recorded under ice, with
variations of air temperature and surface wind
speeds; underwater noise being caused by thermal
cracks]

B-49

Bogorodskii, V.V.; Khokhlov, G.P. (1971)
EFFECT OF SOME SALT COMPONENTS AND THEIR
COMPOSITION ON THE ELECTRICAL PROPERTIES OF ICE.
Arkticheskii i Antarkticheskii Nauchno-
Issledovatel'skii Institut. Transactions, v. 295,
1971, p. 76-81. 3 ref. NTIS: TT70-50158.
(Translated from "Vliianie nekotorykh solevykh
komponent i ikh sostava na elektricheskie svoistva
l'da," Arkticheskii i Antarkticheskii Nauchno-
Issledovatel'skii Institut. Trudy, v. 295, 1970,
p. 89-95.) [ice composition, ice physics, ice
electrical properties]

B-50

Bondarev, E.A.; Kolmogorov, A.V. (1974)
DINAMIKA LEDIANYKH MASS (Ice dynamics). (In:
Fizika L'da i Ledotekhnika (Ice physics and ice
engineering). Yakutsk, 1974, p. 60-86. 17 ref.)
In Russian. [ice structure, impurities, ice
strength, polycrystalline ice, ice creep, ice
mechanics, viscoelasticity, deformation, ultrasonic
tests, models]

B-51

Bourkland, Martin T. (1968)
OCEANOGRAPHIC CRUISE SUMMARY, WESTERN GREENLAND
SEA, AUG.-SEPT. 1965. U.S. Naval Oceanographic
Office. Informal Report no. 10, March 1968. 18p.
NTIS: AD-671 058.

B-52

Bradley, D.L.; Colvin, G.M. (1972)
ACOUSTIC MEASUREMENTS IN THE WEST GREENLAND SEA.
U.S. Naval Ordnance Laboratory. Technical Report
NOLTR-72-134, June 1972. 17p. NTIS: AD-746 839.
[ice acoustics, underwater acoustics, acoustic
measuring equipment]

B-53

Bradley, D.L.; Colvin, G.M. (1973)
LONG RANGE ACOUSTIC TRANSMISSION LOSS IN THE
MARGINAL ICE ZONE OF ICELAND. U.S. Naval
Ordnance Laboratory. Technical Report
NOLTR-72-217, April 1973. 33p. NTIS: AD-763 662.
[sound transmission, ice acoustics, acoustic
measurement]

B-54

Bradley, D.L.; Colvin, G.M. (1972)
LONG RANGE ACOUSTIC TRANSMISSION LOSS IN THE
NORTHERN DENMARK STRAIT. U.S. Naval Ordnance
Laboratory. Technical Report NOLTR-72-178, 1972.
24p. NTIS: AD-754 394.

B-56

Brown, J.R.; Milne, A.R. (1967)
REVERBERATION UNDER ARCTIC SEA-ICE. Acoustical
Society of America. Journal, v. 42(1), 1967,
p. 76-82. Fig., 8 ref. [measurements of back-
scattering strength and correlation with surface
roughness]

B-57

Brown, J.R.; Brown, D.W. (1966)
REVERBERATION UNDER ARCTIC SEA-ICE. Acoustical
Society of America. Journal, v. 40(2), 1966,
p. 399-404. 8 fig., 7 ref. [strong dependence
of under-ice back-scattering on surface roughness]

B-58 *

Buck, Beaumont M. (1965)
ICE DRILLING IN FLETCHER'S ICE ISLAND (T-3) WITH
A PORTABLE MECHANICAL DRILL. Arctic, v. 18(1),
1965, p. 51-54. [operational details using
Houston Model V-100 drill in "pressure mode";
temperature and chlorinity measurements on ice]

B-59

Byrd, Robert C. (1971)
DIELECTRIC PROPERTIES OF SEA ICE IN THE FREQUENCY
RANGE FROM 26GHZ TO 40GHZ. (In: Alaska. Univ.
Institute of Arctic Environmental Engineering.
Report no. 7203, 1971. 88p. 15 ref. M.S. thesis.
NTIS: AD-736 593.) [ice dielectrics, temperature
effects, salinity, electromagnetic prospecting,
radar echoes, ice surface, topographic features]

B-60

Campbell, Kerry J.; Orange, Arnold S. (1974)
ELECTRICAL ANISOTROPY OF SEA ICE IN THE HORIZONTAL
PLANE. Journal of Geophysical Research, v. 79(33),
Nov. 1974, p. 5059-63. 7 ref. [electrical
properties of sea ice]

B-61

Chapman, R.P.; Scott, H.D. (1966)
BACKSCATTERING STRENGTHS OF SEA ICE. Acoustical
Society of America. Journal, v. 39(6), 1966,
p. 1191-93. 5 ref. [measurements for "point"
sources of sound in sea-water scattered back from
smooth young ice and heavily rafted winter ice]

B-62

Cherepanov, N.V. (1973)
CLASSIFICATION OF THE CRYSTALLINE STRUCTURE OF
ARCTIC ICE. (In: Treshnikov, A.F., ed. Problems
of the Arctic and Antarctic, v. 40. Jerusalem,
Israel Program for Scientific Translations, 1973,
p. 75-80. Map. NTIS: TT72-50089.) (Trans-
lated from "Sistemalizatsiya kristallicheskih
struktur l'dov v Arktiki," Problemy Arktiki i
Antarktiki, v. 40, 1972, p. 78-83.)

B-63 *

Cherepanov, N.V. (1975)
MAIN RESULTS OF AN INVESTIGATION OF THE CRYSTAL
STRUCTURE OF SEA ICE. (In: Treshnikov, A.F., ed.
Problems of the Arctic and Antarctic, v. 41. New
Delhi, Amerind, 1975, p. 55-68. 6 fig., ref.
NTIS: TT74-52009.) (Translated from "Osnovnyye
rezul'taty issledovaniya kristallicheskoj
struktury morskikh l'dov," Problemy Arktiki i
Antarktiki, v. 41, p. 43-54.)

B-64 *

Cherepanov, N.V. (1970)
ROLE OF THE THERMAL REGIME OF A WATER BODY IN THE
FORMATION OF THE CRYSTAL STRUCTURE OF ICE. (In:
Treshnikov, A.F., ed. Problems of the Arctic and
Antarctic, v. 29-33. Jerusalem, Israel Program
for Scientific Translations, 1970, p. 56-64.
6 ref. NTIS: TT70-50017.) (Translated from
"Rol' termicheskogo rezhima vodoema v formirovanii
kristallicheskoj struktury l'da," Problemy Arktiki
i Antarktiki, v. 29, 1968, p. 55-63.)

B-65 *

Cherepanov, N.V. (1973)
SPATIAL ARRANGEMENT OF SEA ICE CRYSTAL STRUCTURE.
(In: Treshnikov, A.F., ed. Problems of the Arctic
and Antarctic, v. 38. New Delhi, Amerind, 1973,
p. 176-81. 2 fig., 6 ref. NTIS: TT72-52007.)
(Translated from "Prostranstvennaja
uporiadochennost' kristallicheskoj struktury
morskikh l'dov," Problemy Arktiki i Antarktiki,
v. 38, 1971, p. 137-40.) [ice crystal structure,
ice crystal optics, ice crystal size]

B-66

Cherepanov, N.V. (1966)
STRUCTURE OF SEA ICE OF GREAT THICKNESS. Canada.
Defence Research Board. Directorate of Scientific
Information Services. Translation, no. T-448-R,
Jan. 1966. 7p. 4 fig., 5 ref. NTIS: AD-631 236.
(Translated from "Skruktura morskikh l'dov
bol'shoi tolshchiny," Arkticheskii i
Antarkticheskii Nauchno-Issledovatel'skii Institut.
Trudy, v. 267, 1964, p. 13-18.) [thickness, ice
island, sea ice structure]

B-67

Chikovskii, S.S. (1976)
O RASCHETE TEMPERATURY MORSKOGO L'DA NA
STANDARTNYKH GORIZONTAKH NABLIUDENII (Calcula-
tion of sea ice temperature at standard depths of
observation). Arkticheskii i Antarkticheskii
Nauchno-Issledovatel'skii Institut. Trudy, v. 331,
1976, p. 185-88. 4 ref. In Russian. [ice
temperature, ice cover strength, thermal conduc-
tivity, ice salinity, air temperature, analysis
(mathematics)]

B-68 *

Chikovskii, S.S. (1973)
SUPERCOOLING OF SEA WATER UNDER NATURAL AND
LABORATORY CONDITIONS. (In: Yakovlev, G.N., ed.
Studies in Ice Physics and Ice Engineering, v. 300.
Jerusalem, Israel Program for Scientific Trans-
lations, 1973, p. 121-34. 35 ref.
NTIS: TT72-50005.) (Translated from "O
pereokhlazhdenii morskikh vod v prirodnykh i
laboratornykh usloviyakh," Arkticheskii i
Antarkticheskii Nauchno-Issledovatel'skii Institut.
Trudy, v. 300, 1971, p. 137-52.) [supercooled
water, ice formation, ice growth, ocean currents,
water temperature, ice water interface]

B-69

Chugui, I.V.; Legen'kov, A.P.; Eremin, N.N.
(1975)
TEMPERATURE MEASUREMENTS FROM DRIFTING ICE ISLAND
"NORTH POLE 19." Oceanology, v. 14(4), May 1975,
p. 495-98. (Translated from Okeanologiya, v. 14(4),
1975.)

B-70

Coon, Max D.; Mohaghegh, Mohammed M. (1972)
PLASTIC ANALYSIS OF COULOMB PLATES AND ITS
APPLICATION TO THE BEARING CAPACITY OF SEA ICE.
Washington. Univ. Dept. of Atmospheric Sciences.
Scientific Report no. 12, 1972. 159p.
NTIS: AD-745 764. [bearing capacity of floating
ice sheets was determined by application of
analysis methods]

B-72 *

Cox, G.F.N.; Weeks, Wilford F. (1975)
BRINE DRAINAGE AND INITIAL SALT ENTRAPMENT IN
SODIUM CHLORIDE ICE. CRREL Research Report
no. 345, Dec. 1975. 85p. 33 fig., 8 tables,
41 ref. NTIS: AD-A021 765.

B-73

Cox, G.F.N. (1974)
BRINE DRAINAGE IN SODIUM CHLORIDE ICE. Hanover,
N.H., Dartmouth College, 1974. Ph.D. thesis.
Univ. Microfilm order no. 74-23090.

B-74 *

Cox, G.F.N.; Weeks, Wilford F. (1973)
SALINITY VARIATIONS IN SEA ICE. CRREL Research
Report no. 310, 1973. 23p. Fig., ref. (Also
in: Journal of Glaciology, v. 13(67), 1974,
p. 109-20 and AIDJEX Bulletin, no. 19, 1973,
p. 1-17.)

B-75

Cox, G.F.N. (1972)
VARIATION OF SALINITY IN THE MULTI-YEAR SEA ICE
AT THE AIDJEX 1972 CAMP. Hanover, N.H., Dartmouth
College, 1972. M.S. thesis.

B-76

Craig, H.; Hom, B. (1968)
RELATIONSHIPS OF DEUTERIUM, OXYGEN 18, AND
CHLORINITY IN THE FORMATION OF SEA ICE. American
Geophysical Union. Transactions, v. 49(1), March
1968, p. 216-17. [abstract only]

B-77

Croasdale, K.R. (1974)
CRUSHING STRENGTH OF ARCTIC ICE. (In: Reed,
John C.; Sater, J.E., ed. The Coast and
Shelf of the Beaufort Sea. Proceedings of a
symposium held in San Francisco, 7-9 Jan. 1974.
Arlington, Va., Arctic Institute of North
America. 1974. p. 377-99.)

B-78 *

Croasdale, K.R. (In press)
ICE ENGINEERING FOR OFFSHORE PETROLEUM
EXPLORATION IN CANADA. Presented at International
Conference on Port and Ocean Engineering under
Arctic Conditions, 4th, Proceedings, Memorial
Univ. of Newfoundland, 26-30 Sept. 1977. 32p.

B-79 *

Croasdale, K.R. (1970)
THE NUTCRACKER ICE STRENGTH TESTER AND ITS
OPERATION IN THE BEAUFORT SEA. (In: I.A.H.R.
Symposium on Ice and Its Action on Hydraulic
Structures, 1st, Proceedings. Held in Reykjavik,
Iceland, 7-10 Sept. 1970. International Assn. for
Hydraulic Research, 1970, Part 6.4. 10p.) In
English with French summary.

B-80

Darby, D.A. et al (1974)
AIRBORNE DUST ON THE ARCTIC PACK ICE, ITS
COMPOSITION AND FALLOUT RATE. Earth and Planetary
Science Letters, v. 24(2), 1974, p. 166-72.
21 ref. [fall-out rates show marked decrease in
atmospheric dust from area off Ellesmere Island to
sampling stations north of Point Barrow, Alaska,
1,400 km west]

B-81

Davis, H.; Munis, R.H. (1973)
EFFECT OF SALINITY ON THE OPTICAL EXTINCTION OF
SEA ICE AT 6328A. CRREL Research Report no. 308,
July 1973. 17p. NTIS: AD-763 882.

B-82*

Davis, H.; Munis, R.H. (1976)
EFFECT OF SEA ICE SALINITY ON OPTICAL EXTINCTION
AT WAVELENGTH 6328A. CRREL Translation no. 539,
Aug. 1976, p. 63-68. 2 ref. NTIS: AD-A030 818.
(Translated from "Vliianie solenosti morskogo
l'da na opticheskuiu ekstinktsiiu s dlinoi volny
6328A," Arkticheskii i Antarkticheskii Nauchno-
Issledovatel'skii Institut. Trudy, v. 326, 1975,
p. 66-70.)

B-83*

de Jong, J.J.A.; Stigter, C.; Steyn, B. (1976)
DESIGN AND BUILDING OF TEMPORARY ARTIFICIAL
ISLANDS IN THE BEAUFORT SEA. (In: International
Conference on Port and Ocean Engineering under
Arctic Conditions, 3rd, Proceedings, v.2. Held
11-15 Aug. 1975, Fairbanks, Alaska. Institute
of Marine Science, Univ. of Alaska, 1976, p. 753-
89.)

B-84

DenHartog, S.L. (1971)
SS MANHATTAN TESTS: A REVIEW OF THE ICE PROGRAM.
(In: International Conference on Port and Ocean
Engineering under Arctic Conditions, 1st, Proceed-
ings, v. 1. Held 23-30 Aug. 1971, in Norway.
Trondheim, Technical Institute of Norway, 1971,
p. 101-11. 2 ref.) [sea ice, tensile strength,
ice breaking, ice temperature, ice salinity]

B-85 *

Dixit, Bharat; Pounder, Elton R. (1975)
SPECIFIC HEAT OF SALINE ICE. Journal of
Glaciology, v. 14(71), 1975, p. 459-465. Ref.
In English with French and German summaries.

B-86

Dorsey, N. Ernest (1968)
PROPERTIES OF ORDINARY WATER SUBSTANCE IN ALL ITS
PHASES: WATER-VAPOR, WATER, AND ALL THE ICES.
New York, Hafner Publishing Co., 1968. 696p.
13 fig., tables, ref. (American Chemical Society
Monograph Series no. 81.)

B-87

Dykins, J.E. (1971)
ICE ENGINEERING--MATERIAL PROPERTIES OF SALINE
ICE FOR A LIMITED RANGE OF CONDITIONS, FINAL
REPORT, JULY 1969-MAY 1970. U.S. Naval Civil
Engineering Laboratory. Technical Report,
no. R-720, April 1971. 101p. NTIS: AD-887 840.
[linear equation relating flexural strength
(rupture modulus) with brine volume developed for
temperature range -2C to -10C for normal seawater
ice]

B-88

Dykins, J.E. (1966)
ICE ENGINEERING--TENSILE AND BENDING PROPERTIES
OF SEA ICE GROWN IN A CONFINED SYSTEM. U.S. Naval
Civil Engineering Laboratory. Technical Report
no. R-415, Jan. 1966. 74p. 43 fig., 3 tables,
12 ref. NTIS: AD-626 585.

B-89

Dykens, J.E. (1970)
ICE ENGINEERING--TENSILE PROPERTIES OF SEA ICE GROWN IN A CONFINED SYSTEM. U.S. Naval Civil Engineering Laboratory. Technical Report no. R-689, July 1970. 60p. [laboratory study using axially loaded test specimens of artificially grown polycrystalline ice, frozen from natural sea water and distilled water diluted with natural sea water]

B-90*

Dykens, J.E. (1969)
TENSILE AND FLEXURE PROPERTIES OF SALINE ICE. (In: Riehl, N.; Bullemer, B. et al, ed. Proceedings of the International Symposium on Physics of Ice. Munich, Germany, Sept. 9-14, 1968. N.Y., Plenum, 1969, p. 251-270. 18 fig., 6 ref.)

B-91*

Dykens, J.E. (1967)
TENSILE PROPERTIES OF SEA ICE GROWN IN A CONFINED SYSTEM. (In: Oura, Hirobumi, ed. Physics of Snow and Ice: Proceedings of the International Conference on Low Temperature Science, v. 1, part 1. Sapporo, Institute of Low Temperature Science, Hokkaido Univ., 1967, p. 523-37.) [test on laboratory-grown sea ice compared with natural sea ice; grain structure most important parameter]

B-92

Efimov, V.A. (1974)
K RASCHETU GLAVNYKH OSEI TENZORNYKH ELLIPSOV VNESHNIKH NAPRIAZHENII, DEISTVUIUSHCHIKH NA LEDIANOI POKROV (Calculating the principal axes of stress-tensor ellipses for pack ice). Arkticheskii i Antarkhticheskii Nauchno-Issledovatel'skii Institut. Trudy, v. 316, 1974, p. 52-58. 3 ref. In Russian.

B-93*

Eide, Lars Ingolf; Martin, Seelye (1975)
THE FORMATION OF BRINE DRAINAGE FEATURES IN YOUNG SEA ICE. Journal of Glaciology, v. 14(70), 1975, p. 137-154. 10 fig., ref.
NTIS: AD-A011 190. [laboratory experiments on the growth of sea ice clearly show formation and development of brine drainage channels]

B-94

Evans, R.J. (1972)
CORRECTION TO "CRACKS IN PERENNIAL SEA ICE DUE TO THERMALLY INDUCED STRESS." Journal of Geophysical Research, v. 77(9), 1972, p. 1701.

B-95*

Evans, R.J. (1971)
CRACKS IN PERENNIAL SEA ICE DUE TO THERMALLY INDUCED STRESS. Journal of Geophysical Research, v. 76(33), 1971, p. 8153-55. NTIS: AD-737 452. [lowering of surface temperature below that of the water temperature underneath a floating sea-ice sheet often results in thermal cracking]

B-96 *

Evans, R.J.; Parmeter, R. (1976)
GRAVITATIONAL STRESSES IN FLOATING ICE SHEETS. AIDJEX Bulletin, no. 31, March 1976, p. 86-91. 4 fig., 3 ref.

B-97*

Evans, R.J. (1970)
NOTES ON A POSSIBLE CONSTITUTIVE LAW FOR ARCTIC SEA ICE. AIDJEX Bulletin, no. 2, 1970, p. 13-17. NTIS: AD-715 450. (Also in: Washington. Univ. Dept. of Atmospheric Sciences. Annual report no. 2, Dec. 1970, p. A15-A19.)

B-98*

Evans, R.J. (1975)
ON THE CONTINUUM APPROXIMATION FOR THE AIDJEX MODEL. AIDJEX Bulletin, no. 28, 1975, p. 99-117. 5 fig., ref. [drift, dynamic properties, mathematical models, viscous flow]

B-99

Evans, R.J.; Rothrock, D.A. (1975)
STRESS FIELDS IN PACK ICE. (In: Frankenstein, Guenther E., ed. International Symposium on Ice Problems, 3rd, Proceedings. Held 18-21 Aug. 1975, Hanover, N.H. International Assn. of Hydraulic Research, 1975, p. 527-39. 8 ref.)

B-100*

Evans, R.J.; Untersteiner, Norbert (1971)
THERMAL CRACKS IN FLOATING ICE SHEETS. Journal of Geophysical Research, v. 76(3), 1971, p. 694-703. NTIS: AD-721 414. [quantitative aspects of thermal cracking from a strength of materials viewpoint]

B-101

EXPERIMENTAL INVESTIGATION OF ICE FLOE UNDER WAVE ACTION. Pasadena, Calif., National Engineering Science Co., Final Report, Jan. 1965. 35p.
NTIS: AD-456 969. [thermal stresses, polyethylene plastics, brittleness, model tests, strain gauges, transducers, gravity]

B-102

Farrar, John; Hamilton, W.S. (1965)
NUCLEATION AND GROWTH OF ICE CRYSTALS. U.S. Dept. of the Interior. Research and Development Progress Report, no. 127, 1965. 51p. [ice growth in supercooled water measured as function of crystal orientation, temperature, flow, salt concentration and additives; mechanism of ice formation in sea water]

B-103

Fedotov, V.I. (1976)
STROYENIYE ODNOLETNEGO L'DA MORYA LAPTEVYKH V VESENYY PERIOD (Structure of one-year-old first-year ice in the Laptev Sea in spring). Arkticheskii i Antarkhticheskii Nauchno-Issledovatel'skii Institut. Trudy, v. 331, 1976, p. 151-56. In Russian.

B-104

Feldman, H.R.; Garrison, G.R.; Pence, E.A.; Shah, S.R. (1973)
STUDIES IN THE MARGINAL ICE ZONE OF THE CHUKCHI SEA: ANALYSIS OF 1972 DATA. Washington. Univ. Applied Physics Laboratory. Report no. APL-JW-7309, July 1973. 157p. NTIS: AD-767 043. [ice floes, microstructure, sea ice, sound propagation, sound scattering, temperature profiles]

84/559

B-105

Feldman, H.R.; Garrison, G.R.; Pence, E.A. et al (1974)

STUDIES IN THE MARGINAL ICE ZONE OF THE CHUKCHI SEA: ANALYSIS OF 1972 DATA. Washington. Univ. Applied Physics Laboratory. Report no. APL-UW-7311, March 1974. 142p. NTIS: AD-779 856. [ice floes, oceanographic data, sound propagation, sound pulses, sound scattering, sound transmission, temperature profiles, thermoclines]

B-106

Fertuck, L.; Spyker, J.W.; Husband, W.H.W. (1972) COMPUTING SALINITY PROFILES IN ICE. Canadian Journal of Physics, v. 50(3), 1972, p. 264-67. Equation obtained for calculating ice salinity for temperature gradients up to 1.3°C/cm]

B-107

Finke, Siegfried (1972) UNTERSUCHUNGEN ZUM VERFORMUNGSVERHALTEN DES MEEREISES IM ECLIPSE SOUND (BAFFIN ISLAND) UND MESSUNGEN DES REIBUNGSKOEFFIZIENTEN STAHL-EIS (Investigation on the deformation behavior of sea ice in Eclipse Sound (Baffin Island) and measurements of the coefficient of friction of steel-ice). Polarforschung, Jahrg. 42, Bd. 7, Nr. 2, 1972, p. 75-81. In German. [observations on plastic behavior of sea ice, samples being subjected to various methods of deformation; describes measurement of friction parameter steel-ice, referring to drilling holes]

B-108

Finkel'shtein, M.I.; Glushnev, V.G.; Petrov, A.N. et al (1970)

ANISOTROPIC ATTENUATION OF RADIO WAVES IN SEA ICE. Akademiya Nauk SSSR. Izvestiya. Atmospheric and Oceanic Physics, v. 6(3), 1970, p. 175-76. 2 ref. (Translated from "Ob anizotropii zatukhaniya radiovoln v morskogo l'da," Akademiya Nauk SSSR. Izvestiya. Fizika Atmosfery i Okeana, v. 6(3), March 1970, p. 311-13.)

B-109

Finkel'shtein, M.I.; Glushnev, V.G. (1973) ELECTROPHYSICAL PROPERTIES OF SEA ICE MEASURED BY RADAR SOUNDING IN THE ONE-METER WAVE RANGE. Akademiya Nauk SSSR. Doklady. Earth Science Section, v. 203(1/6), 1973, p. 7-9. 3 ref. (Translated from "O nekotorykh elektrofizicheskikh kharakteristikakh morskogo l'da, izmerennykh putem radiolokatsionnogo zondirovaniia v metrovom diapazone voln," Akademiya Nauk SSSR. Doklady, v. 203(3), March 1972, p. 578-80.)

B-110

Finkel'shtein, M.I.; Kozlov, A.I.; Mendel'son, V.L. (1970)

MODELLING OF REFLECTION OF RADIO WAVES FROM SEA ICE. Radio Engineering and Electronic Physics, v. 15(11), 1970, p. 1999-2005. (Translated from "O modelirovanii otrazheniya radiovoln ot morskogo l'da," Radiotekhnika i Elektronika, v. 15(11), 1970, p. 2282-88.) [from a rigorous solution of the problem of reflection of a plane electromagnetic wave from sea ice, equivalent frequency characteristics are constructed for signals reflected from the upper and lower edges]

B-111

Finkel'shtein, M.I. (1970)

OPTIMUM FORM OF PULSES IN RADAR SOUNDING OF SEA ICE. Radio Engineering and Electronic Physics, v. 15(12), 1970, p. 2179-82. (Translated from "Ob optimal'noy forme impul'sov pri radiolokatsionnom zondirovanii morskogo l'da," Radiotekhnika i Elektronika, v. 15(12), 1970, p. 2468-72.) [presents optimum wave form for which the resolving characteristics of the signal are retained after reflection from the edges of the ice]

B-112 *

Finkel'shtein, M.I.; Glushnev, V.G.; Petrov, A.N. (1970)

ON THE ANISOTROPY OF THE RADIOWAVE ATTENUATION IN THE SEA ICE. SERIES ON THE PHYSICS OF THE ATMOSPHERE AND THE OCEAN. (In: Gudmandsen, P., ed. Proceedings of the International Meeting on Radioglaciology, Lyngby, May 1970. Lyngby, Technical Univ. of Denmark, Laboratory of Electromagnetic Theory, 1970, p. 159-65.)

B-113

Firouzabadi, A.K. (1968) PROPAGATION OF RADIO WAVES OVER ICE WITH UNDERLYING SEA WATER. College Park, Maryland, Maryland Univ., 1968. 82p. Ph.D. thesis. Univ. Microfilms order no. 63-6524. [analyzes the problem theoretically by using Maxwell's field equations and satisfying the appropriate conditions imposed by the various boundaries]

B-114

Fletcher, Neville H. (1970) CHEMICAL PHYSICS OF ICE. Cambridge, Cambridge Univ. Press, 1970. (Monographs on physics series.)

B-115

Foldvik, A.; Kvinge, T. (1974) CONDITIONAL STABILITY OF SEA WATER AT THE FREEZING POINT. Deep-sea Research, v. 21(3), March 1974, p. 169-74. 6 ref. [sea water freezing, ice crystal formation, convection, water temperature, salinity; thermohaline convection mechanism based on the depression of the freezing point of sea water with increasing pressure discussed]

B-116

Foster, Theodore D. (1969) EXPERIMENTS ON HALINE CONVECTION INDUCED BY THE FREEZING OF SEA WATER. Journal of Geophysical Research, v. 74(28), 1969, p. 6967-74. [laboratory study of convection below freezing layer of sea ice]

B-117

Foster, Theodore D. (1968) HALINE CONVECTION INDUCED BY THE FREEZING OF SEA WATER. Journal of Geophysical Research, v. 73(6), 1968, p. 1933-38. [onset of haline convection investigated, and applied to formation of sea ice]

B-118

Foster, Theodore D. (1972) HALINE CONVECTION IN POLYNYAS AND LEADS. Journal of Physical Oceanography, v. 2, 1972, p. 462-69.

B-119 *

Frankenstein, Guenther E.; Garner, Robert (1970)
DYNAMIC YOUNG'S MODULUS AND FLEXURAL STRENGTH OF
SEA ICE. CRREL Technical Report no. 222, May
1970. 19p. Ref. NTIS: AD-710 975.

B-120 *

Frankenstein, Guenther E.; Garner, Robert (1967)
EQUATIONS FOR DETERMINING THE BRINE VOLUME OF SEA
ICE FROM -0.5 DEGREES TO -22.9 DEGREES C. Journal
of Glaciology, v. 6(48), Oct. 1967, p. 943-44.
1 ref. In English with French and German
summaries.

B-121

Frankenstein, Guenther E. (1970)
FLEXURAL STRENGTH OF SEA ICE AS DETERMINED FROM
SALINITY AND TEMPERATURE PROFILES. Canada.
National Research Council. Associate
Committee on Geotechnical Research. Technical
Memorandum no. 98, Nov. 1970, p. 66-73.

B-122 *

Frankenstein, Guenther E. (1969)
RING TENSILE STRENGTH STUDIES OF ICE. CRREL
Technical Report no. 172, 1969. 36p. 8 ref.
NTIS: AD-686 284.

B-123 *

Frederking, R. (1974)
DOWNDRAG LOADS DEVELOPED BY A FLOATING ICE COVER:
FIELD EXPERIMENTS. Canadian Geotechnical Journal,
v. 11(3), Aug. 1974, p. 339-47. 10 fig., 6 ref.
[Information obtained on dependence of pile
displacement rate on applied stress for snow ice
at temperature within 10°C of melting point]

B-124

Frederking, R. (1976)
MECHANICAL PROPERTIES OF ICE AND THEIR APPLICATION
TO ARCTIC ICE PLATFORMS. (In: Ice Tech 75:
Symposium on Icebreaking and Related Technologies.
Held 9-11 April 1975 in Montreal, Canada. New
York, Society of Naval Architects and Marine
Engineers, 1976, p. K/1-K/18.)

B-125 *

Prolov, A.D.; Slesarenko, Iu.E. (1974)
CHARACTERISTICS OF ELASTICITY OF SEA ICE OF
DIFFERENT COMPOSITIONS. (In: I.A.H.R. Symposium
of Ice and Its Action on Hydraulic Structures,
2nd, Proceedings. Held in Leningrad, 26-29 Sept.
1972. Leningrad, International Assn. for
Hydraulic Research, 1972, p. 88-90.) [application
of ultrasonic pulse method]

B-126 *

Prolov, A.D. (1972)
VLIYANIYE FAZOVOGO SOSTAVA I STRUKTURY MORSKOGO
L'DA NA EGO UPRUGIYE I DIELEKTRICHESKIYE SVOYSTVA
(The influence of phase composition and sea ice
structure upon its dielectric and strength
properties). Akademiya Nauk SSSR. Institut
Geografii. Materialy Gilyatsiologicheskikh
Issledovaniy. Khronika, Obsuzhdeniya, no. 19,
1972, p. 203-09. In Russian with English summary.

B-127 *

Fujino, Kazuo (1970)
DIELECTRIC PROPERTIES OF SEA ICE. Hanover, N.H.,
CRREL, 1970. 54p. NTIS: AD-877 403. (Trans-
lated from "Kaikyō no yūdenteki seishitsu ni
kansuru kenkyū," Teion Kagaku, Series A, no. 25,
1967, p. 127-69.) [Ice dielectrics, conductivity]

B-128 *

Fujino, Kazuo (1967)
ELECTRICAL PROPERTIES OF SEA ICE. (In: Oura,
Hirobumi, ed. Physics of Snow and Ice: Proceed-
ings of the International Conference on Low Temp-
erature Science, v. 1, part 1. Sapporo, Institute
of Low Temperature Science, Hokkaido Univ., 1967,
p. 633-48.) [measurements of permittivity and
conductivity of sea ice 100 Hz-50 kHz from -5° to
-70°C; relation with geometrical arrangement of
brine cells]

B-129

Gaitskhoki, B.Ia.; Morozov, P.T.; Sovalkov, L.I.
(1970)
ISSLEDOVANIE STROENIIA I SOSTAVA MORSKIKH L'DOV
V ARKTICHESKOM BASSEINE (Investigation of the
structure and composition of sea ice in the Arctic
Basin). Arkticheskii i Antarkticheskii Nauchno-
Issledovatel'skii Institut. Trudy, v. 295, 1970,
p. 108-15. In Russian.

B-130 *

Gaitskhoki, B.Ia. (1976)
OPTICAL CHARACTERISTICS OF SOME VARIETIES OF
NATURAL ICE. CRREL Translation no. 539, Aug.
1976, p. 69-72. 2 ref. NTIS: AD-A030 818.
(Translated from "Opticheskoe kharakteristiki
nekotorykh raznovidnostei estestvennykh l'dov,"
Arkticheskii i Antarkticheskii Nauchno-
Issledovatel'skii Institut. Trudy, v. 326, 1975,
p. 71-73.)

B-131

Gaitskhoki, B.Ia.; Spitsyn, V.A. (1971)
SOME RESULTS OF TEMPERATURE MEASUREMENT IN ICE ON
THE DRIFTING STATIONS NP-13F. Arkticheskii i
Antarkticheskii Nauchno-Issledovatel'skii Institut.
Transactions, v. 295, 1971, p. 154-58.
NTIS: TT70-50158. (Translated from "Nekotorye
rezultaty izmereniia temperatury l'da na
dreifuishchei stantsii Severnyi Polius-13F,"
Arkticheskii i Antarkticheskii Nauchno-
Issledovatel'skii Institut. Trudy, v. 295, 1970,
p. 129-32.)

B-132

Gaitskhoki, B.Ia. (1971)
SPECTRAL TRANSMISSION OF SNOW AND SOME ICE
VARIETIES. Arkticheskii i Antarkticheskii
Nauchno-Issledovatel'skii Institut. Transactions,
v. 295, 1971, p. 44-47. 4 ref. NTIS: TT70-50158.
(Translated from "Spektral'naia prozrachnost'
snega i nekotorykh raznovidnostei l'da,"
Arkticheskii i Antarkticheskii Nauchno-
Issledovatel'skii Institut. Trudy, v. 295, 1970,
p. 50-54.)

B-133

Gaitskhoki, B.Ia.; Morozov, P.T.; Sovalkov, L.I. (1971)

STUDIES OF THE STRUCTURE AND COMPOSITION OF SEA ICE IN THE ARCTIC BASIN. Arkticheskii i Antarkticheskii Nauchno-Issledovatel'skii Institut. Transactions, v. 295, 1971, p. 92-97. 4 ref.

NTIS: TT70-50158. (Translated from "Issledovanie stroeniia i sostava morskikh l'dov v Arkticheskoi basseine," Arkticheskii i Antarkticheskii Nauchno-Issledovatel'skii Institut. Trudy, v. 295, 1970, p. 109-15.)

B-134

Gaitskhoki, B.Ia.; Tikhonov, Iu.P. (1974)

TERMOMETRICESKAIA USTANOVKA DLIA IZMERENIIA TEMPERATURY LEDIANOGO POKROVA (Temperature measuring device for establishing ice cover temperatures). Arkticheskii i Antarkticheskii Nauchno-Issledovatel'skii Institut. Trudy, v. 324, 1974, p. 193-96. 2 ref. In Russian.

B-135

Galkina, A.I.; Spitsyn, V.A. (1971)

MEASURING THE TEMPERATURE OF THE SURFACE OF WATER, SNOW, AND ICE WITH A RADIATION THERMOMETER.

Arkticheskii i Antarkticheskii Nauchno-Issledovatel'skii Institut. Transactions, v. 295, 1971, p. 56-59. NTIS: TT70-50158. (Translated from "Izmerenie temperatury poverkhnosti vody, snega i l'da radiatsionnym termometrom," Arkticheskii i Antarkticheskii Nauchno-Issledovatel'skii Institut. Trudy, v. 295, 1970, p. 64-68.)

B-136

Canton, J.H.; McMillin, D.J.; Milne, A.R. (1967)

AMBIENT NOISE UNDER SEA ICE AND FURTHER MEASUREMENTS OF WIND AND TEMPERATURE DEPENDENCE. Acoustical Society of America. Journal, v. 41(2), Feb. 1967, p. 525-28. Fig., 3 ref. [wind effects, under ice, air temperature, ambient noise]

B-137

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TEMPERATURE- AND WIND-DEPENDENT AMBIENT NOISE UNDER MIDWINTER PACK ICE. Acoustical Society of America. Journal, v. 38(3), 1965, p. 406-11. [measurement of noise reveals two sources, cracking due to thermal stresses and wind effects]

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CREEP OF FLOATING ICE SHEET, U. San Marino, Calif., Science Engineering Associates, April 1967. 52p. 8 fig., 14 ref. (Also U.S. Naval Civil Engineering Laboratory. Report no. CR-67-025, 1967. NTIS: AD-654 742.) [linear visco-elasticity, floating ice sheet, creeping plate behavior, nonlinear creep]

B-139

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B-140

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SOUND ABSORPTION MEASUREMENTS AT 10-60 KHZ IN NEAR-FREEZING SEA WATER. Acoustical Society of America. Journal, v. 58(3), Sept. 1975, p. 608-19. Ref. [sound propagation measurements at various frequencies between 10 and 60 kHz were made in April 1974 under the pack ice near Point Barrow, Alaska]

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ACOUSTIC RECORDING ON THE CRITICAL STATE OF STRESS IN ICE. Arkticheskii i Antarkticheskii Nauchno-Issledovatel'skii Institut. Transactions, v. 295, 1971, p. 139-45. 11 ref. NTIS: TT70-50158.

(Translated from "O vozmozhnosti akusticheskoi registratsii kriticheskogo napriazhenno-go sostoiianiia ledianogo pokrova," Arkticheskii i Antarkticheskii Nauchno-Issledovatel'skii Institut. Trudy, v. 295, 1970, p. 166-73.) [acoustic wave generation, sea ice temperatures, sea ice breakup]

B-144

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FRIKTSIONNYE KHARAKTERISTIKI MORSKOGO L'DA (Friction properties of sea ice). Arkticheskii i Antarkticheskii Nauchno-Issledovatel'skii Institut. Trudy, v. 316, 1974, p. 107-12. 7 ref. In Russian. [pack ice, ice friction, pressure ridges, experimental data, drift stations]

B-145

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STATISTICS OF AIR INCLUSIONS IN ICE. Arkticheskii i Antarkticheskii Nauchno-Issledovatel'skii Institut. Transactions, v. 295, 1971, p. 125-28. 2 ref. NTIS: TT70-50158. (Translated from "K voprosu o statistike vozdukhnykh vklucheni vo l'du," Arkticheskii i Antarkticheskii Nauchno-Issledovatel'skii Institut. Trudy, v. 295, 1970, p. 149-53.)

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A SIMPLE FIELD MEASURE OF ICE STRENGTH. (In: Frankenstein, Guenther E., ed. International Symposium on Ice Problems, 3rd, Proceedings. Held 18-21 Aug. 1975, Hanover, N.H. International Assn. of Hydraulic Research, 1975, p. 589-600.) [penetration test for testing strength of floating ice]

B-147

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DEVELOPMENT OF A SEA-ICE THICKNESS GAGE. AN ATTEMPT TO USE SHEAR WAVES. U.S. Coast Guard. Report USCG-D-44-75. Kingston, Rhode Island Univ., 1973. 218p. NTIS: AD-A006 599. [experimental apparatus for the measurement of the thickness of sea ice by the use of a shear wave reflection technique]

B-148 *

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PHYSICS OF ICE. CRREL Monograph II-C2a, April 1974. 81p.

B-149 *

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FAILURE PROCESS IN COLUMNAR-GRAINED ICE. Canada. National Research Council. Division of Building Research. Technical Paper 369, May 1972. 108p.

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THE INITIAL CREEP OF COLUMNAR-GRAINED ICE--PART 1: OBSERVED BEHAVIOR; PART 2: ANALYSIS. Canadian Journal of Physics, v. 43(8), 1965, p. 1414-34. Table.

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A STUDY OF THE STRUCTURE OF SEA ICE. (In: Yakovlev, G.N., ed. Studies in Ice Physics and Ice Engineering, v. 300. Jerusalem, Israel Program for Scientific Translations, 1973, p. 177-80. 3 ref. NTIS: TT72-50005.) (Translated from "Issledovanie struktury morskogo l'da," Arkticheskii i Antarkticheskii Nauchno-Issledovatel'skii Institut. Trudy, v. 300, 1971, p. 205-09.)

B-152

Golovkov, M.P. (1972)
THE HYDROCHEMISTRY OF NATURAL ICE. Washington, D.C., Arctic Institute of North America, Jan. 1972. 13p. NTIS: AD-738 188. (Translated from "O gidrokhimii prirodnykh l'dov," Gidrokhimicheskie Materialy, v. 20, 1953, p. 46-48.) [need of further study of the diverse kinds of natural ice discussed]

B-153

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SURFACE STRAIN RATE MEASUREMENTS ON SEA-ICE AND GLACIERS. Geophysical Journal, v. 49(1), 1977, p. 268.

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Goodrich, L.E. (1975)
NUMERICAL MODEL FOR CALCULATING TEMPERATURE PROFILES IN AN ICE COVER. Canada. National Research Council. Associate Committee on Geotechnical Research. Technical Memorandum no. 114, Jan. 1975, p. 44-59. 5 ref. [ice temperature, profiles, mathematical models, floating ice, ice cover thickness, temperature variations]

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MAJOR ELEMENTARY HYDROLOGICAL PROCESSES IN THE ARCTIC SEAS. (In: Treshnikov, A.F., ed. Problems of the Arctic and Antarctic, v. 40. Jerusalem, Israel Program for Scientific Translations, 1973, p. 1-8. NTIS: TT72-50089.) (Translated from "Osnovnye elementarnye gidrologicheskie protsessy v arkticheskikh moriakh," Problemy Arktiki i Antarktiki, v. 40, 1972, p. 5-12.) [ice conditions, water temperature, sea water, salinity, ocean currents, sea level]

B-156 *

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GAS MOVEMENT THROUGH SEA ICE. Nature, v. 263(5572), 1976, p. 41-42. [letter; data indicate gas migration is important factor in ocean-atmosphere winter communication particularly when surface temperature is above -10°C]

B-157 *

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Gow, Anthony J.; Williamson, T.C. (1972)
LINEAR COMPRESSIBILITY OF ICE. Journal of Geophysical Research, v. 77(32), 1972, p. 6348-52.

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O MIKROREL'EFE RIZHNEI POVERKHNOSTI MORSKIKH DREIFUIUSHCHIKH L'DOV (Microrelief of the bottom surface of drifting sea ice). Arkticheskii i Antarkticheskii Nauchno-Issledovatel'skii Institut. Trudy, v. 320, 1976, p. 208-13. 2 ref. In Russian. [microrelief, ice bottom surface, sea ice, seasonal variations, drift]

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ELECTROMAGNETIC STUDIES OF SEA ICE. International Scientific Radio Union. Information Bulletin, no. 177, 1970, p. 7-9. [further studies required on dielectric properties of sea ice, remote sensing of sea ice, and wave propagation in inhomogeneous anisotropic ice structures]

B-163 *

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RADIO ECHO SOUNDING OF POLAR ICE. Lyngby, Technical Univ. of Denmark. Report D-170, 1972. 27p.

B-164 *

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IMPACT PENETRATION OF ARCTIC SEA ICE. (In: I.A.H.R. Symposium on Ice and Its Action on Hydraulic Structures, 1st, Proceedings. Held in Reykjavik, Iceland, 7-10 Sept. 1970. International Assn. for Hydraulic Research, 1971, Paper 5.5. 8p.) [development of large-deformation theory techniques involving use of computer code]

B-165

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A CALCULATION OF THE ACOUSTIC SHEAR WAVE ATTENUATION IN SEA ICE. Washington. Univ. Applied Physics Laboratory. Report APL-UW-7310, July 1974. 46p. NTIS: AD-786 707. [attenuation of an acoustic disturbance propagating in ice]

B-166

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MEASUREMENT OF BRINE DROPLET MIGRATION IN ICE. Journal of Applied Physics, v. 36(12), 1965, p. 3811-15. [observations of velocity and changes of size and shape of droplets of NaCl, KF, and KI through ice from -6° to 0°C]

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SOLUTE TRANSPIRATION PORES IN ICE. Journal of Applied Physics, v. 36(1), Jan. 1965, p. 326-27. 13 ref. [ice grown by progressive freezing of water samples containing various solutes at different concentration]

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OPERATION "HAZEN-TANQUARY" 1965-68. Canada. Defence Research Board. Geophysics Section, Hazen 37, DREO Report no. 580, 1969. 20p. [field studies outlined in northern Ellesmere Island, including glacier studies and sea ice physics]

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TENSILE STRENGTH OF ICE UNDER TRIAXIAL STRESSES. CRREL Research Report no. 312, Dec. 1973. 21p.

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ELASTISCHEN WELLEN IN EIS (Elastic waves in ice). Zeitschrift für Geophysik, v. 31(6), 1965, p. 293-99. In German. [measurements of propagation and dispersion of elastic waves in floating ice; influence of water on group velocity of flexural waves]

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INTERACTION THEORY FOR A FLOATING ELASTIC SHELF OF FINITE LENGTH WITH GRAVITY WAVES IN WATER OF FINITE DEPTH, INCLUDING A COMPARISON WITH EXPERIMENTAL DATA. Port Hueneme, Calif., U.S. Naval Civil Engineering Laboratory, 1966. 178p. [assessment of internal stress state in an ice floe due to wave action and degree to which such forces are major cause of breakup]

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WAVE-ICE INTERACTION MODEL EXPERIMENTS. Stevens Institute of Technology. Davidson Laboratory. Report no. 1314, Dec. 1968. 52p. NTIS: AD-680 449. [measurements of amplitude and bottom pressure were made over a range of free-surface wave lengths incident upon simulated floes of varying solidity and size]

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MESO-SCALE STRAIN MEASUREMENTS ON THE BEAUFORT SEA PACK ICE (AIDJEX 1971). AIDJEX Bulletin, no. 13, 1972, p. 35-76. (Also in: Journal of Glaciology, v. 12(65), 1973, p. 187-206.) (Translated into "Izmerenie srednemashtabnoi deformatsii morskikh l'dov v more Boforta (Aidzheks-1971)," Problemy Arktiki i Antarktiki, v. 43-44, 1974, p. 119-38. In Russian.) [pack ice, ice deformation, drift, aerial reconnaissance, ice reporting, aerial photographs]

B-174 *

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DIELECTRIC PROPERTIES OF SEA AND SODIUM CHLORIDE ICE AT UHF AND MICROWAVE FREQUENCIES. Journal of Geophysical Research, v. 76(20), 1971, p. 4922-31. Fig., 20 ref.

B-175 *

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THE DIELECTRIC PROPERTIES OF SEA ICE AT UHF AND MICROWAVE FREQUENCIES. (In: Gudmandsen, P., ed. Proceedings of the International Meeting on Radio-glaciology, Lyngby, May, 1970. Lyngby, Technical Univ. of Denmark, Laboratory of Electromagnetic Theory, 1970, p. 32-53.)

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THE MIGRATION OF LIQUID INCLUSIONS IN SINGLE ICE CRYSTALS. Journal of Geophysical Research, v. 70(20), 1965, p. 5035-41. (Also CRREL Research Report no. 183, 1965. 8p.) [migration of brine pockets under influence of temperature gradient investigated; results help in understanding composition of sea ice]

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MOVEMENT OF WATER IN A FILM BETWEEN GLASS AND ICE. CRREL Research Report no. 153, May 1965. 8p. Fig., ref. [properties of the film between glass and ice]

B-178 *

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THE DEFORMATION OF AN ARCTIC ICE ISLAND. (In: International Conference on Port and Ocean Engineering under Arctic Conditions, 2nd, Proceedings. Held 27-30 Aug. 1973, Reykjavik. Univ. of Iceland, 1974, p. 419-40. 14 fig., 1 table, 6 ref.)

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FLEXURE OF A FLOATING ICE TONGUE. Journal of Glaciology, v. 8(54), Oct. 1969, p. 385-97. Fig., ref. In English with French and German summaries. [several analyses for the flexure of a floating polar ice tongue]

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RESULTS OF PRELIMINARY FLAT JACK TESTS FOR DETERMINING THE ELASTIC AND CREEP PROPERTIES OF IN SITU SEA ICE. EOS, v. 57(3), 1976, p. 151. [abstract only; experimental studies, creep curves, elastic moduli, stress]

B-181

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EFFECT OF NATURAL CONVECTION ON ICE CRYSTAL GROWTH IN SALT SOLUTIONS. Syracuse, N.Y., Syracuse Univ., 1975. 118p. Ph.D. thesis. Univ. Microfilms order no. 76-18524. [Ice crystal growth, solutions, convection, salt water]

B-182 *

Hunkins, Kenneth L. (1975)
GEOSTROPHIC DRAG COEFFICIENTS FOR RESISTANCE BETWEEN PACK ICE AND OCEAN. AIDJEX Bulletin, no. 28, 1975, p. 61-67. 3 fig., ref.

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SALINITY AND TEMPERATURE MEASUREMENTS FROM THE AIDJEX MANNED ARRAY. Presented at Symposium on Sea Ice Processes and Models, Seattle, Univ. of Washington, 6-9 Sept. 1977, sponsored by ICISI and AIDJEX.

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FLOATING SEA ICE PLATES AND THE SIGNIFICANCE OF THE DEPENDENCE OF THE POISSON RATIO ON BRINE CONTENT. Royal Society of London. Proceedings, no. 343, 1975, p. 85-108. 6 fig., 8 ref. In English with French and German summaries.

B-186 *

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ON THE SIGNIFICANCE OF POISSON'S RATIO FOR FLOATING SEA ICE. Zurich. Eidgenossische Technische Hochschule. Versuchsanstalt für Wasserbau, Hydrologie und Glaziologie. Mitteilung no. 11, May 1974. 78p. 11 ref. In English with German and French summaries. [Investigates influence of temperature profile in ice plates on plate characteristic coefficients for dynamical theory of flexible plates that accounts for such effects as variation of Poisson's ratio across plate thickness]

B-187 *

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CALCULATION OF ICE-COVER BENDING ALLOWING FOR VISCOUS PROPERTIES OF ICE. CRREL Translation no. 425, Sept. 1974. 9p. NTIS: AD-A002 378. (Translated from "K voprosu ob izgibe ledianogo prokrova s uchetom viazkikh svoistv l'da," Novosibirsk. Institut Inzhenerov Zheleznodorozhnogo Transporta. Trudy, v. 79, 1968, p. 72-82.) [linear viscoelastic deflections and stresses of floating ice sheet]

B-189

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OPREDELENIYE VNUTRENNIKH NAPRYAZHENIY V LEDYANOM POKROVE, VOZNIKAYUSHCHIKH PRI DREYFA L'DA (Measurement of internal strains in ice cover occurring during ice drift). Problemy Arktiki i Antarktiki, v. 43-44, 1974, p. 84-91. In Russian.

B-190

ICE IS SAFE ONLY IN A GLASS. Canadian Mining Journal, v. 95(1), 1974, p. 11. [table showing load-carrying capacity of floating ice of various thicknesses for loads ranging from one person on skis to 7-8 ton truck]

B-191

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REVIEW OF THE ELECTRICAL PROPERTIES OF ICE AND HISS DOWN-LOOKING RADAR FOR MEASURING ICE THICKNESS. Canadian Aeronautics and Space Journal, v. 17(10), Dec. 1971, p. 429-30. [Ice cover thickness, ice electrical properties, radar echoes, airborne radar, ice dielectrics, measuring instruments, holography]

B-192

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CRYSTAL FABRIC VARIATIONS IN ARCTIC SEA ICE. (In: Reed, John C.; Sater, J.E., ed. The Coast and Shelf of the Beaufort Sea. Proceedings of a symposium held in San Francisco, 7-9 Jan. 1974. Arlington, Va., Arctic Institute of North America, 1974, p. 205-19.) [results from examination of sea ice collected off southwest coast of Amund Ringnes]

B-193 *

Ishida, Tamotsu; Tabata, Tadashi; Suzuki, Y. et al. (1972)
PRELIMINARY TESTS OF STRESS AND STRAIN MEASUREMENT WITHIN ICE SHEET. (In: Karlsson, T., ed. Sea Ice: Proceedings of an International Conference. Held 10-13 May 1971, Reykjavik. National Research Council, 1972, p. 174-75.)

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ICE INTERFACE. (In: Horne, R.A., ed. Water and Aqueous Solutions: Structure, Thermodynamics, and Transport Processes. N.Y., Wiley-Interscience, 1972, p. 65-107.)

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Johnson, Philip R. (1976)
AN EARLY DESALINATION AND ICE STRUCTURES PROJECT USING NATURAL FREEZING. (In: International Conference on Port and Ocean Engineering under Arctic Conditions, 3rd, Proceedings. Held 11-15 Aug. 1975, Fairbanks, Alaska. Institute of Marine Science, Univ. of Alaska, 1976, p. 285-86.)

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ANISOTROPY OF RADIO-WAVE DELAY IN SEA ICE. Akademiya Nauk SSSR. Izvestiya. Atmospheric and Oceanic Physics, v. 7(10), Oct. 1971, p. 738. (Translated from "Ob anizotropii zapazdyvaniya radiovoln v morskoy l'du," Akademiya Nauk SSSR. Izvestiya. Fizika Atmosfery i Okeana, v. 7(10), 1971, p. 115-16.)

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EXPERIMENTAL RECRYSTALLIZATION OF ICE UNDER DEFORMATION. American Geophysical Union. Transactions, v. 47(1), 1966, p. 187-88. [abstract only]

B-201

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ISSLEDOVANIYA DIELEKTRICHESKIKH SVOYSTV MORSKOGO L'DA V DIAPAZONE SVCh (Research into the dielectric properties of sea ice in the VHF spectrum). Arkticheskii i Antarkticheskii Nauchno-Issledovatel'skii Institut. Trudy, v. 298, 1972, p. 116-20. In Russian.

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LABORATORY DETERMINATION OF THE DYNAMIC MODULI OF FROZEN SOILS AND OF ICE. (In: Permafrost International Conference, Lafayette, Ind., 1963, Proceedings. National Research Council. Publication no. 1287, 1966, p. 293-301.) (Also CRREL Research Report no. 163, 1969. 45p.)

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Kashtelian, V.I.; Pozniak, I.I.; Ryvlin, A.Ia. (1968)
SOPROTIVLENIE L'DA DVIZHENIIU SUDNA (Ice resistance to the ship's movement). Leningrad, Izdatelstvo Sudostroenie, 1968. 238p. Tables, 110 ref. In Russian. [theoretical and experimental problems of a vessel's movement through loose pack, solid, and hummocky sea ice]

B-204 *

Kashtelian, V.I.; Ryvlin, A.Ia. (1966)
UCHET PRIRODNYKH KHARAKTERISTIK SPLOSHNOGO L'DA PRI OTSENKE EGO PROKHODIMOSTI LEDOKOLOM (Calculation of natural properties of close pack ice by appraisal of its penetrability by icebreakers). Problemy Arktiki i Antarktiki, v. 22, 1966, p. 75-80. In Russian. [icebreaker movement in Arctic Basin ice where transit is significantly affected by the ice thickness, degree of decay, hummocking, etc.]

B-205

Katona, Michael G.; Vaudrey, K.D. (1973)
ICE-ENGINEERING-SUMMARY OF ELASTIC PROPERTIES RESEARCH AND INTRODUCTION TO VISCOELASTIC AND NONLINEAR ANALYSIS OF SALINE ICE. U.S. Naval Civil Engineering Laboratory. Technical Report no. 797, Aug. 1973. 72p. NTIS: AD-768 279. [previous studies on elastic behavior with emphasis placed on plate analysis]

B-206

Katona, Michael G. (1974)
ICE ENGINEERING: VISCOELASTIC FINITE ELEMENT FORMULATION. U.S. Naval Civil Engineering Laboratory. Technical Report no. 803, Jan. 1974. 60p. NTIS: AD-774 482. [sea ice, viscoelasticity, loads (forces), stress strain relations, landing fields, boundary value problems, computerized simulation]

B-207

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SUPERCOOLING AT THE SURFACE OF AN ARCTIC LEAD. Journal of Physical Oceanography, v. 3(4), 1973, p. 482-86. [field observations verify the supposition that supercooling of the surface water on open leads acts as a source of water for observed sub-surface freezing]

B-208

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ON THE EXPANSION OF A FLOATING ICE SHEET WITH TEMPERATURE CHANGE. Canada. National Research Council. Associate Committee on Geotechnical Research. Technical Memorandum no. 92, March 1968, p. 185-87.

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THE BEARING CAPACITY OF FLOATING ICE PLATES SUBJECTED TO STATIC OR QUASI-STATIC LOADS: A CRITICAL SURVEY. CRREL Research Report no. 333, March 1975. 43p. 28 fig., tables, 157 ref. NTIS: AD-A009 363.

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THE DEFORMATIONS AND STRESSES IN FLOATING ICE PLATES. New York. Univ. School of Engineering and Science. Dept. of Aeronautics and Astronautics. Report no. S-70-3, NYU-AA-70-17, 1970. 22p. [further mathematical development of Assur's work on flexural and other properties of sea ice sheets]

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Kerr, Arnold D. (1966)
ON PLATES SEALING AND INCOMPRESSIBLE LIQUID.
International Journal of Mechanical Sciences,
v. 3(4), 1966, p. 295-304. (Also CRREL Research
Report no. 260, 1966. 11p.) [mathematical study
of problem of bearing capacity of ice floes on
which melt water has partially refrozen]

B-212

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THE PREFERRED ORIENTATION IN THE GROWTH OF ICE
FROM THE MELT. Journal of Crystal Growth, v. 1,
1967, p. 263-70.

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Kheisin, D.E. (1969)
DYNAMICS OF THE ICE COVER. U.S. Air Force Systems
Command. Foreign Technology Division. Wright-
Patterson Air Force Base. Translation no.
FTD-HT-23-485-69, Sept. 1969. 252p. (Translated
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Gidrometeorologicheskoye Izdatel'stvo, 1967.)

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Kheisin, D.E. (1972)
EXCITATION OF COMPRESSIVE STRESSES IN ICE DURING
THE HYDRODYNAMIC STAGE OF COMPACT ICE DRIFT.
AIDJEX Bulletin, no. 16, Oct. 1972, p. 97-107.
[external and internal forces affecting the drift
of ice floes; time scales required to describe ice
drift]

B-215

Kheisin, D.E.; Cherepanov, N.V. (1970)
IZMENENIYE STRUKTURY L'DA V ZONE UDARA TVERDOGO
TELA O POVERKHNOST' LEDYANOGO POKROVA (Change of
ice structure in a region where a solid object
has struck the ice cover). Problemy Arktiki i
Antarktiki, v. 34, 1970, p. 79-84. In Russian.
[studies with floating ice, with possible appli-
cation to shipping problems]

B-216

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ON THE PROPAGATION OF FLEXURAL GRAVITATIONAL
WAVES ON AN ICE-COVERED SEA. Akademiya Nauk SSSR.
Izvestiya. Atmospheric and Oceanic Physics,
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more, pokrytom l'dom," Akademiya Nauk SSSR.
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Dec. 1969, p. 1334.)

B-217

Kheisin, D.E.; Ivchenko, V.O. (1976)
OPREDELENIE TANGENTSIAL'NYKH NAPRIAZHENII NA
NIZHNEI POVERKHNOSTI L'DA PRI CHISTO VETROVOM
DREIFE (Calculating tangential stress on the
lower surface of ice during drift due entirely to
wind). Arkticheskii i Antarkticheskii Nauchno-
Issledovatel'skii Institut. Trudy, v. 332, 1976,
p. 51-59. 7 ref. In Russian. [drift, turbulence,
ice mechanics, stresses, sea ice, analysis
(mathematics), wind factors]

B-218*

Kheisin, D.E. (1971)
O VOZBUZHDENII USILII LEDOVOGO SZHATIIA NA
GIDRODINAMICHESKOI STADII DREIFA SPLOCHENNYKH
L'DOV (Activation of ice compaction stresses at
the hydrodynamic stage of packed ice drift).
Arkticheskii i Antarkticheskii Nauchno-
Issledovatel'skii Institut. Trudy, v. 303, 1971,
p. 89-97. 11 ref. In Russian. [ice compression,
drift, pack ice, stresses, analysis (mathematics),
sea ice]

B-219

Kheisin, D.E.; Ivchenko, V.O. (1976)
PRESSURE DISTRIBUTION IN CONSOLIDATED ICE.
Oceanology, v. 15(5), May 1976, p. 542-46. 8 ref.
(Translated from Okeanologiya, v. 15(5), 1975.)

B-220*

Kheisin, D.E. (1971)
SOME UNSTEADY-STATE PROBLEMS IN ICE-COVER DYNAMICS.
(In: Yakovlev, G.N., ed. Studies in Ice Physics
and Ice Engineering, v. 300. Jerusalem, Israel
Program for Scientific Translations, 1973, p. 69-
78. 3 fig., 5 ref. NTIS: TT72-50005.)

B-221

Khokhlov, G.P. (1970)
RESULTS OF EXPERIMENTAL MEASUREMENTS OF THE
ELECTRICAL PARAMETERS OF ARCTIC SEA ICE AT
FREQUENCIES BETWEEN 100 HZ and 1MHZ. Arkticheskii
i Antarkticheskii Nauchno-Issledovatel'skii
Institut. Transactions, v. 295, 1971, p. 64-70.
NTIS: TT70-50158. (Translated from "Resul'taty
eksperimental'nykh issledovaniy elektricheskikh
kharakteristik arkticheskogo morskogo l'da v
diapazone chastot 100 Gts - 1 Mgtz," Arkticheskii
i Antarkticheskii Nauchno-Issledovatel'skii
Institut. Trudy, v. 295, 1970, p. 74-82.)

B-222

Kiselev, Iu.G. (1971)
IZUCHENIYE SEZONNYKH IZMENENIY UPRUGIKH SVOYSTV
LEDOVOGO POKROVA V ARKTIKE (Study of seasonal
changes in elastic properties of the arctic pack
ice). Geofizicheskiye Metody Razvedki v Arktike,
no. 6, 1971, p. 79-82. In Russian.

B-223

Kiviniemi, A. (1975)
MEASUREMENTS OF WAVE MOTION IN THE ICE SURFACE.
Suomen Geodeettinen Laitos. Tiedonantoja, v. 75(4),
1975. 13p. 2 ref. [geodetic surveys, lake ice,
gravimetric prospecting, water waves]

B-224 *

Kivisild, H.R. (1976)
ICE MECHANICS. (In: International Conference on
Port and Ocean Engineering under Arctic Conditions,
3rd, Proceedings. Held 11-15 Aug. 1975, Fairbanks,
Alaska. Institute of Marine Science, Univ. of
Alaska, 1976, p. 287-313.)

B-225 *

Knight, Charles A.; Knight, Nancy C. (1968)
ORIENTATION FABRICS IN SEA ICE. (In: Sater,
J.E., ed. Arctic Drifting Stations: A Report
on Activities Supported by the Office of Naval
Research. Proceedings of a symposium held 12-15
April 1966 in Warrenton, Va. Washington, D.C.,
Arctic Institute of North America, 1968, p. 217-
224.)

B-226

Kohnen, Heinz (1976)
ON THE DC-RESISTIVITY OF SEA ICE. Zeitschrift für Gletscherkunde und Glazialgeologie, Bd. 11, Heft 2, 1976, p. 143-54. 12 ref.

B-227

KOLEBANIYA LEDIANOGO POKROVA, OBUSLOVLENNYE SVOBODNYMI Vnutrennimi gravitatsionnymi volnami (Ice cover oscillations caused by free internal gravity waves). Arkticheskii i Antarkhticheskii Nauchno-Issledovatel'skii Institut. Trudy, v. 316, 1974, p. 113-17. 5 ref. In Russian. [pack ice, oscillations, water waves, analysis (mathematics)]

B-228

Korunov, M.M. (1967)
AN APPROXIMATE METHOD FOR THE DETERMINATION OF THE BEARING CAPACITY OF AN ICE COVER. Sverdlovskii Nauchno-Issledovatel'skii Institut Lesnoi Promyshlennosti. Trudy, v. 3, 1967. In Russian.

B-229 *

Kovacs, Austin; Weeks, Wilford F. (1977)
DYNAMICS OF NEAR-SHORE ICE. (In: Environmental Assessment of the Alaskan Continental Shelf, v. 4. Boulder, Colo., Environmental Research Laboratories, 1977, p. 106-12.) [fast ice, ice mechanics, radar echoes, logistics]

B-230 *

Krouse, H. Roy (1974)
STABLE ISOTOPES IN THE STUDY OF SNOW AND ICE RESOURCES. (In: Santeford, Henry S.; Smith, J.L., comp. Advanced Concepts and Techniques in the Study of Snow and Ice Resources: An Interdisciplinary Symposium held at Monterey, Calif., 2-6 Dec. 1973. Washington, D.C., National Academy of Sciences, 1974, p. 651-60.) [reviews techniques and applications with reference to studies in the Arctic]

B-231

Kupetskii, V.N. (1967)
O LYUMINISTSENTSII MORSKIKH L'DOV (Luminescence of sea ice). Geograficheskoe Obshchestvo SSSR. Izvestiya, v. 99(1), 1967, p. 67-70. In Russian.

B-232

Kusunoki, Kou; Minoda, Takashi; Fujino, Kazuo et al (1966)
DESCRIPTION OF OCEANOGRAPHIC OBSERVATIONS AT DRIFT STATION ARLIS II IN 1964-1965. Washington, D.C., Arctic Institute of North America, Dec. 1966. 106p. NTIS: AD-652 616. [temperature, chlorinity (salinity), dissolved oxygen, silicate, phosphate, ice drift, subsurface ocean currents]

B-233 *

Kusunoki, Kou (1966)
AN EXAMPLE OF CHLORINITY DISTRIBUTION IN PERENNIAL SEA ICE. Seiryō, v. 28(6), 1966, p. 161-62. In Japanese with English summary. [vertical distribution of salinity in ice core sample from ice island ARLIS 2]

B-234

Kuzenkova, P.O. (1972)
IZMENENIYE SOLENNOSTI VODY PRI OBRAZOVANII L'DA V MELKOVODNYKH MORYAKH (Water salinity variation during ice formation in shallow seas). Meteorologiya i Gidrologiya, no. 5, May 1972, p. 75-79. In Russian. [empirical method for calculating the water salinity during the winter]

B-235

Lake, R.A.; Lewis, Edward L.; Walker, E.R. (1969)
BRINE DRAINAGE DURING SEA ICE GROWTH AND VERTICAL CIRCULATION IN THE UNDERLYING WATER. EOS, v. 50(2), 1969, p. 63. [abstract only]

B-236 *

Lake, R.A.; Walker, E.R. (1973)
NOTES ON THE OCEANOGRAPHY OF D'IBERVILLE FIORD. Arctic, v. 26(3), Sept. 1973, p. 222-29. In English with French and Russian summaries. [sea ice, heat transfer, water temperature, salinity, ice cover effect]

B-237

Lake, R.A.; Lewis, Edward L. (1970)
SALT REJECTION BY SEA ICE DURING GROWTH. Journal of Geophysical Research, v. 75(3), 1970, p. 583-97. [salt rejection shown to take place by cyclic convective processes in small interstitial spaces in bottom centimeters of ice]

B-238 *

Lane, J.W. (1975)
OPTICAL PROPERTIES OF SALT ICE. Journal of Glaciology, v. 15(73), 1975, p. 363-72. 6 fig., ref.

B-239

Langleben, M.P.; Pounder, Elton R. (1968)
ACOUSTIC ATTENUATION IN SEA ICE. McGill Univ. Macdonald Physics Lab. Ice Research Project. Report no. S-14, June 1968. 21p. NTIS: AD 679 627.

B-240

Langleben, M.P.; Pounder, Elton R. (1970)
ACOUSTIC ATTENUATION IN SEA ICE: REFLECTION OF SOUND AT THE WATER-ICE INTERFACE. McGill Univ. Macdonald Physics Laboratory. Ice Research Project. Report no. S-16, May 1970. 36p. NTIS: AD-707 059.

B-241 *

Langleben, M.P. (1969)
ATTENUATION OF SOUND IN SEA ICE, 10-500 KHZ. Journal of Glaciology, v. 8(54), Oct. 1969, p. 399-406. In English with French and German summaries.

B-242 *

Langleben, M.P. (1969)
PHYSICS OF SEA ICE. (In: International Dictionary of Geophysics, 1969, p. 1-5. NTIS: AD-698 722.) [growth and microstructure of sea ice, mechanical properties, ultimate strength, elastic properties, thermal properties, and electrical properties]

B-243*

Langleben, M.P. (1970)
REFLECTION OF SOUND AT THE WATER-SEA ICE INTER-
FACE. Journal of Geophysical Research, v. 75(27),
1970, p. 5243-46. 3 fig., 4 ref.

B-244*

Lavrov, V.V. (1971)
DEFORMATION AND STRENGTH OF ICE. Jerusalem,
Israel Program for Scientific Translations, 1971.
164p. NTIS: TT70-50130. (Translated from
Deformatsiya i Prochnost' L'da. Leningrad,
Gidrometeorologicheskoye Izdatel'stvo, 1969.)
[structure, behaviour of ice under load, mechanical
properties, and shape]

B-245

Lavrov, V.V. (1965)
THE INFLUENCE OF ICE STRUCTURE UPON ITS STRENGTH.
CIREL Translation no. 306, 1965.
NTIS: AD-737 823. (Translated from "Vliianie
struktury l'da na ego prochnost'," Problemy
Arktiki i Antarkтики, v. 20, 1965, p. 61-67.)
[coarse-grained crystalline freshwater ice,
polycrystalline freshwater ice, snow-ice, and sea
ice of 1% salinity are investigated in compression
and bending]

B-246

Lebedev, G.A.; Popov, I.K. (1975)
LOW FREQUENCY NOISE GENERATED IN SEA ICE BY BLOWING
SNOW. (In: Ocean '74: IEEE International
Conference on Engineering in the Ocean Environ-
ment, Halifax, Nova Scotia, Aug. 21-23, 1974,
Record, v. 1. New York, Institute of Electrical
and Electronic Engineers, 1975, p. 102-03. 5 ref.)
[sea ice, ice acoustics, noise (sound), acoustic
properties, blowing snow, snow acoustics, wind
factors]

B-247

Legen'kov, A.P.; Chugui, I.V.; Basova, L.G. (1977)
DEFORMATSIYA LEDYANOGO OSTROVA DREYFUYUSHCHEY
STANTSII "SEVERNYY POLYUS-19" (Deformation of the
ice island of the drifting station SP-19).
Problemy Arktiki i Antarkтики, v. 49, 1977, p. 118-
20. In Russian.

B-248

Legen'kov, A.P. (1970)
K VOPROSU O POVEDENII PREDMETOV, PLAVAIUSHCHIKH
NA POVERKHNOSTI VOLN (Behavior of objects floating
on wave surfaces). Arkticheskii i Antarkticheskii
Nauchno-Issledovatel'skii Institut. Trudy, v. 293,
1970, p. 134-40. 2 ref. In Russian. [analysis
(mathematics), ocean currents, drift]

B-249

Legen'kov, A.P. (1970)
ON THE THERMAL STRESSES AND STRAINS IN ICE FIELDS.
Akademiya Nauk SSSR. Izvestiya. Atmospheric and
Oceanic Physics, v. 6(8), 1970, p. 490-94. (Trans-
lated from "K voprosu o termicheskikh
napryazheniyakh i deformatsiyakh ledyanykh poley,"
Akademiya Nauk SSSR. Izvestiya. Fizika Atmosfery
i Okeana, v. 6(8), 1970, p. 832-39.) [simplified
method of computing thermal stress and deformation
of sea ice]

B-250

Legen'kov, A.P.; Uglev, V.D. (1970)
RESULTS OF MEASUREMENTS OF THE DEFORMATION OF A
MULTIYEAR ICE-FLOE BY INVARI WIRES. Akademiya
Nauk SSSR. Izvestiya. Atmospheric and Oceanic
Physics, v. 6(5), 1970, p. 310-12. (Translated
from "Rezultaty izmereniya deformatsii
mnogoletnego ledyanogo polya invarnymi provolokami,"
Akademiya Nauk SSSR. Izvestiya. Fizika Atmosfery
i Okeana, v. 6(5), 1970, p. 537-40.)

B-251*

Legen'kov, A.P.; Chugui, I.V. (1973)
RESULTS OF MORPHOMETRIC MEASUREMENTS OF THE ICE
ISLAND OF THE SEVERNYY POLYUS-19 DRIFTING STATION.
(In: Treshnikov, A.F., ed. Problems of the Arctic
and Antarctic, v. 42. Jerusalem, Israel Program
for Scientific Translation, 1973, p. 53-60.)
(Translated from Problemy Arktiki i Antarkтики,
v. 42, 1973, p. 44-48.)

B-252

Legen'kov, A.P.; Chugui, I.V.; Eremin, N.N. (1975)
RESULTS OF TEMPERATURE MEASUREMENTS ON THE DRIFTING
ICE ISLAND NORTH POLE 19. (In: Ocean '74: IEEE
International Conference on Engineering in the
Ocean Environment, Halifax, Nova Scotia, Aug. 21-23,
1974, Record, v. 1. New York, Institute of
Electrical and Electronic Engineers, 1975, p. 137-
39. 2 ref.) (Also in: Okeanologiya, v. 14(4),
1974, p. 619-22. In Russian.) [ice temperature,
temperature distribution, ice islands, drift
stations, freezing points]

B-253

Legen'kov, A.P. (1974)
THERMAL STRESSES AND DEFORMATIONS OF THE DRIFTING
ICE ISLAND STATION NORTH POLE 19. Oceanology,
v. 13(6), Dec. 1974, p. 804-08. 5 ref. (Trans-
lated from "Termicheskiye naprazheniya i deformatsii
ledyanogo ostrova deyfuyushchey stantsii Severnyy
polyus-19," Okeanologiya, v. 13(6), 1973, p. 975-
80.) [calculations based on ice temperature and
salinity data]

B-254

Lerner, B.A.; Poliakova, T.V.; Popov, I.K. (1973)
HIGH FREQUENCY MICROSEISMIC OSCILLATIONS OF ICE
COVER. Soviet-Bloc Research in Geophysics,
Astronomy and Space, no. 310, Oct. 1973, p. 36-37.
[abstract of Russian article, "Statistical charac-
teristics of high-frequency microseismic oscil-
lations of the ice cover in the Arctic Basin,"
Avtomatizatsiya Nauchnogo-Issledovaniya Morey i
Okeanov. Simpozium, Chast' 1, 1972, p. 254-58]

B-255*

Lewis, Edward L.; Lake, R.A. (1971)
SEA ICE AND SUPERCOOLED WATER. Journal of Geo-
physical Research, v. 76(24), 1971, p. 5836-41.
[literature review and laboratory experiments sug-
gest that existence of supercooled water below
growing sea ice is temporary if it is there at all]

B-256

Lewis, Edward L.; Walker, E.R. (1970)
THE WATER STRUCTURE UNDER A GROWING SEA ICE SHEET.
Journal of Geophysical Research, v. 75(33), 1970,
p. 6836-45. [data illustrating seasonal changes
in temperature and salinity profile beneath an
annual sea ice cover]

B-257 *

Ling, Chi-Hai; Campbell, William J. (1976)
ANTISYMMETRIC STRESS FOR SEA ICE. AIDJEX Bulletin,
no. 33, Sept. 1976, p. 77-84. 14 ref.

B-258 *

Little, Edward M.; Allen, M.B.; Wright, F.F.
(1972)
FIELD MEASUREMENT OF LIGHT PENETRATION THROUGH SEA
ICE. Arctic, v. 25(1), 1972, p. 28-33. Fig.

B-259 *

Lofgren, Gary; Weeks, Wilford F. (1969)
EFFECT OF GROWTH PARAMETERS ON SUBSTRUCTURE
SPACING IN NaCl ICE CRYSTALS. CRREL Research
Report no. 195, Jan. 1969. 20p. NTIS: AD-687 280.
[effect of growth velocity and solute concentration
on cellular substructure that develops in NaCl ice]

B-260

Luchininov, V.S. (1968)
ELECTRICAL CHARACTERISTICS OF ICE. Soviet Physics,
Technical Physics, v. 13(3), 1968, p. 418-23.
(Translated from "Elektricheskiye kharakteristiki
l'da," Zhurnal Tekhnicheskoy Fiziki, v. 38(3),
1968, p. 565-72.) [study of electrical properties
of sea ice as a function of frequency and temper-
ature]

B-261*

Mänttänen, M. (1976)
ON THE FLEXURAL STRENGTH OF BRACKISH WATER ICE BY
IN SITU TESTS. (In: International Conference on
Port and Ocean Engineering under Arctic Conditions,
3rd, Proceedings. Held 11-15 Aug. 1975, Fairbanks,
Alaska. Institute of Marine Sciences, Univ. of
Alaska, 1976, p. 349-59.)

B-262*

McNeill, Duncan; Hoekstra, Pieter (1971)
IN-SITU MEASUREMENTS ON THE CONDUCTIVITY AND
SURFACE IMPEDANCE OF SEA-ICE AT VLF FREQUENCIES.
Copenhagen. Polyteknisk Laereanstalt. Laboratoriet
for Elektromagnetisk Feltteori. Report no. R105,
Dec. 1971. 19p. 5 ref. (Also in: Radio Science,
v. 8(1), Jan. 1973, p. 23-30.) [experimental
program to measure in-situ values of the electrical
conductivity and surface impedance of sea ice at
VLF frequencies]

B-263

Mahrenholtz, O. (1966)
ZUR TRAGFÄHIGKEIT VON EISDECKEN (Load-bearing
capacity of ice layers). Zeitschrift für
Angewandte Mathematik und Mechanik, Bd. 46,
Sonderheft, 1966, p. T170-73. In German. [compu-
tation of load-bearing capacity of ice layers]

B-264 *

Malmberg, Svend-Aage (1972)
ANNUAL AND SEASONAL HYDROGRAPHIC VARIATIONS IN THE
EAST ICELANDIC CURRENT BETWEEN ICELAND AND JAN
MAYEN. (In: Karlsson, T., ed. Sea Ice: Proceed-
ings of an International Conference. Held 10-13
May 1971, Reykjavik. National Research Council,
1972, p. 42-54.) [discusses variations and relates
to drift ice conditions in north Icelandic waters]

B-265

Malmberg, Svend-Aage (1969)
ASTAND SJAVAR MILLI ISLANDS OG JAN MAYEN I JUNI
1962 OG 1969 (Hydrographic conditions between
Iceland and Jan Mayen in June 1962 and 1969).
Aegir, v. 62(22), Dec. 1969, p. 404-08. 15 ref.
In Icelandic with English summary. [sea ice,
salinity, ice conditions, temperature effects,
drift, fish migration]

B-266

Malmberg, Svend-Aage (1969)
ASTAND SJAVAR MILLI ISLANDS OG JAN MAYEN OG HAFIS
VID ISLAND (Temperature and salinity conditions
between Iceland and Jan Mayen and relationship with
pack ice occurrence in north Icelandic waters).
Aegir, v. 62(22), 1969, p. 410-13. In Icelandic
with English summary.

B-267*

Malmberg, Svend-Aage (1970)
HYDROGRAPHIC CHANGES IN THE WATERS BETWEEN ICELAND
AND JAN MAYEN IN THE LAST DECADE. Jökull, v. 19,
1970, p. 30-43. [influence of salinity and temper-
ature changes in East Icelandic current on drift
ice conditions in Icelandic waters]

B-268*

Martin, Patrick; Thorndike, Alan S. (1972)
ACOUSTIC BOTTOM REFERENCING SYSTEM. AIDJEX
Bulletin, no. 14, 1972, p. 59.

B-269 *

Martin, Seelye; Kauffman, Peter (1974)
THE EVOLUTION OF UNDER-ICE MELT PONDS, OR DOUBLE
DIFFUSION AT THE FREEZING POINT. Journal of
Fluid Mechanics, v. 64(3), 1974, p. 507-27.
NTIS: AD-785 321. (Abstract in: EOS, v. 53(11),
1972, p. 1011.) [describes experimental and
theoretical study modelling phenomenon observed
in summer Arctic]

B-270

Martin, Seelye (1971)
AN EXPERIMENTAL STUDY OF SOME CONVECTIVE MODELS
FOR NATURAL DESALINATION OF SEA ICE. Washington.
Univ. Final Report, Oct. 1971. 8p.
NTIS: AD-733 064. [growth of brine channels in
sea ice; growth of stalactites under sea ice]

B-271

Martynova, V.A.; Spitsyn, V.A. (1974)
TEPLOVYE KONTRASTY ESTESTVENNOI VODNO-
LEDVOSNEZHNOI POVERKHNOSTI I VOZMOZHNOST'
KOLICHESTVENNOI OTSENKI IKH PO DANNYM IZMERENII
IK METODAMI (Thermal contrasts in a natural
water-ice-snow surface and possibilities of their
quantitative evaluation from infrared data).
Arkticheskii i Antarkicheskii Nauchno-
Issledovatel'skii Institut. Trudy, v. 324, 1974,
p. 148-50. 2 ref. In Russian.

B-272

Maser, K.R. (1971)
DETERMINATION OF THE STRENGTH OF AN ICE SHEET FROM
SMALL SAMPLE DATA. (In: Offshore Technology
Conference, 3rd, Preprints, v. 2. Held in Houston,
Texas, 19-21 April 1971, p. 1187-94.) [ice sheets,
plasticity, strength prediction, sea ice, grain
size, load rates]

B-273

Masterson, D.M. (1974)
FLOATING ICE SHEETS. Northern Engineer, v. 6(3),
Fall 1974, p. 11-18. 14 fig., ref.

B-274

Mayer, Walter G. (1974)
DETERMINATION OF TRANSVERSE-WAVE VELOCITY IN
TRANSITION LAYER OF SEA ICE FROM REFLECTION OF
WATER-BORNE SOUND. Journal of Geophysical
Research, v. 79(6), 1974, p. 885-886. 7 ref.

B-275

Mayer, Walter G.; Diachok, O.I. (1973)
SCALE MODEL ULTRASONIC STUDY OF ARCTIC ICE.
Georgetown Univ. Dept. of Physics. Technical
Report, no. 1, Sept. 1973. 14p.
NTIS: AD-766 485. [sea ice, ultrasonic prop-
erties, sound transmission, sea ice, reflection,
model tests, interfaces]

B-276

Mayer, Walter G. (1975)
SCALE MODEL ULTRASONIC STUDY OF ARCTIC ICE. FINAL
TECHNICAL REPORT 1 OCT. 1972-15 JAN. 1975.
Georgetown Univ. Dept. of Physics. Final Report,
1975. NTIS: AD-A004 249. [scale-model study of
sonic reflectivity, transmissivity and the
partition of energy upon sonic incidence at the
arctic ice cover]

B-277

Mayer, Walter G.; Behravesh, M.; Plona, T.J.
(1974)
SONIC REFLECTIVITY FROM SEA-ICE/WATER INTERFACES.
Georgetown Univ. Dept. of Physics. Technical
Report no. 2, March 1974. 41p. NTIS: AD-775 655.
[reflectivity curves calculated for sea-ice/water
boundaries in which the densities and sonic
velocities in the two media are changed in
increments]

B-278 *

Maykut, Gary A.; Grenfell, T.C. (1975)
THE SPECTRAL DISTRIBUTION OF LIGHT BENEATH FIRST-
YEAR SEA ICE IN THE ARCTIC OCEAN. Limnology and
Oceanography, v. 20(4), July 1975, p. 554-63.
7 fig., ref. NTIS: AD-A017 413.

B-279

Mendel'son, V.L.; Kozlov, A.I.; Finkel'shtein, M.I.
(1972)
INVESTIGATION OF SOME ELECTRODYNAMIC MODELS OF ICE
(SHEETS USEFUL) IN RADAR-SOUNDING PROBLEMS.
Akademiya Nauk SSSR. Izvestiya. Atmospheric and
Oceanic Physics, v. 8(4), 1972, p. 225-29. (Trans-
lated from "Issledovaniye nekotorykh
elektrodinamicheskikh modeley l'da v zadachakh
radiolokatsionnogo zondirovaniya," Akademiya Nauk
SSSR. Izvestiya. Fizika Atmosfery i Okeana,
v. 8(4), 1972, p. 396-402.) [method developed for
estimating intensities of signals reflected from
upper and lower interfaces of floating ice sheets,
assuming a variety of models]

B-280

Merino, M.P. (1974)
INTERNAL SHEAR STRENGTH OF FLOATING FRAGMENTED ICE
COVERS. Iowa City, Univ. of Iowa, May 1974. 80p.
6 ref. M.S. thesis.

B-281

Metge, M.; Strilchuk, A.; Trofimenkoff, P. (1975)
ON RECORDING STRESSES IN ICE. (In: Frankenstein,
Guenther E., ed. International Symposium on Ice
Problems, 3rd, Proceedings. Held 18-21 Aug. 1975,
Hanover, N.H. International Assn. of Hydraulic
Research, 1975, p. 459-68. 7 ref.) In English
with French summary. [ice mechanics, stresses,
strains, temperature effects]

B-282 *

Michel, Bernard (1970)
ICE PRESSURE ON ENGINEERING STRUCTURES. CRREL
Monograph III-B1b, 1970. 71p. Graphs, tables,
85-ref. [summarizes the existing knowledge on
forces exerted by an expanding ice sheet, impact
forces of ice on structures, and vertical forces
exerted by ice on hydraulic structures, including
mathematical computations]

B-283

Milne, A.R.; Canton, J.H.; McMillin, D.J. (1967)
AMBIENT NOISE UNDER SEA ICE AND FURTHER MEASURE-
MENTS OF WIND AND TEMPERATURE DEPENDENCE.
Acoustical Society of America. Journal, v. 41(2),
1967, p. 525-28. [letter; noise under shore-fast
ice related to wind and temperature changes, that
under moving ice is not so easily accounted for]

B-284

Milne, A.R. (1971)
PREDICTIONS OF TEMPERATURES IN SNOW-FREE SEA ICE
WITH HOURLY CHANGES IN ATMOSPHERIC HEAT FLUXES.
Canada. Defence Research Board. Defence Research
Establishment Pacific. Report, no. 71-3, 1971.
30p. [calculations made of temperatures vs. time
and depth in arctic ice with hourly atmospheric
heat fluxes as input data for April 1968]

B-285

Milne, A.R.; Brown, J.R. (1967)
REVERBERATION UNDER ARCTIC SEA-ICE. Acoustical
Society of America. Journal, v. 42(1), July 1967,
p. 78-82. Fig., 6 ref.

B-286

Milne, A.R. (1967)
SOUND PROPAGATION AND AMBIENT NOISE UNDER SEA ICE.
(In: Albers, V.M., ed. Underwater Acoustics,
v. 2. N.Y., Plenum Press, 1967, p. 103-38.)
[effects of characteristic of arctic seas and of
ice cover]

B-287

Milne, A.R.; Canton, J.H. (1965)
A STATISTICAL DESCRIPTION OF NOISE UNDER SHORE-
FAST SEA ICE IN WINTER. Canada. Defence Research
Board. Pacific Naval Laboratory. Report no. 65-1,
Jan. 1965. 23p. Map, 6 ref.

B-288

Milne, A.R. (1966)
STATISTICAL DESCRIPTION OF NOISE UNDER SHORE-FAST
SEA ICE IN WINTER. Acoustical Society of America.
Journal, v. 39(6), 1966, p. 1174-82. [attempt to
relate field measurements of noise to wind action
and cracking origins]

B-289 *

Milne, A.R. (1972)
THERMAL TENSION CRACKING IN SEA ICE: A SOURCE OF UNDERICE NOISE. Journal of Geophysical Research, v. 77(12), 1972, p. 2177-92. Fig., 31 ref.

B-290

Milne, A.R. (1974)
WIND NOISE UNDER WINTER ICE FIELDS. Journal of Geophysical Research, v. 79(6), 1974, p. 803-09. 12 ref. [explains mechanism of noise production]

B-291

Mohaghegh, Mohammed M. (1973)
ANALYSIS OF THE FAILURE OF SEA ICE BEAMS. (In: Offshore Technology Conference, 5th, Papers, v. 1. Held in Houston, Texas, 30 April-2 May 1973, p. I/727-I/732. Paper no. OTC 1809. 12 ref.) [ice sheets, ice bearing capacity, ice plasticity, ice deformation, ice loads, strain measurement]

B-292 *

Mohaghegh, Mohammed M. (1973)
DETERMINING THE STRENGTH OF SEA ICE SHEETS. AIDJEX Bulletin, no. 18, 1973, p. 96-109. 4 fig., 15 ref. [describes method for determining axial and bending strength]

B-293

Mohaghegh, Mohammad M. (1972)
PLASTIC ANALYSIS OF COULOMB PLATES AND ITS APPLICATION TO THE BEARING CAPACITY OF SEA ICE. Seattle, Wash., Univ. of Washington, 1972. 144p. Ph.D. thesis. Univ. Microfilm order no. 72-28636.

B-294

Mohaghegh, Mohammad M. (1972)
STRENGTH OF SEA ICE SHEETS. EOS, v. 53(11), 1972, p. 1009. [abstract only]

B-295 *

Nazintsev, Iu.L. (1973)
ISOSTATIC PHENOMENA ON PACK-ICE FLOES. (In: Iakovlev, G.N., ed. Studies in Ice Physics and Ice Engineering, v. 300. Jerusalem, Israel Program for Scientific Translations, 1973, p. 87-94. 3 ref. NTIS: TT72-50005.) (Also CRREL Translation no. 394, Aug. 1973. 14p. NTIS: AD-798 828.) (Translated from "Izostaticheskie yavleniya na dreyfuyushchikh ledyanykh polyakh," Arkticheskii i Antarkticheskii Nauchno-Issledovatel'skii Institut. Trudy, v. 300, 1971.) [sea ice, ice floes, isostasy, ice plasticity, ice elasticity, ice cover thickness, ice melting]

B-296

Nazintsev, Iu.L. (1974)
KOLICHESTVENNYE SOOTNOSHENIYA V FAZOVOM SOSTAVE MORSKOGO L'DA (Quantitative relations in phase composition of sea ice). Problemy Arktiki i Antarktiki, v. 45, 1974, p. 62-67. In Russian. [ice physics, salinity and thermal properties]

B-297

Nazintsev, Iu.L.; Panov, V.V. (1975)
TEPLOFIZICHESKIE KHKARAKTERISTIKI MORSKOGO L'DA (Thermal characteristics of sea ice). Arkticheskii i Antarkticheskii Nauchno-Issledovatel'skii Institut. Trudy, v. 317, 1975, p. 172-82. 14 ref. In Russian.

B-298 *

Nelson, Richard D. (1976)
INTERNAL STRESS MEASUREMENTS IN ICE SHEETS USING EMBEDDED LOAD CELLS. (In: International Conference on Port and Ocean Engineering under Arctic Conditions, 3rd, Proceedings. Held 11-15 Aug. 1975, Fairbanks, Alaska. Institute of Marine Science, Univ. of Alaska, 1976, p. 361-73.)

B-299

Nelson, Richard D. (1974)
MEASUREMENTS OF TIDE- AND TEMPERATURE-GENERATED STRESSES IN SHOREFAST SEA ICE. (In: Reed, John C.; Sater, J.E., ed. The Coast and Shelf of the Beaufort Sea. Proceedings of a symposium held in San Francisco, 7-9 Jan. 1974. Arlington, Va., Arctic Institute of North America, 1974, p. 195-204.)

B-300

Nelson, Richard D.; Sackinger, William M. (1976)
STRESSES IN SEA ICE. (In: American Society of Mechanical Engineers Joint Petroleum Mechanical Engineering and Pressure Vessels and Piping Conference, Mexico City, 19-24 Sept. 1976.)

B-301

Nelson, Richard D.; Tauriainen, M.J.; Borghorst, J. (1972)
TECHNIQUES FOR MEASURING STRESS IN SEA ICE. Univ. of Alaska, Institute of Arctic Environmental Engineering, 1972.

B-302

Neshyba, Steve; Neal, Victor T. (1971)
TEMPERATURE AND CONDUCTIVITY MEASUREMENTS UNDER ICE ISLAND T-3. Journal of Geophysical Research, v. 76(33), Nov. 1971, p. 8107-20. [salinity variations, temperature profiles, ice islands, vertical profiles]

B-303 *

Nevel, Donald Eugene (1970)
CONCENTRATED LOADS ON PLATES. CRREL Research Report no. 265, March 1970. 8p. 11 ref. NTIS: AD-703 876. [analysis (mathematics), ice bearing capacity, elastic properties, loads (forces)]

B-304

Nevel, Donald Eugene (1976)
CREEP THEORY FOR A FLOATING ICE SHEET. Hanover, N.H., Dartmouth College, 1976. 110p. Ph.D. thesis. Univ. Microfilm order no. 76-23966. (Also CRREL Special Report no. 76-4, June 1976. 112p. NTIS: AD-A026 122.)

B-305

Nevel, Donald Eugene; Perham, Roscoe E.; Hogue, Gary B. (1972)
ICE FORCES ON VERTICAL PILES. Hanover, N.H., Cold Regions Research and Engineering Laboratory, 1972. 11p. NTIS: AD-750 358. [limiting force level; failure process in ice]

B-306 *

Nevel, Donald Eugene (1970)
MOVING LOADS ON A FLOATING ICE SHEET. CRREL Research Report no. 261, May 1970. 13p. 10 ref. NTIS: AD-707 923.

B-307 *

Nevel, Donald Eugene. (1966)
TIME DEPENDENT DEFLECTION OF A FLOATING ICE SHEET.
CRREL Research Report no. 196, July 1966. 16p.
7 fig., 12 ref. NTIS: AD-638 717.

B-308 *

Nevel, Donald Eugene (1970)
VIBRATION OF A FLOATING ICE SHEET. CRREL
Research Report no. 281, Aug. 1970. 9p.
NTIS: AD-712 995. (Also in: Canada. National
Research Council. Associate Committee on Geo-
technical Research. Technical Memorandum, no. 98,
Nov. 1970, p. 57-65.) [develops solution for
vibration of elastic plate floating on water]

B-309 *

Niedrauer, Terren M. (1977)
BRINE DRAINAGE AND CONVECTION IN YOUNG SEA ICE.
Washington. Univ. Dept. of Atmospheric Sciences.
Scientific Report no. 15, July 1977. 67p.

B-310

Nipcon, P.; Osterkamp, T.E.; Weller, Gunter E.
(1971)
MEASUREMENTS OF LIGHT TRANSMISSION IN SHOREFAST
ICE. (In: Science in Alaska: Alaska Science
Conference, 22nd, Proceedings. Held 17-19 Aug.
1971, in College, Alaska, 1971, p. 122.) [abstract
only; measurements made with photocells in core
holes]

B-311

Novikov, Iu.R. (1973)
PRIBOR DLYA AVTOMATICHESKOGO OPREDELENIYA
SPLOCHENNOSTI L'DA (An instrument for automatic
determination of ice cohesion). Arkticheskii i
Antarkticheskii Nauchno-Issledovatel'skii Institut.
Trudy, v. 307, 1973, p. 183-86. In Russian.
[floating ice]

B-312

Numrich, S.K. (1974)
LOW-FREQUENCY SOUND PROPAGATION IN THE MARGINAL ICE
ZONE OF THE GREENLAND SEA. Acoustical Society of
America. Journal, v. 56(Suppl. S-50), Fall 1974.
[abstract only; acoustic measurements, hydrophones,
sound propagation, sound sources, sound transmis-
sion, towed instruments]

B-313 *

Nye, John F. (1976)
COORDINATE SYSTEM FOR THE TWO-DIMENSIONAL STRESS
AND STRAIN-RATE AND ITS APPLICATION TO THE DEFOR-
MATION OF SEA ICE. AIDJEX Bulletin, no. 33, Sept.
1976, p. 131-43. 2 ref.

B-314 *

Nye, John F. (1976)
DISCLINATIONS AND CATASTROPHES IN THE VECTOR AND
TENSOR FIELDS OF SEA ICE. AIDJEX Bulletin, no. 33,
Sept. 1976, p. 105-29. 7 ref. [pack ice, mathe-
matical models, vector analysis, tensor analysis]

B-315 *

Nye, John F. (1975)
DISCONTINUITIES IN THE AIDJEX MODEL. AIDJEX
Bulletin, no. 28, 1975, p. 119-26. Ref.

B-316 *

Nye, John F. (1973)
THE MEANING OF TWO-DIMENSIONAL STRAIN-RATE IN A
FLOATING ICE COVER. AIDJEX Bulletin, no. 21, 1973,
p. 9-17. [sets up definition of strain and then
seeks how what is actually measured relates to
defined quantity]

B-317 *

Nye, John F. (1973)
THE PHYSICAL MEANING OF TWO-DIMENSIONAL STRESSES
IN A FLOATING ICE COVER. AIDJEX Bulletin, no. 21,
1973, p. 1-8. [discusses how to relate two-
dimensional stresses in models to real three-
dimensional ones]

B-318

Offenbacher, E.L.; Roselman, I.C. (1971)
HARDNESS ANISOTROPY OF SINGLE CRYSTALS OF ICE IH.
Nature, Physical Science, v. 234(49), Dec. 1971,
p. 112-13. [hardness of both basal and prismatic
plane of ice has been measured between -5 and
-12°C]

B-319 *

Ono, Nobuo (1976)
ARCTIC SEA ICE RESEARCH, PART III: MEASUREMENTS OF
STATE OF THERMAL STRESS INDUCED IN SURFACE LAYER OF
SEA ICE COVER. Teion Kagaku, Series A, no. 34,
1976, p. 221-26. 2 ref. In Japanese with English
summary.

B-320

Ono, Nobuo (1965)
KAIHYO NO NETSU NO SEISHITSU NO KENKYU, I: USU I
TOHYO NO NETSU DENDORITSU NO SOKUTEI (Thermal
properties of sea ice, I: Measurements of the
thermal conductivity of young winter ice). Teion
Kagaku, Series A, no. 23, 1965, p. 167-76. In
Japanese with English summary.

B-321

Ono, Nobuo (1965)
KAIHYO NO NETSU NO SEISHITSU NO KENKYU, II:
FUKINSHITSUNA HYOSO NO K/CP NO ATAI O MOTOMERU
(Thermal properties of sea ice, II: A method for
determining the K/cp-value of a non-homogeneous
ice sheet). Teion Kagaku, Series A, no. 23, 1965,
p. 177-83. In Japanese with English summary.

B-322

Ono, Nobuo (1966)
KAIHYO NO NETSUTEKI SEISHITSU NO KENKYU, III:
KAIHYO NO HINETSU NI TSUITE (Thermal properties of
sea ice, III: On the specific heat of sea ice).
Teion Kagaku, Series A, no. 24, 1966, p. 249-58.
In Japanese with English summary. [two methods of
calculating specific heat]

B-323 *

Ono, Nobuo (1967)
SPECIFIC HEAT AND HEAT OF FUSION OF SEA ICE. (In: Oura, Hirobumi, ed. Physics of Snow and Ice: Proceedings of the International Conference on Low Temperature Science, v. 1, part 1. Sapporo, Institute of Low Temperature Science, Hokkaido Univ., 1967, p. 599-610. 8 ref. In English.) (Also "Udel'naia teploemkost' i teplota plavleniia morskogo l'da," Eksperimental'nye Issledovaniia Protssessov Teploobmena v Merzlykh Gornykh Proдах (Experimental studies of heat transfer processes in frozen rocks). Moscow, Nauka, 1972, p. 52-60. In Russian.) [deduction of values on basis of thermal and phase equilibrium; laboratory tests to see whether such equilibrium is established, and with what time-lag]

B-324 *

Ono, Nobuo; Tanuma, Kunio (1973)
STRAIN MEASUREMENTS ON PACK-ICE FLOW WITH INFRARED DISTANCE. Teion Kagaku, Series A, no. 31, 1973, p. 221-29. 6 fig., 5 ref. In Japanese with English summary.

B-325

Ono, Nobuo (1975)
THERMAL PROPERTIES OF SEA ICE, PART 4: THERMAL CONSTANTS OF SEA ICE. CRREL Translation no. 467, Jan. 1975. 19p. NTIS: AD-B000 929. (Translated from Teion Kagaku, Series A, no. 26, 1968, p. 329-49.)

B-326

OPERATION TANQUARY ELLESMERE ISLAND, N.W.T. 1963-1966. Canada. Dept. of Energy, Mines and Resources. Canadian Oceanographic Data Centre. Data Record Series, no. 13, 1969. 152p. 28 ref. [meteorological data, salinity, statistical data, oceanography, traverses]

B-327

Ostoich, G. (1972)
THE THERMAL CONDUCTIVITY OF SALINE ICE. Montreal, Canada, McGill Univ., 1972. M.S. thesis.

B-328 *

Oura, Hirobumi, ed. (1967)
PHYSICS OF SNOW AND ICE: PROCEEDINGS OF THE INTERNATIONAL CONFERENCE ON LOW TEMPERATURE SCIENCE, v. 1, part 1. Sapporo, Institute of Low Temperature Science, Hokkaido Univ., 1967. 711p. [papers presented at the meeting held in Sapporo, 14-19 Aug. 1966]

B-329

Outcalt, S.I. (1973)
SIMULATION OF THE DIURNAL SURFACE TEMPERATURE CONTRAST IN SEA ICE AND TUNDRA TERRAIN. Archiv fur Meteorologie, Geophysik und Bioklimatologie, Series B, v. 21(2-3), 1973, p. 147-56. 9 ref. In English with German summary. [environment simulation, climate, thermal analysis, temperature variations, tundra terrain, active layer thickness]

B-330

Paige, R.A.; Kennedy, R.A. (1967)
STRENGTH STUDIES OF SEA ICE: EFFECTS OF LOAD RATE ON RING TENSILE STRENGTH. U.S. Naval Civil Engineering Laboratory. Technical Report no. R-545, Oct. 1967. 28p. 13 fig., 1 table, 12 ref. NTIS: AD-659 298. [sea ice, load carrying capacity]

B-331

Panfilov, D.F. (1966)
ANALYSIS OF THE BEARING CAPACITY OF AN ICE COVER TAKING INTO CONSIDERATION ITS NONHOMOGENEITY WITH HEIGHT. Izvestiya Vuzov, Stroitel'stvo i Arkhitektura, no. 2, 1966. In Russian.

B-332

Panfilov, D.F. (1972)
APPROXIMATE FORMULAS FOR THE DETERMINATION OF THE CARRYING CAPACITY OF ICE. U.S. Army. Foreign Science and Technology Center, 1972. 12p. NTIS: AD-765 968. (Translated from "Priblizhennyye formuly dlya opredeleniya nesushchei sposobnosti l'da," Koordinatsionnykh Soveshchaniy po Gidrotekhnike. Trudy, no. 10, 1964.) [rigorous calculation of the carrying capacity of ice based on the theory of elastic foundation]

B-333

Panfilov, D.F. (1970)
BENDING OF A FLOATING ICE STRIP SUBJECTED TO LOCAL LOADS NEAR THE EDGE. Izvestiya Vuzov, Stroitel'stvo i Arkhitektura, no. 1, 1970. In Russian.

B-334

Panfilov, D.F. (1966)
BENDING OF THE INFINITE ICE STRIP WHICH IS SUBJECTED TO A LOAD OF SHORT DURATION. Izvestiya Vuzov, Stroitel'stvo i Arkhitektura, no. 12, 1966. In Russian.

B-335

Panfilov, D.F. (1970)
CALCULATING ICE COVER STRENGTH. Izvestiya Vuzov, Stroitel'stvo i Arkhitektura, no. 6, 1970. In Russian.

B-336

Panfilov, D.F. (1970)
THE CHANGE OF THE BEARING CAPACITY OF AN ICE COVER DUE TO LOADS OF LONG DURATION. Izvestiya Vuzov, Stroitel'stvo i Arkhitektura, no. 3, 1970. In Russian.

B-337

Panfilov, D.F. (1965)
ON CREEP DEFORMATIONS OF ICE. Koordinatsionnykh Soveshchenii po Gidrotekhnike. Trudy, v. 23. Moscow/Leningrad, Izdatel'stvo Energia, 1965. In Russian.

B-338

Panin, G.N. (1967)
VLIYANIYE SOLENI STI NA PROCHNOST' L'DA (Influence of salinity on ice strength). Moscow. Univ. Vestnik. Seriya 5: Geografiya, v. 22(5), 1967, p. 108-11. In Russian.

B-339

Paquette, R.O.; Bourke, R.H. (1976)
OCEANOGRAPHIC INVESTIGATION OF THE MARGINAL SEA-ICE ECNE OF THE CHUKCHI SEA, MIZPAC 1974. FINAL REPORT. 11 JUNE 1974-30 JUNE 1975. Monterey, Calif., U.S. Naval Postgraduate School, 1976. 129p. NTIS: AD-A025 854.

B-340

Paron, J.G.; Walker, J.C.F. (1971)
INFLUENCE OF LIMITED SOLUBILITY ON THE ELECTRICAL AND MECHANICAL PROPERTIES OF ICE. Nature, Physical Science, v. 230(12), March 1971, p. 77-79. Ref. [at low temperatures, the hydrated salts in polar ices have negligible dielectric loss]

B-341 *

Parmeter, R. (1974)
DIMENSIONLESS STRENGTH PARAMETERS FOR FLOATING ICE SHEETS. AIDJEX Bulletin, no. 23, 1974, p. 83-95. (Also in: International Conference on Port and Ocean Engineering under Arctic Conditions, 2nd. Proceedings. Held 27-30 Aug. 1973, Reykavik. Univ. of Iceland, 1974, p. 490-501.) [equations governing floating ice sheet subjected to vertical loading are studied in dimensionless form; more complex problems in which in-plane forces interact through vertical deformations to create additional loading as in rafting]

B-342

Pekhovitch, A.I.; Zhidkikh, V.M.; Shatalina, I.N. et al (1975)
CONTROL OF THE THICKNESS AND STRENGTH OF THE ICE COVER. (In: Frankenstein, Guenther E., ed. International Symposium on Ice Problems, 3rd. Proceedings. Held 18-21 Aug. 1975, Hanover, N.H. International Assn. of Hydraulic Research, 1975, p. 487-98. 2 ref.) [ice growth, ice strength, ice cover thickness, heat transfer, temperature control]

B-343

Persidsky, M.D.; Richards, V. (1965)
NEW APPROACHES IN MEASURING THE LINEAR RATE OF ICE CRYSTALLIZATION IN WATER AND AQUEOUS SOLUTIONS. New York Academy of Sciences. Annals, v. 125(2), 1965, p. 677-88. Graphs, 17 ref. [design of an instrument for measuring the velocity of crystallization]

B-344 *

Peschanskii, I.S.; Chikovskii, S.S. (1973)
O FIZIKO-MEKHANICHESKIKH SVOYSTVAKH LEDYANOGO POKROVA MOREY KARSKOGO I LAPTEVYKH (On the mechanical properties of ice cover in the Kara and Laptev Seas). Akademiya Nauk SSSR. Institut Geografii. Materialy Glvatsiologicheskikh Issledovaniy. Karonika, Obsuzhdeniya, no. 21, 1973, p. 149-53. In Russian with English summary.

B-345 *

Peschanskii, I.S. (1973)
STATIC PRESSURE OF SEA ICE. (In: Yakovlev, G.N., ed. Studies of Ice Physics and Ice Engineering, v. 300. Jerusalem, Israel Program for Scientific Translations, 1973, p. 1-4. 2 fig. NTIS: TT72-50005.) (Also CRREL Translation no. 404, Aug. 1973. 8p. NTIS: AD-769 727.)

B-346 *

Petrov, I.G. (1971)
DIVISION OF THE ARCTIC MARINE ICE COVER INTO REGIONS ACCORDING TO ICE STRUCTURE. (In: Yakovlev, G.N., ed. Studies in Ice Physics and Ice Engineering, v. 300. Jerusalem, Israel Program for Scientific Translations, 1971, p. 33-45. 7 fig. NTIS: TT72-50005.)

B-347

Peyton, Harold R. (1968)
ICE AND MARINE STRUCTURES, PART 2: SEA ICE PROPERTIES. Ocean Industry, v. 3(9), 1968, p. 59-65. Graphs, 13 ref. [geometric model of the growth of ice indicating the entrapment of brine between platelets]

B-348 *

Peyton, Harold R. (1966)
SEA ICE STRENGTH. Alaska. Univ. Geophysical Institute. Final Report no. UAG R-182, Dec. 1966. 274p. Fig., 48 ref. NTIS: AD-653 883. (Also Fairbanks, Univ. of Alaska, 1967. 270p. Ph.D. thesis.) [ice failure, sea ice]

B-349 *

Peyton, Harold R. (1968)
SEA-ICE STRENGTH: EFFECTS OF LOAD RATES AND SALT REINFORCEMENT. (In: Sater, J.E., ed. Arctic Drifting Stations: A Report on Activities Supported by the Office of Naval Research. Proceedings of a symposium held 12-15 April 1966 in Warrenton, Va. Washington, D.C., Arctic Institute of North America, 1968, p. 197-216.)

B-350

PIER MEASURES ICE PRESSURES. Engineering News-Record, v. 179(24), Dec. 1967, p. 34. 2 fig. [ice pressure, ice load recorders]

B-351

Pounder, Elton R.; Langleben, M.P. (1968)
ACOUSTIC ATTENUATION IN SEA ICE. (In: I.A.S.H. Commission of Snow and Ice. Reports and Discussions. International Assn. of Scientific Hydrology. Publication no. 79, 1968, p. 161-69. NTIS: AD-690 437.) (Also McGill Univ. McDonald Physics Laboratory. Ice Research Project. Report S-14, June 1968. 18p. NTIS: AD-679 627.) [laboratory and field measurements in frequency range 10-500 kHz]

B-352

Pounder, Elton R.
HIGH-FREQUENCY AUDIO ABSORPTION IN SEA ICE. U.S. Office of Naval Research Code 463, April 1966. Unpublished report.

B-353

Pounder, Elton R.; LeBlanc, A. (In press)
ICE WATER STRESS AT STATION SNOW BIRD, AIDJEX. Presented at Symposium on Sea Ice Processes and Models, Seattle, Univ. of Washington, 6-9 Sept. 1977, sponsored by ICSI and AIDJEX.

63 575

B-354 *

Pounder, Elton R. (1965)
PHYSICS OF ICE. Oxford, Pergamon Press, 1965.
151p. [mechanical, thermal, electrical properties
and crystallography of pure and sea ice; formation
and growth of an ice cover; ice drift and ice
control]

B-355

Pounder, Elton R. (1969)
STRENGTH AND GROWTH RATES OF SEA ICE. (In: Ice
Seminar. Held at Calgary, Alberta, in 1968.
Canadian Institute of Mining and Metallurgy,
Special Volume no. 10, 1969, p. 73-76. Graph,
tables, 4 ref.)

B-356

Prentiss, David; Davis, Edward; Kutschale, Henry
(1965)
NATURAL AND MAN-MADE ICE VIBRATIONS IN THE CENTRAL
ARCTIC OCEAN IN THE FREQUENCY RANGE FROM 0.1 TO
100 CPS. Columbia Univ. Lamont Geological
Observatory. Technical Report, no. 4, June 1965.
54p. 42 fig., 5 ref.

B-357 *

Pritchard, Robert S. (1974)
ELASTIC STRAIN IN THE AIDJEX SEA ICE MODEL. AIDJEX
Bulletin, no. 27, 1974, p. 45-62. 4 fig., ref.

B-358 *

Pritchard, Robert S. (1976)
ESTIMATE OF THE STRENGTH OF ARCTIC PACK ICE.
AIDJEX Bulletin, no. 34, Dec. 1976, p. 94-113.
3 ref. [pack ice, ice strength, ice models]

B-359

Proskuriakov, B.V.; Berdennikov, V.P. (1971)
METOD OPREDELENIYA NAPRIAZHENIY LEDIANOGO POKROVA
I OPYT EGO PRIMENENIYA (Method of determining
stresses in ice cover and its application).
Gosudarstvennyi Gidrologicheskii Institut. Trudy,
v. 184, 1971, p. 3-22. 3 ref. In Russian.

B-360

Pruppacher, Hans R. (1967)
SOME RELATIONS BETWEEN THE STRUCTURE OF THE ICE-
SOLUTION INTERFACE AND THE FREE GROWTH RATE OF ICE
CRYSTALS IN SUPERCOOLED AQUEOUS SOLUTIONS. Journal
of Colloid and Interface Science, v. 25(2), Oct.
1967, p. 285-94. Fig., ref. [experimental method
devised to determine the rate at which ice crystals
grow freely in supercooled water and in dilute
aqueous solutions of various salts]

B-361 *

Ramseier, René O. (1972)
FORMATION OF PRIMARY ICE LAYERS. (In: I.A.H.R.
Symposium on Ice and Its Action on Hydraulic
Structures, 2nd, Proceedings. Held in Leningrad,
26-29 Sept. 1972. Leningrad, International Assn.
of Hydraulic Research, 1972, Paper 3.1. 8p.)
[reviews effects of water temperature and current
on primary ice crystal formation]

B-362

Reeh, Niels (1970)
THERMAL STRESS IN A VISCO-ELASTIC PLATE IN SIMPLE
EXTENSION. Denmark. Technical Univ. Danish
Center for Applied Mathematics and Mechanics.
Report no. 7, 1970. 19p. [analysis of temperature
variations in plate, and analysis of internal
stress caused by those variations, applied to
natural ice covers]

B-363

Reismann, Herbert; Lee, Yu-Chang (1968)
DYNAMICS OF A FLOATING ICE SHEET. Journal of
Hydrodynamics, v. 2(2), April 1968, p. 108-11.
7 fig., 1 table, 7 ref. [surface loading, plate
theory, floating ice]

B-364

Rhoads, E.M. (1973)
ICE CROSSINGS. Northern Engineer, v. 5(1), 1973,
p. 19-24. [techniques developed for improving
upon the natural freezing process to increase the
capacity and duration of ice crossings]

B-365 *

Richardson, Charles; Keller, E.E. (1966)
THE BRINE CONTENT OF SEA ICE MEASURED WITH A
NUCLEAR MAGNETIC RESONANCE SPECTROMETER. Journal
of Glaciology, v. 6(43), 1966, p. 89-100. 5 fig.,
19 ref.

B-366 *

Richardson, Charles (1976)
PHASE RELATIONSHIPS IN SEA ICE AS A FUNCTION OF
TEMPERATURE. Journal of Glaciology, v. 17(77),
1976, p. 507-19. 12 ref. In English with
French and German summaries. [phase transfor-
mations, salt ice, brines, nuclear magnetic
resonance, water temperature]

B-367

Riehl, M. et al (1969)
PHYSICS OF ICE. New York, Plenum Press, 1969.

B-368

Rose, G.D.; Masterson, D.M.; Friesen, C.E. (1975)
SOME MEASUREMENTS OF Laterally-Loaded ICE SHEETS.
(In: Frankenstein, Guenther E., ed. Inter-
national Symposium on Ice Problems, 3rd, Proceed-
ings. Held 18-21 Aug. 1975, Hanover, N.H. Inter-
national Assn. of Hydraulic Research, 1975,
p. 555-66. 3 ref.) [ice deformation, ice
strength, static loads, ice elasticity]

B-369 *

Ross, Bernard (1967)
PENETRATION AND FRACTURE OF SEA ICE DUE TO IMPACT
LOADING. (In: Oura, Hirobumi, ed. Physics of
Snow and Ice: Proceedings of the International
Conference on Low Temperature Science, v. 1, part
1. Sapporo, Institute of Low Temperature Science,
Hokkaido Univ., 1967, p. 499-521. 13 ref.)
[reports on studies to explore the possibility of
air-dropping scientific instrumentation packages
in remote ice-covered regions of the Arctic for
oceanographic research]

576

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B-416 *

Tabata, Tadashi (1972)
MICROSCALE STRAIN EXPERIMENT. AIDJEX Bulletin,
no. 14, 1972, p. 26-27.

B-417 *

Tabata, Tadashi (1967)
STUDIES OF THE MECHANICAL PROPERTIES OF SEA ICE,
PART 10: THE FLEXURAL STRENGTH OF SMALL SEA ICE
BEAMS. (In: Oura, Hirobumi, ed. Physics of
Snow and Ice: Proceedings of the International
Conference on Low Temperature Science, v. 1, part
1. Sapporo, Institute of Low Temperature Science,
Hokkaido Univ., 1967, p. 481-97.)

B-418 *

Tabata, Tadashi; Fujino, Kazuo; Aota, Masaaki
(1967)
STUDIES OF THE MECHANICAL PROPERTIES OF SEA ICE,
PART 11: THE FLEXURAL STRENGTH OF SEA ICE IN SITU.
(In: Oura, Hirobumi, ed. Physics of Snow and Ice:
Proceedings of the International Conference on Low
Temperature Science, v. 1, part 1. Sapporo,
Institute of Low Temperature Science, Hokkaido
Univ., 1967, p. 539-56.)

B-419

Tarbeev, Iu.V. (1965)
OPREDELENIE NAPRIAZHENII I PROCHNOSTI PRIPAI PO
IZGIBU, VYZVANNOMU KOLEBANIIAMI UROVNIA VODY
(Determination of fast-ice stress and strength for
bending caused by variations in the water level).
Gosudarstvennyi Okeanograficheskii Institut.
Trudy, no. 86, 1965, p. 124-43. 6 ref., tables,
graphs. In Russian. [methods of determination,
using experimental data obtained under natural
conditions in an ice basin]

B-420

Tatinclaux, J.C.; Wu, C.Y. (1976)
LABORATORY STUDY OF THE FLEXURAL STRENGTH AND
ELASTIC MODULUS OF FRESHWATER AND SALINE ICE.
Iowa Univ. Iowa Institute of Hydraulic
Research. Report no. 190, June 1976. 137p.
9 ref.

B-421

Tauriainen, M.J. (1971)
SEA ICE TESTING: NEW TECHNIQUES AND EQUIPMENT FOR
CANTILEVER BEAM TESTS. Alaska Univ. Institute
of Arctic Environmental Engineering. Bulletin
no. 7101, July 1971. 13p. 9 ref.

B-422

Teuscher, L.H.; England, W.G.; Hauser, L.E. (1972)
THE CALCULATION OF THE TEMPERATURE DISTRIBUTION
WITHIN A MELTING/FREEZING MATERIAL USING FINITE
ELEMENT TECHNIQUES. EOS, v. 53(11), 1972, p. 1020.
[abstract only]

B-423

Timokhov, L.A. (1974)
NAPRIAZHENIIA V SZHATOM LEDIANOM POKROVE (Stresses
in compressed pack ice). Arkticheskii i
Antarkticheskii Nauchno-Issledovatel'skii Institut.
Trudy, v. 316, 1974, p. 42-51. 5 ref. In Russian.
[pack ice, ice floes, drift, ice pressure,
stresses, analysis (mathematics), ice cover,
rheology]

B-424 *

Tinawi, R.; Murat, J.R. (In press)
SEA ICE-TESTING IN FLEXURE. Presented at Inter-
national Conference on Port and Ocean Engineering
under Arctic Conditions, 4th, Memorial Univ. of
Newfoundland, 26-30 Sept. 1977.

B-425

Traetteberg, A.; Gold, I.W.; Frederking, R. (1975)
STRAIN RATE AND TEMPERATURE DEPENDENCE OF YOUNG'S
MODULUS OF ICE. (In: Frankenstein, Guenther E.,
ed. International Symposium on Ice Problems, 3rd,
Proceedings. Held 18-21 Aug. 1975, Hanover, N.H.
International Assn. of Hydraulic Research, 1975,
p. 479-86. 4 ref.) [ice mechanics, strain tests,
temperature effects, ice strength, relaxation
(mechanics)]

B-426

Tripp, R.B. (1967)
PHYSICAL AND CHEMICAL DATA FROM FLETCHER'S ISLAND
(T-3): BEAUFORT SEA AREA, JANUARY-MAY 1966.
Washington Univ. Dept. of Oceanography.
Technical Report no. 187, 1967. 62p. 12 ref.
NTIS: AD-670 471. [physical properties, ice
islands, sea ice, sea water, chemical composition]

B-427

Tripp, R.B.; Kusunoki, Kou (1967)
PHYSICAL, CHEMICAL, AND CURRENT DATA FROM ARLIS
II: EASTERN ARCTIC OCEAN, GREENLAND SEA, AND
DENMARK STRAIT AREAS, FEBRUARY 1964-MAY 1965,
VOLUME I. Washington Univ. Dept. of Ocean-
ography. Technical Report no. 185, March 1967.
341p. 15 ref. NTIS: AD-670 474. [ocean
currents, ice islands, sea ice, sea water,
chemical composition]

B-428 *

Tryde, P. (In press)
EFFECT ON STRENGTH OF SEA ICE FROM POSSIBLE
OVERPRESSURE IN BRINE POCKETS AT DYNAMIC LOADING.
Presented at International Conference on Port and
Ocean Engineering under Arctic Conditions, 4th,
Memorial Univ. of Newfoundland, 26-30 Sept. 1977.

B-429

Tsurikov, V.L. (1968)
CHANGES IN THE SALINITY OF SEA ICE DUE TO THE
MIGRATION OF BRINE POCKETS. Oceanology, v. 7(5),
July 1968, p. 694-702. 2 fig., 1 table, 16 ref.
(Translated from "Ismeneniye solenosti morskogo
l'da valedstviye migratsii yacheyek s rassolom,"
Okeanologiya, v. 7(5), 1967, p. 894-900.)

B-430

Tsurikov, V.L. (1976)
FORMATION OF SEA ICE POROSITY. Oceanology,
v. 15(5), 1976, p. 547-50. 6 ref. (Translated
from Okeanologiya, v. 15(5), 1975, p. 813-19.)

B-431 *

Tsurikov, V.L. (1966)
FORMATION OF THE IONIC COMPOSITION AND SALINITY OF
SEA ICE. Oceanology, v. 5(3), 1966, p. 59-66.
4 fig., 2 tables, 23 ref. (Translated from "O
formirovani ionnogo sostava i solennosti morskogo
l'da," Okeanologiya, v. 5(3), 1965, p. 463-72.)

~~577~~ 577

B-400

Smirnov, V.N. (1973)
ICE COVER OSCILLATIONS RESULTING FROM INTERNAL WAVES OF THE ICE OCEAN. Akademiya Nauk SSSR. Doklady. Earth Science Sections, v. 206(1-6), Nov. 1973, p. 16-18. 4 ref. (Translated from "Kolebaniia ledianogo pokrova, obuslovlennye vnutrennimi volnami ledovitogo okeana," Akademiya Nauk SSSR. Doklady, v. 206(5), 1972, p. 1106-08.)

B-401 *

Smirnov, V.N. (1966)
ISSLEDOVANIYE IZGIBNYKH KOLEBANIY DREYFUYUSHCHEGO LIA (Study of bending variations of drifting ice). Problemy Arktiki i Antarktiki, v. 23, 1966, p. 47-49. In Russian.

B-402

Smirnov, V.N. (1976)
NEKOTORYE VOPROSY NATURNOGO ISSLEDOVANIYA DEFORMATSIY I NAPRIAZHENIY V LEDIANOM POKROVE (In-situ investigations of deformation and stresses in an ice cover). Arkticheskii i Antarkticheskii Nauchno-Issledovatel'skii Institut. Trudy, v. 331, 1976, p. 133-40. 8 ref. In Russian.

B-403 *

Smirnov, V.N. (1965)
TIPY UPRUGIKH VOLN V TONKOM LEDYANOM SLOYE (Types of elastic wave in a thin layer of ice). Problemy Arktiki i Antarktiki, v. 19, 1965, p. 64-65. In Russian.

B-404

Smirnov, V.N. (1976)
UPRUGIE IZGIBNYE VOLNY V LEDIANOM POKROVE (Flexural elastic waves in an ice cover). Arkticheskii i Antarkticheskii Nauchno-Issledovatel'skii Institut. Trudy, v. 331, 1976, p. 117-23. 7 ref. In Russian. [Ice cover thickness, ice physics, elastic waves, wave propagation, ice mechanics]

B-405 *

Solomon, Harold (1972)
NOTE ON THE NO-STRESS BOUNDARY CONDITION AT THE EDGE OF THE ICE PACK. Arctic, v. 25(1), 1972, p. 57-59. 7 ref. [boundary value problems, ice pressure, stress analysis]

B-406

Spetzler, H.A.W. (1970)
EFFECT OF TEMPERATURE AND PARTIAL MELTING ON VELOCITY AND ATTENUATION IN A SIMPLE BINARY SYSTEM. Pasadena, Calif. Institute of Technology, 1970. Ph.D. thesis. [study of NaCl-ice system, acoustic wave propagation]

B-407

Spetzler, H.A.W.; Anderson, Duwayne M. (1968)
THE EFFECT OF TEMPERATURE AND PARTIAL MELTING ON VELOCITY AND ATTENUATION IN A SIMPLE BINARY SYSTEM. Journal of Geophysical Research, v. 73(18), 1968, p. 6051-60. [study of propagation of sound waves through ice-salt mixtures with and without appreciable brine volumes]

B-408 *

Sprenger, Robert M. (1972)
CONTINUOUS OBSERVATIONS OF THE STRUCTURAL CHANGES IN DEFORMING POLYCRYSTALLINE ICE. Washington. Univ. Dept. of Atmospheric Sciences. Scientific Report no. 14, Nov. 1972. 69p. Fig., 25 ref.

B-409 *

Squire, V.A.; Allan, A.J. (In press)
PROPAGATION OF FLEXURAL GRAVITY WAVES IN SEA ICE. Presented at Symposium on Sea Ice Processes and Models, Seattle, Univ. of Washington, 6-9 Sept. 1977, sponsored by ICSI and AIDJEX. 10p.

B-410

Starheim, O.K.; Brooks, P.N. (1972)
A REVIEW OF ICE PENETRATION BY KINETIC ENERGY PENETRATORS. Quebec. Defence Research Establishment Valcartier. DRAV Technical Memorandum TN-1979/72, 1972. 72p. NTIS: AD-913 075. [feasibility of placing a sonobuoy for arctic operation under the ice by means of a kinetic energy penetrator]

B-411 *

Stehle, Nancy S. (1967)
MIGRATION OF BUBBLES IN ICE UNDER A TEMPERATURE GRADIENT. (In: Oura, Hirobumi, ed. Physics of Snow and Ice: Proceedings of the International Conference on Low Temperature Science, v. 1, part 1. Sapporo, Institute of Low Temperature Science, Hokkaido Univ., 1967, p. 219-32.) [Investigation into physical mechanism governing behavior of bubbles in glaciers and of brine pocket migration in sea ice]

B-412

Stewart, Michael K. (1974)
HYDROGEN AND OXYGEN ISOTOPE FRACTIONATION DURING CRYSTALLIZATION OF MIRABILITE AND ICE. Geochimica and Cosmochimica Acta, v. 38(1), 1974, p. 167-72. [equilibrium fractionation factors between ice and 2.5 molal NaCl solution at -10°C; results are of use in assessing mirabilite as a climatic indicator]

B-413 *

Tabata, Tadashi; Kawamura, T.; Takizawa, T. (1976)
HOKKYOKUKEN KAIHYO CHOSA, I: SHOSHIRYO NO MAGE-KYODO NO SOKUTEI (Arctic sea ice research, 1: Measurements of flexural strength of small sea ice beams). Teion Kagaku, Series A, no. 34, 1976, p. 201-07. 13 ref. In Japanese with English summary.

B-414

Tabata, Tadashi; Fujino, Kazuo (1965)
KAIHYO NO RIKIGAKU NO SEISHITSU NO KENKYU, VIII. (Studies of the mechanical properties of sea ice, 8: Measurement of flexural strength in situ, 2). Teion Kagaku, Series A, no. 23, 1965, p. 157-66. In Japanese with English summary.

B-415

Tabata, Tadashi (1966)
KAIHYO NO RIKIGAKUTEKI SEISHITSU NO KENKYU, IX: GENJO NI IKERU MAGE KYODO NO SOKUTEI (Studies of the mechanical properties of sea ice, 9: Measurement of flexural strength in situ, 3). Teion Kagaku, Series A, no. 24, 1966, p. 259-68. In Japanese with English summary.

B-370

Ross, Bernard; Hanagud, S. (1969)
PENETRATION STUDIES OF ICE WITH APPLICATION TO
ARCTIC AND SUBARCTIC WARFARE. Stanford Research
Institute. Report, Sept. 1969. 526p. 103 ref.
NTIS: AD-861 771L.

B-371

Ross, Bernard (1967)
PENETRATION STUDIES OF ICE WITH APPLICATION TO
ARCTIC AND SUBARCTIC WARFARE, PHASE II STUDY.
Stanford Research Institute. Report NWRC-3072,
May 1967. 168p. 33 ref. NTIS: AD-817 598L.
[penetration tests, projectile penetration, impact
tests, ice cover thickness, temperature factors,
mathematical models, computer applications]

B-372

Ross, Bernard; Hanagud, S.; Sidhu, G. (1971)
PENETRATION STUDIES OF ICE WITH APPLICATION TO
ARCTIC AND SUBARCTIC WARFARE, PHASE IV. Stanford
Research Institute. Report, April 1971. 68p.
18 ref. NTIS: AD-736 633. [projectile
penetration, impact tests, stress analysis, snow
cover effect, ice structure, computer programs]

B-373

Ross, Bernard (1969)
PERFORATION OF THE ARCTIC SEA-ICE COVER BY
PROJECTILE IMPACT. Journal of Hydronautics,
v. 3(3), July 1969, p. 115-21. 5 fig., 2 tables,
18 ref. (Also abstract in: American Geographical
Union. Transactions, v. 49(1), March 1968,
p. 219.) [in situ measurements, penetration, ice
cover, mechanical properties]

B-374 *

Ryvlin, A.Ia. (1976)
FIELD ANALYSIS OF PHYSICOMECHANICAL PROPERTIES OF
ICE COVER. CRREL Translation no. 539, Aug. 1976,
p. 204-09. NTIS: AD-A030 818. (Translated from
"Naturanoe issledovaniia fiziko-mekhanicheskikh
svoistv ledianogo pokrova," Arkticheskii i
Antarkticheskii Nauchno-Issledovatel'skii Institut.
Trudy, v. 326, 1975, p. 205-09.) [ice physics, ice
strength, ice elasticity, ice navigation, ice
breaking, ice bearing capacity]

B-375

Ryvlin, A.Ia. (1974)
METOD PROGNOZIROVANIYA PREDELA PROCHNOSTI
LEDYANOGO POKROVA NA IZGIB (A method of fore-
casting ice cover bending strength). Problemy
Arktiki i Antarktiki, v. 45, 1974, p. 79-86. In
Russian.

B-376

Sackinger, William M.; Byrd, Robert C. (1973)
BACKSCATTER MILLIMETER WAVES FROM SNOW, ICE AND SEA
ICE. Alaska. Univ. Institute of Arctic Environ-
mental Engineering. Report 7207, 1973. 73p.
NTIS: AD-758 071. [measurements of complex
permittivity of sea ice as function of temperature
and salinity for frequency range 26-40 GHz]

B-377

Sala, I.; Olkkonen, E. (1971)
ON THE VISCO-ELASTIC PROPERTIES OF ICE AND WOOD.
Geophysica, v. 11(2), 1971, p. 249-60.

B-378

Savel'ev, B.A. (1972)
MANUAL FOR THE STUDY OF THE PROPERTIES OF ICE.
Washington, D.C., Arctic Institute of North
America, April 1972. 287p. NTIS: AD-741 870.
(Translated from Rukovodstvo po Izuchenyu Svoistv
Lda. Moscow, 1963.) [methods for studying the
structure of ice and snow, salinity and brine in
ice]

B-379

Savel'ev, B.A. (1973)
STRUCTURE, COMPOSITION AND PROPERTIES OF ICE COVER
ON MARINE AND FRESH WATER BODIES. U.S. Army.
Foreign Science and Technology Center. Technical
Translation HT-23-50-72, April 1973. 553p.
NTIS: AD-765 896. (Translated from Stroenie,
Sostav i Svoistva Ledyanogo Pokrova Morskikh i
Presnykh Vodoemov. Moscow, 1963. 541p.)
[structural properties, thermal properties,
chemical properties, porosity, salinity, hardness,
thickness, melting, freezing]

B-380 *

Schwarz, J.; Weeks, Wilford F. (1977)
ENGINEERING PROPERTIES OF SEA ICE. (In: Environ-
mental Assessment of the Alaskan Continental Shelf,
v. 4. Boulder, Colo., Environmental Research
Laboratories, 1977, p. 142-224. 109 ref.)

B-381

Schwarz, J. (1975)
ON THE FLEXURAL STRENGTH AND ELASTICITY OF SALINE
ICE. (In: Frankenstein, Guenther E., ed. Inter-
national Symposium on Ice Problems, 3rd, Proceed-
ings. Held 18-21 Aug. 1975, Hanover, N.H. Inter-
national Assn. of Hydraulic Research, 1975,
p. 373-86. 6 ref.) [salt ice, brines, flexural
strength, ice elasticity, ice temperature]

B-382 *

Schwarz, J.; Miloh, T. (1972)
ON THE TIME DEPENDENT TEMPERATURE VARIATION WITHIN
ICE SHEETS. (In: I.A.H.R. Symposium on Ice and
Its Action on Hydraulic Structures, 2nd, Proceed-
ings. Held in Leningrad, 26-29 Sept. 1972.
Leningrad, International Assn. for Hydraulic
Research, 1972, p. 262-69. 10 ref.) In English
with French summary. [ice sheets, ice temperature,
ice thermal]

B-383 *

Seidensticker, R.G. (1966)
COMMENT ON PAPER BY P. HOEKSTRA, T.E. OSTERKAMP,
AND W.F. WEEKS, "THE MIGRATION OF LIQUID INCLU-
SIONS IN SINGLE ICE CRYSTALS." Journal of Geo-
physical Research, v. 71(8), April 1966, p. 2180-
81. 9 ref.

B-384

Serikov, M.I. (1975)
GRUZOPOD' 'YEMNOST' L'DA I OPREDELENIYE USULIY,
RAZRUSHAYUSHCHIKH LEDYANOY POKROV (Load-carrying
capacity of ice and determination of its breaking
strength). Problemy Arktiki i Antarktiki, v. 46,
1975, p. 128-30. In Russian.

B-386

Shamont'ev, V.A. (1967)
O VLIYANII ZIMNIIKH GIDROLOGICHESKIKH USLOVIY NA NEKOTORYYE ELEMENTY GIDROLOGICHESKOGO REZHIMA CHUKOTSKOGO MORYA V NAVIGATSIONNOM SEZONE (Influence of winter hydrological conditions on certain elements of the hydrological regime of the Chukchi Sea in the navigation season). Okeanologiya, v. 7(3), 1967, p. 450-56. In Russian. [effect on ice cover]

B-387 *

Shapiro, Lewis H.; Hoskins, E.R. (1976)
THE USE OF FLATJACKS FOR THE IN SITU DETERMINATION OF THE MECHANICAL PROPERTIES OF SEA ICE. (In: International Conference on Port and Ocean Engineering under Arctic Conditions, 3rd, Proceedings. Held 11-15 Aug. 1975, Fairbanks, Alaska. Institute of Marine Science, Univ. of Alaska, 1976, p. 417-25.)

B-388 *

Shaver, Ralph; Hunkins, Kenneth L. (1965)
GEOPHYSICAL STUDIES OF THE CHUKCHI CAP AREA OF THE ARCTIC OCEAN. American Geophysical Union. Transactions, v. 46(1), 1965, p. 70. [abstract only]

B-389

Shesteporov, I.A. (1970)
OBSERVATIONAL VERIFICATION OF TSURIKOV'S FORMULA. Oceanology, v. 9(4), March 1970, p. 502-04. (Translated from "Proverka formuly Tsurikova po resul'tatam nabliudenii," Okeanologiya, v. 9(4), July/Aug. 1969, p. 616-18.)

B-390

Shpaikher, A.O. (1976)
KOLICHESTVO PRESNOI VODY V MORSKIKH L'DAKH POLIARNYKH OBLASTEI ZEMNOGO SHARA (Amount of fresh water in polar sea ice). Arkticheskii i Antarkticheskii Nauchno-Issledovatel'skii Institut. Trudy, v. 323, 1976, p. 168-77. 21 ref. In Russian. [ice composition, ice salinity]

B-391

Shpaikher, A.O. (1974)
ZAPASY PRESNOY VODY V MORSKIKH L'DAKH (Reserves of fresh water in sea ice). (In: Mirovoy Vodnyy Balans i Vodnyye Resursy Zemli. Leningrad, Gidrometeoizdat, 1974, p. 557-60.) In Russian.

B-392 *

Shvaishtein, Z.I. (1973)
EXPERIMENTAL STUDIES IN AN ICE-RESEARCH LABORATORY. (In: Yakovlev, G.N., ed. Studies in Ice Physics and Ice Engineering, v. 300. Jerusalem, Israel Program for Scientific Translations, 1973, p. 16-25. 3 ref. NTIS: TT72-50005.) (Translated from "Eksperimental'nye raboty v ledoissledovatel'skoi laboratorii," Arkticheskii i Antarkticheskii Nauchno-Issledovatel'skii Institut. Trudy, v. 300, 1971, p. 21-31.) [ice cover strength, ice navigation, models]

B-393 *

Sinha, N.K. (1977)
TECHNIQUE FOR STUDYING STRUCTURE OF SEA ICE. Journal of Glaciology, v. 18(79), 1977, p. 315-23. [microtoming and replicating technique for examining microstructure optically and by scanning electron microscope]

B-394 *

Slesarenko, Iu.E.; Frolov, A.D. (1974)
COMPARISON OF ELASTICITY AND STRENGTH CHARACTERISTICS OF SALT-WATER ICE. (In: I.A.H.R. Symposium on Ice and Its Action on Hydraulic Structures, 2nd, Proceedings. Held in Leningrad, 26-29 Sept. 1972. Leningrad, International Assn. for Hydraulic Research, 1974, p. 85-87.) [fairly distinct correlation between elasticity and strength characteristics of NaCl ice confirms feasibility of indirect procedure for estimating strength by acoustic measurements]

B-395

Slesarenko, Iu.E.; Frolov, A.D. (1975)
KHARAKTERISTIKI UPUGOSTI LEDIANYKH POKRYTII (Ice cover elasticity). Arkticheskii i Antarkticheskii Nauchno-Issledovatel'skii Institut. Trudy, v. 317, 1975, p. 80-91. 16 ref. In Russian. [icing, ice elasticity, ice adhesion]

B-396

Slesarenko, Iu.E. (1973)
UL'TRAZVUKOVOI SPOSOB OPREDELENIYA FAZOVOGO SOSTAVA LEDIANYKH OBRAZOVANII IZ MORSKOI VODY I RASTVOROV (Ultrasonic techniques for determining phase composition of ice grown from sea water and solutions). (In: International Conference on Permafrost, 2nd, v. 4. Yakutsk, 1973, p. 215-18. 9 ref.) In Russian.

B-397

Smirnov, V.I. (1968)
ON THE POSSIBILITY OF CALCULATING THE STRENGTH LIMITS OF SEA ICE UNDER LOADS OF SHORT DURATION. Oceanology, v. 7(3), March 1968, p. 331-38. 5 fig., 2 tables, 18 ref. (Translated from "O vozmozhnosti rascheta predela prochnosti ledianogo pokrova pri kratkovremennyykh nagruzkakh," Okeanologiya, v. 7(3), May/June 1967, p. 428-36.)

B-398 *

Smirnov, V.I. (1973)
POTENTIAL ICE RESISTIVITY ACCORDING TO DATA FROM AIRBORNE OR SHIPBOARD OBSERVATION. (In: Treshnikov, A.F., ed. Problems of the Arctic and Antarctic, v. 33-35. Jerusalem, Israel Program for Scientific Translations, 1973, p. 122-26. 1 fig., 6 ref. NTIS: TT72-50006.) (Translated from "O potentsial'noi soprotivliaemosti l'da po nabliudeniiam za ledianym pokrovom s borta samoleta ili sudna," Problemy Arktiki i Antarktiki, v. 33, 1970, p. 115-18.)

B-399 *

Smirnov, V.N. (1973)
DETERMINATION OF ELASTIC CHARACTERISTICS OF AN UNDISTURBED ICE COVER USING STATIC AND DYNAMIC METHODS. (In: Yakovlev, G.N., ed. Studies in Ice Physics and Ice Engineering, v. 300. Jerusalem, Israel Program for Scientific Translations, 1973, p. 46-49. 4 ref. NTIS: TT72-50005.) (Translated from "Opredelenie uprugikh kharakteristik nenarushehnogo ledianogo pokrova dinamicheskimi i staticheskimi metodami," Arkticheskii i Antarkticheskii Nauchno-Issledovatel'skii Institut. Trudy, v. 300, 1971, p. 56-60.) [ice physics, ice temperature, ice elasticity, ice plasticity, ice deformation, analysis (mathematics)]

B-448

Vaudrey, K.D. (1975)
ICE ENGINEERING: ELASTIC PROPERTY STUDIES ON COMPRESSIVE AND FLEXURAL SEA ICE SPECIMENS. U.S. Naval Civil Engineering Laboratory. Technical Note, no. 1417, Dec. 1975. 19p.
NTIS: AD-A019 028.

B-449 *

Wakahama, Gorow; Akitaya, Eizi; Tabata, Tadashi (1974)
OBSERVATIONS OF SNOW COVERS IN ARCTIC REGIONS. Teion Kagaku, Series A, no. 32, 1974, p. 175-84. In Japanese with English summary. [snow covers greatly influence temperature distributions in sea ice beneath the snow, and also the heat budget of the sea ice and the formation of ice at the bottom of the sea ice]

B-450 *

Wakatsuchi, M. (1974)
EXPERIMENTS ON THE GROWTH OF SEA ICE AND REJECTION OF BRINE. Teion Kagaku, Series A, no. 32, 1974, p. 195-205. 7 ref. In Japanese with English summary.

B-451 *

Walker, H.J. (1973)
SALINITY CHANGES IN THE COLVILLE RIVER DELTA, ALASKA, DURING BREAKUP. (In: International Symposia on the Role of Snow and Ice in Hydrology, Proceedings. Held in Banff, Canada, Sept. 1972. UNESCO-WMO-IAHS, 1973, p. 514-27.)

B-452

Walker, H.J. (1973)
SPRING DISCHARGE OF AN ARCTIC RIVER DETERMINED FROM SALINITY MEASUREMENTS BENEATH SEA ICE. Water Resources Research, v. 9(2), 1973, p. 474-80. [between 27 May and 15 June 1971, the discharge of the Colville River, Alaska, was $5.70 \times 10^9 \text{ m}^3$, which is about 58% of the total for 1971]

B-453

Washington. Univ. Geophysics Program (1971)
FINAL REPORT. CONTRACT U00014-67-A-0103-0020, NR 307-325. Seattle, Wash.; Univ. of Washington, 1971. 8p. [describes 1970-71 work on growth of brine channels in sea ice and growth of stalactites under sea ice, processes which bring about natural desalination]

B-454 *

Weeks, Wilford F.; Lofgren, Gary (1967)
THE EFFECTIVE SOLUTE DISTRIBUTION COEFFICIENT DURING THE FREEZING OF NaCl SOLUTIONS. (In: Oura, Hirobumi, ed. Physics of Snow and Ice: Proceedings of the International Conference on Low Temperature Science, v. 1, part 1. Sapporo, Institute of Low Temperature Science, Hokkaido Univ., 1967, p. 579-97.) [variation of effective solute distribution coefficient as a function of growth velocity is in agreement with theoretical predictions]

B-455 *

Weeks, Wilford F.; Assur, Andrew (1969)
FRACTURE OF LAKE AND SEA ICE. CRREL Research Report no. 269, Sept. 1969. 77p. Fig., photos, table. NTIS: AD-697 750.

B-456 *

Weeks, Wilford F.; Cox, G.F.N. (1974)
LABORATORY PREPARATION OF ARTIFICIAL SEA AND SALT ICE. CRREL Special Report no. 206, 1974. 11p. 4 fig., ref. NTIS: AD-780 694.

B-457 *

Weeks, Wilford F.; Assur, Andrew (1968)
MECHANICAL PROPERTIES OF SEA ICE. Canada. National Research Council. Associate Committee on Geotechnical Research. Technical Memorandum, no. 92, 1968, p. 25-78. Graphs, tables, 200 ref. In English with French summary. (Also CRREL Monograph no. IIC3, 1967. 80p.) [reviews the literature with detailed discussion of published results that contain sufficient data on ice temperatures, salinities and densities to permit adequate analysis]

B-458 *

Weeks, Wilford F. (1972)
MESOSCALE STRAIN AND ICE MORPHOLOGY. AIDJEX Bulletin, no. 14, 1972, p. 24-25.

B-459

Weeks, Wilford F. (1967)
REVIEW OF THE PHYSICS OF ICE BY E.R. POUNDER. American Meteorological Society. Bulletin, v. 48(9), Sept. 1967, p. 735. [book review]

B-460

Weeks, Wilford F.; Cox, G.F.N. (1973)
SALINITY VARIATIONS IN SEA ICE. CRREL Research Report no. 310, Aug. 1973. 25p.

B-461 *

Weeks, Wilford F. (1976)
SEA ICE PROPERTIES AND GEOMETRY. AIDJEX Bulletin, no. 34, Dec. 1976, p. 137-71. Ref. [ice mechanics, ice physics, ice strength, ice cover thickness, pressure ridges]

B-462 *

Weeks, Wilford F.; Hibler, William D., III; Ackley, S.F. (1974)
SEA ICE: SCALES, PROBLEMS AND REQUIREMENTS. (In: Santeford, Henry S.; Smith, J.L., comp. Advanced Concepts and Techniques in the Study of Snow and Ice Resources: An interdisciplinary symposium held at Monterey, Calif. 2-6 Dec. 1973. Washington, D.C., National Academy of Sciences, 1974, p. 255-67.)

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C-1, C-2, C-14, C-26, C-39, C-93, C-94, C-95, C-100, C-110, C-120, C-121, C-130, C-131

D-1, D-2, D-8, D-18, D-20, D-24, D-25, D-26, D-28, D-29, D-31, D-32, D-54, D-57, D-73, D-92, D-95, D-99, D-100, D-107, D-115, D-120, D-126, D-152

E-4, E-32, E-47, E-61, E-63, E-75, E-79, E-81, E-96, E-104, E-125, E-126, E-185, E-192, E-204, E-205, E-232, E-242, E-246, E-247, E-256, E-266, E-267, E-274, E-331, E-365

F-2, F-3, F-19, F-26, F-27, F-28, F-29, F-32, F-46, F-47, F-51, F-54, F-58, F-60, F-61, F-65, F-67

G-10, G-18, G-19, G-20, G-25, G-30, G-32, G-35, G-36

H-22, H-97, H-196, H-221

I-71, I-73, I-90, I-124, I-137, I-151, I-155, I-178, I-228, I-329, I-345, I-346, I-360, I-361.

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Section 5. Frost Heave

-1-

AN - 34001183
TI - Designing gas pipeline crossings of major river valleys in the North
OTI - Proektirovanie perekhodov gazoprovodov cherez doliny krupnykh rek v raionakh Severa
AU - Kondrat'ev, V.G.; Zamolotchikova, S.A.; Poltev, N.F.
SO - Stroitel'stvo truboprovodov, Aug. 1979-No.8, p.30-31, In Russian.
DT - J (JOURNAL ARTICLE)
LA - rus
IT - design; gas pipelines; river crossings; permafrost beneath structures; continuous permafrost; frost heave; pipeline freezing; river ice; ice loads

-2-

AN - 34001030
TI - Upward migration of moisture and heaving in frozen soils
AU - Morel-Seytoux, H.J.
SO - Meeting on Modeling of Snow Cover Runoff, 26-28 September 1978, Hanover, New Hampshire. Proceedings, edited by S.C. Colbeck and M. Ray, p.328-335, 23 refs., U.S. Army Cold Regions Research and Engineering Laboratory, 1979
DT - PA (PAPER)
LA - eng
IT - soil moisture migration; frost heave; ice formation; layers; modeling

-3-

AN - 34000780
TI - Uplift of objects by an upfreezing ice surface
AU - Mackay, J.R.; Burrous, C.
SO - Canadian geotechnical journal, 1979-16(3), p.609-613, In English with French summary. 14 refs.
DT - J (JOURNAL ARTICLE)
LA - eng, fre
IT - active layer; continuous permafrost; ground ice; frost heave

-4-

AN - 34000333
TI - Means of protecting foundations from frost heave
OTI - Nekotorye meropriyatiya po zashchite fundamentov ot moroznogo pucheniya
AU - Pyshchev, N.F.
SO - Promyshlennoe stroitel'stvo, Apr. 1979-No.4, p.14-15, In Russian. 5 refs.
DT - J (JOURNAL ARTICLE)
LA - rus
IT - analysis (mathematics); buildings; foundations; frost heave;

624
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901

frost penetration; soil moisture migration

-5-

AN - 34000290
 TI - Frost heave at ground temperatures below 0C, Inuvik, Northwest Territories
 AU - Mackay, J.R.; Ostrack, J.; Lewis, C.P.; MacKay, D.K.
 SO - Canada. Geological Survey. Paper, 1979-No.79-1A, p.403-405. 4 refs.
 DT - R (REPORT)
 LA - eng
 IT - temperature effects; canada -northwest territories -inuvik; frost heave; active layer; soil freezing; permafrost physics

-6-

AN - 34000288
 TI - Bedrock heave in the central Canadian Arctic
 AU - Dyke, L.
 SO - Canada. Geological Survey. Paper, 1979-No.79-1A, p.241-246, 10 refs.
 DT - R (REPORT)
 LA - eng
 IT - soil freezing; soil moisture migration; water pressure; frost heave; rock mechanics; frozen rocks

-7-

AN - 34000287
 TI - Equilibrium model for hummocks (nonsorted circles), Garry Island, Northwest Territories
 AU - Mackay, J.R.
 SO - Canada. Geological Survey. Paper, 1979-No.79-1A, p.165-167, 15 refs.
 DT - R (REPORT)
 LA - eng
 IT - models; canada -northwest territories -garry island; hummocks; patternec ground; permafrost physics; tundra; frost heave; active layer

-8-

AN - 34000159
 TI - Deformation due to foundation movements
 AU - Crawford, C.B.
 SO - National Research Council, Canada. Division of Building Research. Proceedings, Sep. 1976-No.2, 7p.
 DT - J (JOURNAL ARTICLE)
 LA - eng
 IT - frost heave; permafrost beneath structures; buildings;

625

deformation; cracking (fracturing); foundations; settlement (structural); loads (forces); stresses

-9-

AN - 34000023
TI - Mudboil activity, central District of Keewatin
AU - Egginton, P.A.
SO - Canada. Geological Survey. Paper, 1979-79-1B, p.349-356, 6 refs.
DT - J (JOURNAL ARTICLE)
LA - eng
IT - animals; patterned ground; frost heave; soil creep; soil moisture migration

-10-

AN - 33004703
TI - Influence of subgrade properties on frost heave
AU - Jones, R.H.; Berry, A.N.
SO - Highways and public works, July 1979-47(1832), p.17-22, 15 refs.
DT - J (JOURNAL ARTICLE)
LA - eng
IT - frost heave; soil moisture; low temperature tests; subgrade soils; frost resistance

-11-

AN - 33004550
TI - Thermal and rheological computations for artificially frozen ground construction
AU - Sanger, F.J.; Sayles, F.H.
SO - Engineering geology, REPT. NO. MP 1227, 1979-Vol.13, p.311-337, 32 refs. For another version and abstract see 33-4283.
DT - J (JOURNAL ARTICLE)
LA - eng
IT - frost heave; analysis (mathematics); construction; soil freezing; artificial freezing; frozen ground mechanics; frozen ground thermodynamics; creep properties; rheology; thermal properties

-12-

AN - 33004435
TI - Small-scale testing of soils for frost action and water migration
AU - Sayward, J.M.
SO - U.S. Army Cold Regions Research and Engineering Laboratory, REPT. NO. SR 79-17, May 1979, 17 p., 25 refs.
DT - R (REPORT)
LA - eng
IT - soil tests; frost action; soil moisture migration; frost heave; ice needles
AB - A method is described by which frost action (soil heaving and and

needle ice) and the use of soil additives for its control can be studied. The apparatus and procedure are simple and convenient, requiring no extensive space or services and using only small quantities of materials. The procedure could be useful in developing a standard test for such purposes where small scale and convenience are requisite. Also described are two simple, small-scale accessory tests that likewise relate to permeability of soils. These evaporation and wetting tests might also have similar use, particularly in the study of water migration-inhibiting additives.

-13-

AN - 33004384
TI - Influence of the addition of water vapor diffusion on the numerical simulation of the process of ice segregation
AU - Outcalt, S.
SO - Frost i jrd, May 1979-No. 20, p.45-57, 22 refs.
DT - J (JOURNAL ARTICLE)
LA - eng
IT - ice sublimation; phase transformations; mathematical models; frozen ground analysis; ice needles; vapor diffusion; soil freezing; soil moisture migration; frost heave; unfrozen water content; thermal regime

-14-

AN - 33004382
TI - Suggestions for an improved standard laboratory test for frost heave susceptibility of soils
AU - Loch, J.P.G.
SO - Frost i jrd, May 1979-No. 20, p.33-38, 12 refs.
DT - J (JOURNAL ARTICLE)
LA - eng
IT - experimentation; frost heave; soil freezing; heat flux; heat loss

-15-

AN - 33004381
TI - Influence of the heat extraction rate on the ice segregation rate of soils
AU - Loch, J.P.G.
SO - Frost i jrd, May 1979-No. 20, p.19-30, 12 refs.
DT - J (JOURNAL ARTICLE)
LA - eng
IT - experimentation; frost heave; heat flux; heat loss; soil freezing; soil temperature; ice lenses; soil moisture migration

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-16-

AN - 33004353
 TI - Selecting the structure of nonburied fill foundations
 OTI - Vybór konstruktsii podsypl dlia nezaglublennykh fundamentov
 AU - Tishin, V.G.
 SO - Transportnoe stroitel'stvo, June 1979-No.6, p.49-51, In Russian.
 3 refs.
 DT - J (JOURNAL ARTICLE)
 LA - rus
 IT - buildings; foundations; rock fills; permafrost beneath
 structures; frost heave

-17-

AN - 33004283
 TI - Thermal and rheological computations for artificially frozen
 ground construction
 AU - Sanger, F.J.; Sayles, F.H.
 SO - International Symposium on Ground Freezing, 1st, Bochum, Mar.
 8-10, 1978, Vol.2. Edited by H.L. Jessberger, REPT. NO. MP 1216,
 p.95-117, 32 refs., Bochum, Ruhr University, 1978
 DT - PA (PAPER)
 LA - eng
 IT - construction; analysis (mathematics); frost heave; soil freezing;
 thermal properties; artificial freezing; frozen ground mechanics;
 frozen ground thermodynamics; creep properties; rheology

-18-

AN - 33004280
 TI - Effects of temperature and pressure on frost heaving
 AU - Penner, E.; Walton, T.
 SO - International Symposium on Ground Freezing, 1st, Bochum, Mar.
 8-10, 1978, Vol.2. Edited by H.L. Jessberger, p.65-72, 3 refs.,
 Bochum, Ruhr University, 1978
 DT - PA (PAPER)
 LA - eng
 IT - frost heave; temperature effects; soil pressure; frost action;
 frost penetration; soil freezing; clay soils; ice lenses

-19-

AN - 33004195
 TI - Experience of constructing buildings with foundations on fill
 AU - Tishin, V.G.
 SO - Soil mechanics and foundation engineering, Nov.-Dec. 1978-15(6),
 p.381-384, Translated from Osnovaniia, fundamenty i mekhanika
 gruntov. 2 refs.
 DT - J (JOURNAL ARTICLE)
 LA - eng, rus
 IT - buildings; foundations; rock fills; frost heave; seasonal freeze

628

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 reference page

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-20-

AN - 33004077
TI - Cryogenic processes and phenomena in earth structures and their bases
DTI - Kriogennyye protsessy i iavleniya v gruntovykh sooruzheniyakh i ikh osnovaniyakh
AU - Kronik, I.A.A.
SO - Inzhenernoe merzlotovedenie. Materialy k III Mezhdunarodnoi konferentsii po merzlotovedeniyu (Engineering geocryology. Papers prepared for the 3rd International Conference on Permafrost) edited by F.I. Mel'nikov, p.204-213, In Russian. 19 refs., Novosibirsk, Nauka, 1979
DT - PA (PAPER)
LA - rus
IT - embankments; earth dams; earth fills; cryogenic processes; solifluction; frost heave; naleds; freeze thaw cycles; thermokarst; settlement (structural)

-21-

AN - 33003876
TI - Frost heave in Tomakomai (1977-1978)
AU - Kinoshita, S.; Suzuki, Y.; Horiguchi, K.; Inoue, M.; Takeda, K.; Ishizaki, T.
SO - Seppyo, Mar. 1979-4:(1), p.107-112, In Japanese. 1 ref.
DT - J (JOURNAL ARTICLE)
LA - jap, eng
IT - soil mechanics; frost heave; soil moisture

-22-

AN - 33003806
TI - Studying the stability of wall marks in Yakutsk
DTI - Issledovanie stabil'nosti stennykh nivelirnykh znakov v Yakutske
AU - Pandul, I.S.; Bogdanov, B.G.
SO - Geodeziya i kartografiya, Feb. 1979-No.2, p.37-38, In Russian. 4 refs.
DT - J (JOURNAL ARTICLE)
LA - rus
IT - leveling; buildings; permafrost beneath structures; walls; bench marks; frost heave; foundations; deformation

-23-

AN - 33003722
TI - Freezing and frost heave of peat
OTI - Promerzanie, puchenie i smerzanie torfa
AU - Morareskul, N.N.
SO - Mekhanika gruntov, osnovaniia i fundamenty (Soil mechanics, bases and foundations) edited by B.I. Dalmatov, p.37-39, In Russian., Leningrad, 1968
DT - PA (PAPER)
LA - rus
IT - swamps; peat; frost penetration; ground ice; frost heave

-24-

AN - 33003721
TI - Influence of freezing on the stability of embankments with smelting slag interlayers
OTI - Vliianie promerzaniia na ustoiчивost' nasypel s prosloikami metallurgicheskogo shlaka
AU - Karlov, V.D.
SO - Mekhanika gruntov, osnovaniia i fundamenty (Soil mechanics, bases and foundations) edited by B.I. Dalmatov, p.34-37, In Russian., Leningrad, 1968
DT - PA (PAPER)
LA - rus
IT - snow cover effect; embankments; frost penetration; frost heave

-25-

AN - 33003719
TI - Effectiveness of some means of preventing foundation frost heave
OTI - Effektivnost' primeneniia nekotorykh mer protiv moroznogo vypuchivaniia fundamenta
AU - Ulitskii, V.M.
SO - Mekhanika gruntov, osnovaniia i fundamenty (Soil mechanics, bases and foundations) edited by B.I. Dalmatov, p.28-31, In Russian. 1 ref., Leningrad, 1968
DT - PA (PAPER)
LA - rus
IT - design; foundations; footings; frost heave

-26-

AN - 33003684
TI - Water and salt movement in unsaturated frozen soil: principles and field observations
AU - Cary, J.W.; Papendick, R.I.; Campbell, G.S.
SO - Soil Science Society of America. Journal, Jan.-Feb. 1979-43(1), p.3-8, 18 refs.
DT - J (JOURNAL ARTICLE)
LA - eng

IT - frozen ground hydrology; soil moisture migration; electrical resistivity; frost heave; temperature effects

-27-

AN - 33003678
TI - Significance of frost action and surface soil characteristics to wind erosion at Rocky Flats, Colorado. Final report
AU - Caine, N.
SO - 100p., See also 33-2113 and 33-3131., Boulder, Colorado, Institute of Arctic and Alpine Research, 1978
DT - R (REPORT)
LA - eng
IT - Frozen ground mechanics; frost action; frost heave; soil physics; wind erosion

-28-

AN - 33003636
TI - Heat and mass transfer in freezing unstaured soil
AU - Jame, Y.-W.
SO - n.p., Ph.D. thesis. For abstract see Dissertation abstracts International, Sec.B, Nov 1978, p.2401. Microfilm from the National Library of Canada., Saskatoon, Canada, University of Saskatchewan, 1978
DT - MON (MONOGRAPH)
LA - eng
IT - soil temperature; measuring instruments; soil freezing; heat transfer; mass transfer; soil moisture migration; moisture content; frost heave

-29-

AN - 33003341
TI - Tebelery village in the Chuysk steppe
OTI - Tebelery v Chuiskoi stepi
AU - Krivonosov, B.M.
SO - Zapadno-sibirskii regional'nyi nauchno-issledovatel'skii gidrometeorologicheskii institut. Trudy, 1978-Vol.37, p.87-90, In Russian.
DT - J (JOURNAL ARTICLE)
LA - rus
IT - ussr -altai mountains; cryogenic processes; pingos; nalecs; frost heave

631

153

-30-

AN - 33003311
TI - Reference sites for vegetation-soil studies, northern Keewatin
AU - Zoltai, S.C.; Johnson, J.D.
SO - Canada. Ministry of Indian and Northern Affairs. Publication,
1977-No.QS-8160-019-EE-A1, 29p., In English with French summary.
17 refs.
DT - R (REPORT)
LA - eng, fre
IT - vegetation patterns; tundra vegetation; patterned ground; frost
heave; damage; pipelines

-31-

AN - 33003246
TI - Regularities governing seasonal frost heave in the northern taiga
of West Siberia
OTI - Nekotorye zaknomenosti sezonnogo pucheniia gruntov v
severotaezhnoi zone Zapadnoi Sibiri
AU - Nevecheria, V.L.; Goral'chuk, M.I.
SO - Kriogennye protsessy (Cryogenic processes) edited by S.E.
Grechishchev et al, p.177-188, In Russian. 4 refs., Moscow,
Nauka, 1978
DT - PA (PAPER)
LA - rus
IT - vegetation factors; taiga soils; frost penetration; seasonal
freeze thaw; soil moisture migration; frost heave

-32-

AN - 33003073
TI - Geotechnic evaluation of the proposed ALCAN gas pipeline in Alaska
OS - Iroquois Research Institute
SO - 292p., 143 refs., Falls Church, Virginia, 1976
DT - R (REPORT)
LA - eng
IT - gas pipelines; cold weather construction; environmental impact;
frost heave; river crossings; frozen ground mechanics; frozen
ground thermodynamics

-33-

AN - 33002874
TI - Thufur in the Caucasus
OTI - O tufurakh Kavkaza
AU - Bondyrev, I.V.
SO - Kriogennye iavleniia vysokogorii (Cryogenic phenomena of
highlands) edited by A.P. Gorbunov, p.36-42, In Russian. 7
refs., Novosibirsk, Nauka, 1978
DT - PA (PAPER)
LA - rus

632

DFFE

IT - periglacial processes; pingos; frost heave; hummocks; ground ice;
ice lenses

-34-

AN - 33002872
TI - Cryogenic phenomena of the Pamir-Alai Mountains
OTI - Kriogennyye iavleniya Pamiro-Alaia
AU - Gorbunov, A.P.
SO - Kriogennyye iavleniya vysokogor'ii (Cryogenic phenomena of
highlands) edited by A.P. Gorbunov; p.5-25, In Russian. 37 refs.,
Novosibirsk, Nauka, 1978
DT - PA (PAPER)
LA - rus
IT - ussr -pamirs; cryogenic processes; periglacial processes;
permafrost distribution; ground ice; pingos; naleds; frost heave;
permafrost structure; permafrost beneath lakes

-35-

AN - 33002700
TI - False swamps in the Khantaika River Basin, a right tributary of
the Yenisey River
OTI - Bugristye bolota basseina r. Khantaiki--pravogo pritoka r. Enisei
AU - Preis, A.A.
SO - Botanicheskii zhurnal, Nov. 1978-63(11), p.1663-1671, In Russian.
Refs. 1370-1671.
DT - J (JOURNAL ARTICLE)
LA - rus
IT - classifications; ussr -khantaika river; swamps; hummocks; ground
ice; peat; thermokarst; frost heave; cryogenic processes

-36-

AN - 33002480
TI - Design of foundations, anchored in unfrozen ground, to resist
heaving forces
AU - Solov'ev, I.U.I.; Puskov, V.I.
SQ - National Research Council, Canada. Technical translation, Sep.
1970-TT-1424, 10p., For Russian original see SIP 19768. 4 refs.
DT - R (REPORT)
LA - eng, rus
IT - foundations; frost heave; soil freezing

633

-37-

- AN - 33002478
- TI - Instructions for designing bearing media and foundations in the southern zone of the permafrost region
- OS - Akademiia stroitel'stva i arkhitektury SSSR. Institut osnovanii i podzemnykh soorzenii
- SO - National Research Council, Canada. Technical translation, Sep. 1967-TT-1298, 68p., Translation of Ukazaniia po proektirovaniu osnovanii i fundamentov dlia lizhnoi zony rasprostraneniia vechnomerzlykh gruntov. Moscow, 1962, 77p.
- DT - R (REPORT)
- LA - eng, rus
- IT - standards; permafrost beneath structures; frost heave; active layer; ground thawing; construction; heat transfer; settlement (structural); bearing capacity

-38-

- AN - 33002424
- TI - Concerning M.V. Gol'dshtein's hypothesis on the redistribution of moisture and ice segregation in frozen soil
- AU - Bakulin, F.G.
- SO - National Research Council, Canada. Technical translation, 1962-TT-1006, p.33-36, 13 refs.
- DT - PA (PAPER)
- LA - eng, rus
- IT - soil moisture migration; frozen ground mechanics; frost heave; theories

-39-

- AN - 33002420
- TI - Adfreezing and frost heaving of foundations
- AU - Penner, E.; Eurn, K.N.
- SO - Canadian building digest, Aug. 1970-CBD 128, 4p.
- DT - R (REPORT)
- LA - eng
- IT - frost penetration; frost heave; foundations; thermal insulation

-40-

- AN - 33002418
- TI - Frost action and foundations
- AU - Burn, K.N.
- SO - Canadian building digest, Nov. 1976-CBD 182, 4p., 3 refs.
- DT - R (REPORT)
- LA - eng
- IT - frost heave; soil freezing; foundations

-41-

AN - 33002257
TI - How permafrost affects offshore wells and structures
AU - Goodman, M.A.
SO - World oil, May 1978-86(6), p.90-95, 31 refs.
DT - J (JOURNAL ARTICLE)
LA - eng
IT - frost heave; ground thawing; subsidence; offshore structures; artificial islands; submarine permafrost; permafrost beneath structures

-42-

AN - 33002083
TI - Fundamentals of ice lens formation
AU - Takagi, S.
SO - American Institute of Chemical Engineers. AICHE symposium series, REPT. NO. MP 1173, 1978-74(174), p.235-242, 27 refs. See also 32-3470 and 32-4368.
DT - J (JOURNAL ARTICLE)
LA - eng
IT - frost heave; analysis (mathematics); ice lenses; ice formation; soil moisture; soil freezing; heat transfer
AB - A new concept of the freezing of water, called segregation freezing, is proposed to explain the creation of the suction force that draws pore water up to the interface of a growing ice lens. The temperature of segregation freezing is shown to be lower than that of normal freezing (in situ freezing). This difference determines the pressure that the ice lens exerts while growing and carrying the overlying weight. On the assumption that the soil structure is rigid, equations governing the simultaneous flow of heat and water are formulated and solved for the limit of time t to 0 with the combination of analytical and numerical methods. Numerical computation of the solution yields a result that is reasonable, compared with experience in laboratory and nature.

-43-

AN - 33002078
TI - Chilled pipeline frost heave mitigation concepts
AU - Davison, B.E.; Nottingham, D.; Rooney, J.W.; Vita, C.L.
SO - ASCE Pipeline Division Specialty Conference, New Orleans, Louisiana, Jan. 15-17, 1978. Proceedings. Pipelines in adverse environments a state of the art, Vol.1, p.294-306, 8 refs., New York, N.Y., American Society of Civil Engineers, 1979
DT - FA (PAPER)
LA - eng
IT - frost heave; counter-measures; cold weather construction; gas pipelines; subsurface structures; permafrost thermal properties; permafrost preservation; freeze thaw cycles; frozen ground physics

-44-

AN - 33002070
TI - Pipelines in adverse environments; a state of the art, Vol.1
[American Society of Civil Engineers Pipeline Division Speciality
Conference, New Orleans, Louisiana, Jan. 15-17, 1978]
SO - 394p., Refs. passim. For selected papers see 33-2071 through
33-2080., New York, N.Y., American Society of Civil Engineers,
1979
DT - MON (MONOGRAPH)
LA - eng
IT - remote sensing; design; blasting; pipelines; cold weather
construction; subsurface structures; permafrost structure;
permafrost heat properties; frost heave

-45-

AN - 33001940
TI - Stress-strain fields in freezing ground
OTI - Kharakter napriazhenii v promerzaiushchikh gruntakh
AU - Ershov, E.D.; Shevchenko, L.V.; Gorbacheva, I.V.
SO - Merzlotnye issledovaniia, 1978-Vol.17, p.216-226, In Russian. 9
refs.
DT - J (JOURNAL ARTICLE)
LA - rus
IT - measuring instruments; laboratory techniques; test equipment;
soil freezing; frost penetration; soil moisture migration; phase
transformations; frost heave; deformation

-46-

AN - 33001813
TI - Laboratory technique for determining frost heave coefficients of
clayey grounds
OTI - K metodike laboratornogo opredeleniia koeffitsienta moroznogo
pucheniia glinistykh gruntov
AU - Karlov, V.D.
SO - Nauchnyi seminar: Metodika inzhenerno-geologicheskikh
issledovaniil i kartirovaniia oblasti vechnoi merzloty, Yakutsk,
1977. Tezisy dokladov. Vyp.3 (Seminar on methods of
engineering-geological investigations and mapping in permafrost
areas, Yakutsk, 1977. Abstracts of papers. Vol.3), p.119-120,
In Russian., Yakutskoe knizhnoe izdatel'stvo, 1977
DT - PA (PAPER)
LA - rus
IT - clay soils; frozen fines; frost heave; soil tests; laboratory
techniques

636

636

DFFE

-47-

- AN - 33001E12
 TI - Laboratory technique of determining frost heave characteristics of grounds
 OTI - Laboratornyi sposob opredeleniia puchiniistykh svoistv gruntov
 AU - Ganeles, L.B.; Lapshin, V.IA.
 SO - Nauchnyi seminar: Metodika inzhenerno-geologicheskikh issledovaniy i kartirovaniia oblasti vechnoi merzloty, Yakutsk, 1977. Tezisy dokladov. Vyp.3 (Seminar on methods of engineering-geological investigations and mapping in permafrost areas, Yakutsk, 1977. Abstracts of papers. Vol.3), p.114-116, In Russian., Yakutskoe knizhnoe izdatel'stvo, 1977
 DT - PA (PAPER)
 LA - rus
 IT - laboratory techniques; soil freezing; frost penetration; frost heave; soil tests

-48-

- AN - 330018:1
 TI - Spring and summer frost heave of active layers along the Arctic shores
 OTI - O pucheni i v vesenne-letnii period gruntov sezonnootvalivushchego sloia Arkticheskogo poberezh'ia
 AU - Sheikin, I.V.; Grishin, P.A.; Nikitin, I.U.A.
 SO - Nauchnyi seminar: Metodika inzhenerno-geologicheskikh issledovaniy i kartirovaniia oblasti vechnoi merzloty, Yakutsk, 1977. Tezisy dokladov. Vyp.3 (Seminar on methods of engineering-geological investigations and mapping in permafrost areas, Yakutsk, 1977. Abstracts of papers. Vol.3), p.112-114, In Russian., Yakutskoe knizhnoe izdatel'stvo, 1977
 DT - PA (PAPER)
 LA - rus
 IT - buildings; foundations; permafrost beneath structures; frost heave; tundra soils; active layer

-49-

- AN - 33001688
 TI - Theory of frost heaving
 AU - Deriagin, B.V.; Churaev, N.V.
 SO - Journal of colloid and interface science, Dec. 1978-67(3), p.391-396, 18 refs.
 DT - J (JOURNAL ARTICLE)
 LA - eng
 IT - frost heave; ground ice; ice heat flux; supercooling

637

DFFE

-50-

- AN - 33000965
TI - Bases and foundations on permafrost
OTI - Osnovaniia i fundamenti na vechnomerzlykh gruntakh
OS - Russia. Gosudarstvennyi komitet po delam stroitel'stva
SO - Stroitel'nye normy i pravila. Chast' 2. Normy proektirovaniia, Gl. 18, 46p., In Russian with English table of contents enclosed., Moscow, Stroizdat, 1977
DT - MON (MONOGRAPH)
LA - rus
IT - permafrost beneath structures; permafrost bases; foundations; permafrost control; ground ice; frost heave; settlement (structural); seasonal freeze thaw; saline soils; peat

-51-

- AN - 33000924
TI - Water redistribution in partially frozen, saturated silt under several temperature gradients and overburden loads
AU - Loch, J.P.G.; Kay, B.D.
SO - Soil Science Society of America. Journal, May-June 1978-42(3), p.400-406, 17 refs.
DT - J (JOURNAL ARTICLE)
LA - eng
IT - soil moisture migration; frozen ground mechanics; frost heave; ice lenses; soil pressure

-52-

- AN - 33000769
TI - Periglacial processes
AU - King, C.A.M., ED
SO - Benchmark papers in geology, No.27, 459p., Consists of reprints and reviews of articles. Refs. passim., Stroudsburg, Pa., Dowden, Hutchinson and Ross, 1976
DT - MON (MONOGRAPH)
LA - eng
IT - wind factors; periglacial processes; frost heave; ice wedges; patterned ground; permafrost weathering; avalanche erosion

-53-

- AN - 33000590
TI - Frost heave design of a chilled gas pipeline
AU - Hwang, C.T.
SO - Canadian Geotechnical Conference. Proceedings, Oct. 1977-30th, p.V/59-V/88, 23 refs.
DT - PA (PAPER)
LA - eng
IT - gas pipelines; subsurface structures; frost heave; models; soil mechanics

638

-54-

AN - 33000575
TI - Calculating temperature of the surface layer of freezing ground
OTI - Opredeľenie temperatury poverkhnostnogo sloia promerzaiushchego grunta
AU - Figarov, N.G.; Tsurikov, A.S.
SO - Stroitel'stvo truboprovodov, July 1978-No.7, p.28-29, in Russian. 4 refs.
DT - J (JOURNAL ARTICLE)
LA - rus
IT - active layer; pipelines; permafrost beneath structures; heat transfer; cryogenic processes; frost heave; ground thawing; freeze thaw cycles; frost penetration; stefan problem

-55-

AN - 33000493
TI - Frost resistant stabilization of frost susceptible gravel and sand mixtures
OTI - Frostbeständige Verfestigung frostempfindlicher Kies-Sand-Gemische
AU - Jessberger, H.L.; Ebel, W.
SO - 150p. + 300p. appends., in German. 23 refs., Bochum, West Germany, Ruhr University, 1977
DT - R (REPORT)
LA - ger
IT - soil freezing; soil strength; soil moisture; freeze thaw cycles; frozen sand; frozen gravel; frost heave; frost resistance

-56-

AN - 33000470
TI - Documentation and processing of data on cryogenic structure of hard rocks
OTI - Metodika dokumentatsii i obrabotki fakticheskogo materiala po krigennomu stroeniiu skal'nykh porod
AU - Krivonogova, N.F.; Bratishcheva, N.G.
SO - Moscow. Vsesoiuznyi proektno-izyskatel'skii i nauchno-issledovatel'skii institut "Gidroproekt". Trudy Lengidroproekta, 1976-No.51, p.20-31, in Russian. 3 refs.
DT - PA (PAPER)
LA - rus
IT - data processing; permafrost structure; ground ice; cryogenic structures; cryogenic textures; frost heave; frost shattering

639

639

DFFE

-57-

AN - 33000350
TI - Arctic pipeline construction in the Soviet Union--Part 1
AU - Ivantsov, O.M.
SO - Pipeline and gas journal, Sep. 1978-205(11), p.48-52, 56, 58
DT - J (JOURNAL ARTICLE)
LA - eng
IT - pipe laying; gas pipelines; construction; frost heave; heat transfer; soil moisture migration

-58-

AN - 33000346
TI - Outdoor-laboratory soil freezing experiments
AU - Jumikis, A.R.
SO - International Symposium on Frost Action in Soils, Lulea, Sweden, Feb. 1977. Proceedings, Vol.2, p.110-119, University of Lulea, 1977
DT - PA (PAPER)
LA - eng
IT - subgrade soils; cold weather performance; freeze thaw cycles; frost heave

-59-

AN - 33000345
TI - Mathematical model to predict frost heave
AU - Berg, R.L.; Gartner, K.E.; Guymon, G.L.
SO - International Symposium on Frost Action in Soils, Lulea, Sweden, Feb. 1977. Proceedings, Vol.2, REPT. NO. MP 1131, p.92-109, 14 refs., University of Lulea, 1977
DT - PA (PAPER)
LA - eng
IT - mathematical models; soil moisture migration; heat transfer; frost heave; frost penetration
AB - A mathematical model of coupled heat and moisture flow in soils has been developed. The model includes algorithms for phase change of soil moisture and frost heave, and several types of boundary and initial conditions are permitted. The finite element method of weighted residuals (Galerkin procedure) was chosen to simulate the spatial regime and the Crank-Nicolson method was used for the time domain portion of the model. Comparison of simulated and experimental data illustrates the importance of unsaturated hydraulic conductivity. It is one parameter which is difficult to measure and for which only a few laboratory test results are available. Therefore, unsaturated hydraulic conductivities calculated in the computer model may be a significant source of error in calculations of frost heave.

DFFE

-60-

AN - 33000343
TI - Lens initiation in secondary heaving
AU - Miller, R.D.
SO - International Symposium on Frost Action in Soils, Lulea, Sweden,
Feb. 1977. Proceedings, Vol.2, p.68-74, 13 refs., University of
Lulea, 1977
DT - PA (PAPER)
LA - eng
IT - ice lenses; ice formation; frost heave; mathematical models

-61-

AN - 33000342
TI - Mechanical analogy of a constant heave rate
AU - Ueda, T.; Penner, E.
SO - International Symposium on Frost Action in Soils, Lulea, Sweden,
Feb. 1977. Proceedings, Vol.2, p.57-67, 2 refs., University of
Lulea, 1977
DT - PA (PAPER)
LA - eng
IT - frost heave; soil moisture migration; mathematical models

-62-

AN - 33000341
TI - Fundamental aspects of frost action
AU - Penner, E.
SO - International Symposium on Frost Action in Soils, Lulea, Sweden,
Feb. 1977. Proceedings, Vol.2, p.17-28, 35 refs., University of
Lulea, 1977
DT - PA (PAPER)
LA - eng
IT - mathematical models; ice formation; frozen ground mechanics;
frost heave; ice lenses

-63-

AN - 33000339
TI - Proceedings, Vol.2 [International Symposium on Frost Action in
Soils, Lulea, Sweden, Feb. 1977]
SO - 119p., Includes discussions. For individual papers see 33-340
through 33-346., University of Lulea, 1977
DT - MON (MONOGRAPH)
LA - eng
IT - meetings; frost action; frozen ground mechanics; soil moisture
migration; frost heave

641

-64-

AN - 33000291
TI - Predicting frost heaving susceptibility of Arizona soils
AU - Heidmann, L.J.
SO - U.S. Rocky Mountain Forest and Range Experiment Station, Fort Collins, Colorado. U.S. Forest Service research note, Aug. 1975-RM-295, 7p., 17 refs.
DT - R (REPORT)
LA - eng
IT - analysis (mathematics); frost heave; forecasting; forest soils

-65-

AN - 33000290
TI - Effect of bulk density on frost heaving of six soils in Arizona
AU - Heidmann, L.J.; Thorud, D.B.
SO - U.S. Rocky Mountain Forest and Range Experiment Station, Fort Collins, Colorado. U.S. Forest Service research note, July 1975-RM-293, 4p., 8 refs.
DT - R (REPORT)
LA - eng
IT - tests; frost heave; density (mass/volume); soil physics

-66-

AN - 33000273
TI - Experimental studies of the effect of pressure of the mechanism of the frost heave and the growth-melt relationship of ice in the ground and in glaciers
AU - Radd, F.J.; Ortle, D.H.
SO - International Conference on Permafrost, 2nd, Yakutsk, July 13-18, 1973. Proceedings. Edited by F.J. Sanger and P.J. Hyde, p.827-833, Washington, D.C., National Academy of Sciences, 1978
DT - PA (PAPER)
LA - eng, rus
IT - ground ice; glacier ice; ice growth; ice melting; frozen fines; frost penetration; frost heave; ice lenses; ice formation

-67-

AN - 33000254
TI - Cryogenic phenomena in earthen hydroengineering structures
AU - Kronik, I.A.
SO - International Conference on Permafrost, 2nd, Yakutsk, July 13-18, 1973. Proceedings. Edited by F.J. Sanger and P.J. Hyde, p.668-670, For Russian original see 28-1193. 7 refs., Washington, D.C., National Academy of Sciences, 1978
DT - PA (PAPER)
LA - eng, rus
IT - earth dams; cryogenic processes; frost heave; ice melting; frost shattering; solifluction; naleds

-68-

AN - 33000248
TI - Values of the tangential stresses of ground heave
AU - Kiselev, M.F.
SO - International Conference on Permafrost, 2nd, Yakutsk, July 13-28, 1973. Proceedings. Edited by F.J. Sanger and P.J. Hyde, p.653-655, For Russian original see 28-1187., Washington, D.C., National Academy of Sciences, 1978
DT - PA (PAPER)
LA - eng, rus
IT - design; stresses; cryogenic processes; frost heave; foundations

-69-

AN - 33000223
TI - Study of the interaction of heaving ground with individual foundations
AU - Peretrukhin, N.A.; Dubnov, I.U.D.; Merenkov, N.D.
SO - International Conference on Permafrost, 2nd, Yakutsk, July 13-18, 1973. Proceedings. Edited by F.J. Sanger and P.J. Hyde, p.577-580, For Russian original see 28-1168. 7 refs., Washington, D.C., National Academy of Sciences, 1978
DT - PA (PAPER)
LA - eng, rus
IT - laboratory techniques; foundations; permafrost beneath structures; frost heave; soil moisture migration; models

-70-

AN - 33000228
TI - Interaction of freezing heaving ground with foundations
AU - Dalmatov, B.I.
SO - International Conference on Permafrost, 2nd, Yakutsk, July 13-18, 1973. Proceedings. Edited by F.J. Sanger and P.J. Hyde, p.572-575, For Russian original see 28-1167. 9 refs., Washington, D.C., National Academy of Sciences, 1978
DT - PA (PAPER)
LA - eng, rus
IT - frozen fines; clays; frost heave; permafrost beneath structures; foundations

-71-

AN - 33000217
TI - Engineering-geocryological conditions and principles of construction in Magadan oblast
AU - Gol'dtman, V.G.
SO - International Conference on Permafrost, 2nd, Yakutsk, July 13-18, 1973. Proceedings. Edited by F.J. Sanger and P.J. Hyde, p.515-516, For Russian original see 28-1156. 7 refs., Washington, D.C., National Academy of Sciences, 1978

DT - PA (PAPER)
LA - eng, rus
IT - permafrost distribution; lithology; alluvium; frost heave; ground thawing; settlement (structural)

-72-

AN - 33000151
TI - Effect of freezing and thawing on the structure, composition and properties of cohesive soils
AU - Tiutiunov, I.A.; Averochkina, M.V.; Titov, V.P.
SO - International Conference on Permafrost, 2nd, Yakutsk, July 13-28, 1973. Proceedings. Edited by F.J. Sanger and P.J. Hyde, p.277-280. For Russian original see 28-1090. 6 refs., Washington, D.C., National Academy of Sciences, 1978
DT - PA (PAPER)
LA - eng, rus
IT - frozen fines; ground thawing; loess; bearing strength; cryogenic processes; soil formation; clay minerals; frost heave; soil moisture migration; ground ice; ice growth

-73-

AN - 33000148
TI - Some heave laws of freezing soils
AU - Orlov, V.O.
SO - International Conference on Permafrost, 2nd, Yakutsk, July 13-28, 1973. Proceedings. Edited by F.J. Sanger and P.J. Hyde, p.269-271. For Russian original see 28-1087. 2 refs., Washington, D.C., National Academy of Sciences, 1978
DT - PA (PAPER)
LA - eng, rus
IT - cryogenic processes; frost heave; frozen fines; soil moisture migration; phase transformations; ground ice; ice growth

-74-

AN - 33000145
TI - Effect of coagulators on the magnitude of frost heave of Far Eastern supesses and suglinoks
AU - Voroshilov, G.D.
SO - International Conference on Permafrost, 2nd, Yakutsk, July 13-28, 1973. Proceedings. Edited by F.J. Sanger and P.J. Hyde, p.261-264. For Russian original see 28-1084., Washington, D.C., National Academy of Sciences, 1978
DT - PA (PAPER)
LA - eng, rus
IT - clay soils; lcams; frost penetration; frost heave; soil moisture migration; flow control; coagulation

644

DFFE

-75-

AN - 33000137
 TI - Mechanism of formation of lenslike ice in streams and soils
 AU - Utkin, B.V.
 SO - International Conference on Permafrost, 2nd, Yakutsk, July 13-28, 1973. Proceedings. Edited by F.J. Sanger and P.J. Hyde, p.212-213, For Russian original see 28-1076., Washington, D.C., National Academy of Sciences, 1978
 DT - FA (PAPER)
 LA - eng, rus
 IT - ice lenses; pingos; ice growth; alimentation; frozen fines; frost heave; thixotropy

-76-

AN - 33000087
 TI - Investigation with the help of an electronic digital computer of cryogenous structure and heave of freezing fine-grained soils
 AU - Melamed, V.G.; Medvedev, A.V.
 SO - International Conference on Permafrost, 2nd, Yakutsk, July 13-13, 1973. Proceedings. Edited by F.J. Sanger and P.J. Hyde, p.47-49, For Russian original see 28-1026., Washington, D.C., National Academy of Sciences, 1978
 DT - FA (PAPER)
 LA - eng, rus
 IT - frozen fines; frost penetration; ground ice; ice growth; frost heave; computer applications

-77-

AN - 33000084
 TI - Water migration in soil during frost heaving
 AU - Kinoshita, S.
 SO - International Conference on Permafrost, 2nd, Yakutsk, July 13-28, 1973. Proceedings. Edited by F.J. Sanger and P.J. Hyde, p.40-43, For Russian original see 28-1023. 2 refs., Washington, D.C., National Academy of Sciences, 1978
 DT - PA (PAPER)
 LA - eng, rus
 IT - frost heave; ice lenses; ice growth; soil moisture migration

-78-

AN - 33000074
 TI - USSR Contribution. Permafrost: Second International Conference, July 13-28, 1973 [International Conference on Permafrost, 2nd, Yakutsk, July 13-28, 1973]
 AU - Sanger, F.J., ED; Hyde, P.J., ED
 SO - 866p., For Russian originals see 28-1014 through 28-1198. Refs. passim., Washington, D.C., National Academy of Sciences, 1978
 DT - MON (MONOGRAPH)

LA - eng, rus
IT - meetings; permafrost origin; permafrost thermal cycles; active layer; frozen ground mechanics; frozen ground chemistry; frost heave; frozen fines; ground ice; heat balance; phase transformations; soil moisture migration; permafrost hydrology

-79-

AN - 33000045
TI - Advances in frost heave prediction and mitigation methods for pipeline application
AU - Hwang, C.T.; Yip, F.C.
SO - American Society of Mechanical Engineers. Publication, Dec. 1977-77-WA/HT-19, 11p., Presented at the Winter Annual Meeting, Atlanta, Georgia, Nov. 27-Dec. 2, 1977. 24 refs.
DT - PA (PAPER)
LA - eng
IT - design; frost heave; frost forecasting; pipeline insulation; gas pipelines; soil freezing; soil moisture migration

-80-

AN - 32004657
TI - Approximate evaluation of movement velocities in rock streams
OTI - Priblizhennaya otsenka skorosti dvizheniya kurumov
AU - Kudriavtsev, V.A.; Tiurin, A.I.; Melent'ev, V.S.
SO - Moscow. Universitet. Vestnik. Seriya 4 Geologiya, Mar.-Apr. 1978-No.2, p.114-118, In Russian. 6 refs.
DT - J (JOURNAL ARTICLE)
LA - rus
IT - flow rate; analysis (mathematics); slope processes; rock streams; freeze thaw cycles; frost heave

-81-

AN - 32004642
TI - It is necessary to allow for geocryological processes in the design and construction of quarries in permafrost areas
OTI - Pri stroitel'stve i proektirovanii kar'erov v usloviakh vечноi mёрзлоты neobkhodimo uchityvat' geokriologicheskie protsessy
AU - Pechenin, I.U.I.
SO - Shakhtnoe stroitel'stvo, Dec. 1977-No.12, p.15-18, In Russian.
DT - J (JOURNAL ARTICLE)
LA - rus
IT - mining; quarries; permafrost structure; slope stability; frost heave; ground ice; permafrost hydrology

646

-82-

AN - 32004504
TI - Frost heaved boulders at the surface of salt tidal marshes, east coast of James Bay, Quebec
OTI - Blocs soulevés par le froid dans les schorres de la baie de James, Quebec
AU - Diorne, J.-C.
SO - Revue de géographie de Montreal, 1975-29(2), p.161-166, In French with English summary. 38 refs.
DT - J (JOURNAL ARTICLE)
LA - fre, eng
IT - permafrost physics; soil mechanics; temperature effects; frost heave; periglacial processes; rocks; swamps; freeze thaw cycles; ice lenses

-83-

AN - 32004378
TI - Principles of mechanics of frozen ground
AU - Tsytoich, N.A.; Sumgin, M.I.
SO - U.S. Army Cold Regions Research and Engineering Laboratory (SIPRE), REPT. NO. SIPRE TL 19, Apr. 1959, 288p., For Russian original see SIP 885.
DT - R (REPORT)
LA - eng, rus
IT - loads (forces); frozen ground analysis; permafrost physics; permafrost beneath structures; frost heave; soil moisture migration

-84-

AN - 32004368
TI - Segregation freezing as the cause of suction force for ice lens formation.
AU - Takagi, S.
SO - U.S. Army Cold Regions Research and Engineering Laboratory, REPT. NO. CR 78-06, Apr. 1978, 12p., 38 refs. For another version see 32-3470.
DT - R (REPORT)
LA - eng
IT - mathematical models; frozen ground thermodynamics; ice lenses; ice formation; soil freezing; ground ice; frost heave; soil mechanics

DFFE

-85-

AN - 32004189
TI - Frost heaving rate of silty soils as a function of pore size distribution
AU - Reed, M.A.
SO - 116p., M.S. thesis. Refs. p.100-104., Lafayette, Ind., Purdue University, Aug. 1977
DT - MON (MONOGRAPH)
LA - eng
IT - soil compacting; soil tests; sediments; frost heave; soil freezing; soil texture; porosity

-86-

AN - 32004151
TI - Perennially frozen rock bases of structures
OTI - Mnogoletnemerznye skal'nye osnovaniia sooruzhenii
AU - Kagan, A.A.; Krivonogova, N.F.
SO - 208p., In Russian with English table of contents enclosed. 123 refs., Leningrad, Stroizdat, 1978
DT - MON (MONOGRAPH)
LA - rus
IT - bearing strength; compressive strength; shear strength; tests; permafrost bases; ground ice; permafrost structure; ice structure; frost heave; permafrost thermal properties; frost shattering

-87-

AN - 32004139
TI - Forecasting thermal regime of ground and the development of cryogenic processes
OTI - Prognoz temperaturnogo rezhima gruntov i razvitiia kriogennykh protsessov
AU - Fel'dman, G.M.
SO - 191p., In Russian with English table of contents enclosed. Refs. p.185-190., Novosibirsk, Nauka, 1977
DT - MON (MONOGRAPH)
LA - rus
IT - permafrost forecasting; permafrost thermal properties; frost heave; permafrost hydrology; penetration; moisture transfer

-88-

AN - 32004132
TI - Peculiarities of frost heave manifestation in northern West Siberia
OTI - Osobennosti proiavleniia protsessov puchinoobrazovaniia na severe Zapadnoi Sibiri
AU - Nevecheria, V.L.
SO - Moscow. Vsesoiuznyi nauchno-issledovatel'skii institut

DFFE

gidrogeologii i inzhenernoi geologii. Trudy, 1975-Vol.87,
p.110-116, In Russian. 2 refs.

DT - J (JOURNAL ARTICLE)
LA - rus
IT - active layer; frost heave; seasonal freeze thaw; frost penetration

-89-

AN - 32004123
TI - Method of quick determination of the magnitude and intensity of
heaving during freezing of soils
OTI - K metodike uskorenogo opredeleniya velichiny i intensivnosti
pucheniya gruntov pri promerzani
AU - Nevecheria, V.L.; Kazanskii, O.A.
SO - Moscow. Vsesoluznyi nauchno-issledovatel'skii institut
gidrogeologii i inzhenernoi geologii. Trudy, 1975-Vol.87,
p.14-20, In Russian. 4 refs.
DT - J (JOURNAL ARTICLE)
LA - rus
IT - soil freezing; frost penetration; frost heave; soil moisture
migration; ice formation; ground ice

-90-

AN - 32004041
TI - Foundations for an open skating track with artificially frozen ice
AU - Shutov, M.A.
SO - Soil mechanics and foundation engineering, Nov.-Dec. 1977-14(6),
p.369-370, Translated from Osnovaniya, fundamenty i mekhanika
gruntov.
DT - J (JOURNAL ARTICLE)
LA - eng, rus
IT - foundations; ice rinks; soil freezing; frost heave; artificial ice

-91-

AN - 32003938
TI - Frost heaves a consideration
SO - Oilweek, Apr. 17, 1978-25(10), p.2G, 22
DT - J (JOURNAL ARTICLE)
LA - eng
IT - meetings; frost heave; pipelines

649

DFFE

-92-

- AN - 32003793
TI - Field test results of a chilled pipeline buried in unfrozen ground
AU - Slusarchuk, W.A.
SO - International Conference on Permafrost, 3rd, Edmonton, Alberta, Canada, July 10-13, 1978. Proceedings. Vol.1, p.877-883, With Russian and French summaries. 3 refs., Ottawa, National Research Council of Canada, 1978
DT - PA (PAPER)
LA - eng, rus, fre
IT - design; gas pipelines; frost penetration; frost heave; liquefied gases; heat transfer
ST - Unfrozen ground

-93-

- AN - 32003775
TI - Soil deformation resulting from some laboratory freeze-thaw experiments
AU - Washburn, A.L.; Burrous, C.; Rein, R.
SO - International Conference on Permafrost, 3rd, Edmonton, Alberta, Canada, July 10-13, 1978. Proceedings. Vol.1, p.756-762, With Russian and French summaries. 4 refs., Ottawa, National Research Council of Canada, 1978
DT - PA (PAPER)
LA - eng, rus, fre
IT - tests; soil freezing; freeze thaw cycles; frost heave; frozen fines

-94-

- AN - 32003772
TI - Effect of penetration rate of freezing and confining stress on the frost heave ratio of soils
AU - Takashi, T.; Yamamoto, H.; Ohrai, T.; Masuda, M.
SO - International Conference on Permafrost, 3rd, Edmonton, Alberta, Canada, July 10-13, 1978. Proceedings. Vol.1, p.736-742, With Russian and French summaries. 12 refs., Ottawa, National Research Council of Canada, 1978
DT - PA (PAPER)
LA - eng, rus, fre
IT - models; soil freezing; frost penetration; freezing rate; frost heave; soil moisture migration

650

DFFE

-95-

- AN - 32003770
TI - Soil frost susceptibility test and a basis for interpreting heaving rates
AU - Penner, E.; Ueda, T.
SO - International Conference on Permafrost, 3rd, Edmonton, Alberta, Canada, July 10-13, 1978. Proceedings. Vol.1, p.721-727. With Russian and French summaries. 13 refs., Ottawa, National Research Council of Canada, 1978
DT - PA (PAPER)
LA - eng, rus, fre
IT - tests; laboratory techniques; soil freezing; frost penetration; frost heave; soil moisture migration

-96-

- AN - 32003768
TI - Frost heaving in non-colloidal soils
AU - Miller, F.D.
SO - International Conference on Permafrost, 3rd, Edmonton, Alberta, Canada, July 10-13, 1978. Proceedings. Vol.1, p.708-713. With Russian and French summaries. 11 refs., Ottawa, National Research Council of Canada, 1978
DT - PA (PAPER)
LA - eng, rus, fre
IT - frost heave; mathematical models; heat transfer; frost penetration; ground ice; ice lenses; ice formation

-97-

- AN - 32003763
TI - Observations of frost heaving action in the experimental site, Tomakomai, Japan
AU - Kinoshita, S.; Suzuki, Y.; Horiguchi, K.; Fukuda, M.
SO - International Conference on Permafrost, 3rd, Edmonton, Alberta, Canada, July 10-13, 1978. Proceedings. Vol.1, p.675-678. With Russian and French summaries. 4 refs., Ottawa, National Research Council of Canada, 1978
DT - PA (PAPER)
LA - eng, rus, fre
IT - analysis (mathematics); soil freezing; frost penetration; soil moisture migration; frost heave

OFFE

-98-

- AN - 32003733
 TI - Terrain-forming processes in the permafrost region and the principles of their prevention and limitation in territories under development
 DTI - Rel'efoobrazulushchie protsessy oblasti vechnoi merzloty i printsipy ikh preduprezhdeniya i ogranicheniya na osvalvaemykh territoriyakh
 AU - Grave, N.A.; Sukhodrovskii, V.L.
 SO - International Conference on Permafrost, 3rd, Edmonton, Alberta, Canada, July 10-13, 1978. Proceedings. Vol.1, p.467-472, In Russian with English and French summaries. 22 refs., Ottawa, National Research Council of Canada, 1978
 DT - PA (PAPER)
 LA - rus, eng, fre
 IT - cryogenic relief; solifluction; cryogenic processes; frost weathering; frost heave; thermokarst; permafrost transformation; human factors

-99-

- AN - 32003505
 TI - Arctic gas pipeline soon a reality
 AU - Mirosh, E.A.
 SO - Engineering Journal, Jan. 1978-61(1), p.25-28, 3 refs.
 DT - J (JOURNAL ARTICLE)
 LA - eng
 IT - natural gas; gas pipelines; frost heave; cracking (fracturing)

-100-

- AN - 32003470
 TI - Segregation freezing as the cause of suction force for ice lens formation
 AU - Takagi, S.
 SO - International Symposium on Ground Freezing, 1st, Bochum, Germany, March 8-10, 1978. Proceedings. Edited by H.L. Jessberger, REPT. NO. MP 1081, p.45-51, 20 refs., Bochum, Ruhr University, 1978
 DT - PA (PAPER)
 LA - eng
 IT - soil structure; soil pressure; analysis (mathematics); soil freezing; ground ice; ice lenses; soil moisture migration; frost heave; frozen ground thermodynamics
 AB - A new freezing mechanism, called segregation freezing, is proposed to explain the generation of the suction force that draws pore water up to the freezing surface of a growing ice lens. The segregation freezing temperature is derived by applying thermodynamics to a soil mechanics concept that distinguishes the mechanically effective pressure from the mechanically neutral pressure. The frost-heaving procedure is formulated as part of the solution of the differential equations of the simultaneous flow of heat and water, of which the

segregation freezing temperature is one of the boundary conditions.

-101-

AN - 32003468
TI - Effects of the rate of heat removal on the rate of frost heaving
AU - Horiguchi, K.
SO - International Symposium on Ground Freezing, 1st, Bochum, Germany, March 8-10, 1978. Proceedings. Edited by H.L. Jessberger, p.25-30, 11 refs., Bochum, Ruhr University, 1978
DT - PA (PAPER)
LA - eng
IT - soil texture; frost heave; soil moisture; freezing rate; freeze thaw tests; heat flux

-102-

AN - 32003467
TI - Research of the frost heave of non-water-saturated loamy soil in field conditions
AU - Karlov, V.D.
SO - International Symposium on Ground Freezing, 1st, Bochum, Germany, March 8-10, 1978. Proceedings. Edited by H.L. Jessberger, p.13-23, 3 refs., Bochum, Ruhr University, 1978
DT - PA (PAPER)
LA - eng
IT - mechanical tests; frost heave; soil moisture migration; loams; saturation; soil freezing; soil mechanics; foundations; dislocations (materials)

-103-

AN - 32003466
TI - Effects of initial soil-water conditions on frost heaving characters
AU - Kenoshita, S.
SO - International Symposium on Ground Freezing, 1st, Bochum, Germany, March 8-10, 1978. Proceedings. Edited by H.L. Jessberger, p.3-11, 5 refs., Bochum, Ruhr University, 1978
DT - PA (PAPER)
LA - eng
IT - ice lenses; drill core analysis; unfrozen water content; frost heave; soil moisture migration; water table

DFFE

-104-

AN - 32003462
TI - Heat flux measurement in freezing soils
AU - Fukuda, M.
SO - Low temperature science (Teton kagaku). Series A Physical sciences, 1977-Vol.35, p.329-332, In Japanese. 5 refs.
DT - J (JOURNAL ARTICLE)
LA - jap
IT - soil freezing; heat transfer; frost heave; frozen ground temperature

-105-

AN - 32003459
TI - Frost heave in Tomakomai (1976-1977)
AU - Kinoshita, S.; Suzuki, Y.; Horiguchi, K.; Fukuda, M.; Inoue, M.; Takeda, K.
SO - Low temperature science (Teton kagaku). Series A Physical sciences, 1977-Vol.35, p.307-319, In Japanese with English summary. 10 refs.
DT - J (JOURNAL ARTICLE)
LA - jap, eng
IT - soil freezing; indexes (ratios); frost heave; soil moisture

-106-

AN - 32003457
TI - Water migration during soil freezing
AU - Takeda, K.; Suzuki, Y.
SO - Low temperature science (Teton kagaku). Series A Physical sciences, 1977-Vol.35, p.287-293, In Japanese with English summary. 6 refs.
DT - J (JOURNAL ARTICLE)
LA - jap, eng
IT - frost heave; soil freezing; soil moisture migration; water pressure

-107-

AN - 32003154
TI - Cryogenic formations in the eastern part of Tabanda Basin
OTI - Kriogennye obrazovaniia vostochnoi chast' Tabandinskoj vpadiny
AU - An, V.V.
SO - Voprosy geokriologii v trudakh molodykh uchenykh i spetsialistov (Problems of geocryology in the works of young scientists and specialists) edited by I.V. Klimovskii and A.M. Snegirev, p.23-29, In Russian. 5 refs., Yakutsk, Izd. Inst. Merzlotovedeniia SO AN SSSR, 1976
DT - PA (PAPER)
LA - rus
IT - ussr -tabanda river; alpine tundra; tundra soils; tundra

vegetation; continuous permafrost; swamps; frost heave;
thermokarst; patterned ground; ice veins; cryogenic processes

-108-

AN - 32003001
TI - Determining design variables for thermoinsulated pipelines
allowing for environmental preservation requirements
OTI - Obosnovanie parametrov teploizolirovannykh truboprovodov iskhodja
iz trebovaniy okhrany okruzhayushchei sredy
AU - Krivosheina, B.L.; Agapkin, V.M.; Koval'kov, V.P.
SO - Stroitel'stvo truboprovodov, Jan. 1978-No.1, p.28-30, In Russian.
DT - J (JOURNAL ARTICLE)
LA - rus
IT - design; pipelines; liquefied gases; thermal insulation; soil
freezing; frost heave; permafrost beneath structures;
environmental protection

-109-

AN - 32002910
TI - Qualitative rates of frost heaving in gneissic bedrock on
southeastern Baffin Island, District of Franklin
AU - Dyke, A.S.
SO - Canada. Geological Survey. Paper, 1978-No.78-1A, p.501-502, 1
ref.
DT - R (REPORT)
LA - eng
IT - frost heave; moraines; frost weathering

-110-

AN - 32002795
TI - LR90 frost heave test--interim specification for use with
granular materials
SO - Transport and Road Research Laboratory. Supplementary report.
1977-No.318, 12p. + 5 figs., 4 refs.
DT - R (REPORT)
LA - eng
IT - frost heave; frost resistance; laboratory techniques

-111-

AN - 32002755
TI - Attenuation of frost action: selected problems
AU - Pyskadlo, R.M.
SO - New York (State). Department of Transportation. Research
report, Jan. 1977-NYSDOT-ERD-77-RR 39, 48p., Refs. p.45-43.
DT - R (REPORT)
LA - eng
IT - frost heave; culverts; thermal insulation

DFFE

-112-

AN - 32002520
TI - Construction of houses on fills
OTI - Vozvedenie zdaniy na podsypkakh
AU - Tishin, V.G.; Agibaeva, T.V.; Tsygonskii, G.L.
SO - Lesnaya promyshlennost', 1977-No.8, p.26, In Russian.
DT - J (JOURNAL ARTICLE)
LA - rus
IT - construction costs; houses; foundations; earth fills; frost heave

-113-

AN - 32002320
TI - Improving the norms for roadbed heights in sections with a high ground water level
OTI - Utochnenie norm vozvysheniya zemliannogo polotna avtomobil'nykh dorog na uchastkakh s blizkim zaleganiem gruntovykh vod
AU - Lukina, V.A.; Gur'ev, T.A.; Bondarevskii, V.I.
SO - Russia. Ministerstvo vysshego i srednego spetsial'nogo obrazovaniya. Izvestiya vysshikh uchebnykh zavedeniy. Stroitel'stvo i arkhitektura, 1977-No.11, p.159-162, In Russian.
DT - J (JOURNAL ARTICLE)
LA - rus
IT - roadbeds; seasonal freeze thaw; ground water; frost penetration; frost heave

-114-

AN - 32002309
TI - Frost heave and its effect on building foundations
OTI - Puchenie promerzaiushchikh gruntov i ego vliyanie na fundamenty sooruzhenii
AU - Orlov, V.O.; Eubnov, I.U.D.; Merenkov, N.D.
SO - 183p., In Russian with English table of contents enclosed. 195 refs., Leningrad, Stroizdat, 1977
DT - MON (MONOGRAPH)
LA - rus
IT - buildings; clay soils; frozen fines; design; foundations; frost heave; permafrost beneath structures; soil freezing; frost penetration; soil moisture migration; ground ice

-115-

AN - 32002021
TI - Influence of grain sizes on frost heave of sandy ground
OTI - Vliyanie zernovogo sostava na moroznoe puchenie peschanykh gruntov
AU - Blummer, I.A.I.; Grishin, P.A.
SO - Konstruktsii i fundamenty zdaniy dlia Arktiki (Structures and foundations of buildings for the Arctic) edited by V.V. Dokuchaev, p.49-51, In Russian. 2 refs., Leningrad, Gosgrazhdanstroi, 1974

DFFE

DT - PA (PAPER)
LA - rus
IT - buildings; foundations; permafrost beneath structures; frost heave

-116-

AN - 32002020
TI - Frost heave of fine sands
OTI - Puchinistost' melkikh peskov
AU - Grishin, P.A.; Dokuchaev, V.V.
SO - Konstruktsii i fundamente, zdaniy dlia Arktiki (Structures and foundations of buildings for the Arctic) edited by V.V. Dokuchaev, p.44-48, In Russian. 3 refs., Leningrad, Gosgrazhdanstroi, 1974
DT - PA (PAPER)
LA - rus
IT - buildings; foundations; permafrost beneath structures; frozen fines; frozen sand; frost heave

-117-

AN - 32002014
TI - Evaluation of laboratory suction tests for prediction of heave in foundation soils
AU - Johnson, L.D.
SO - U.S. Army Engineer Waterways Experiment Station, Vicksburg, Miss. Report, Aug. 1977-WES-TR-S-77-7, 118p.
DT - R (REPORT)
LA - eng
IT - forecasting; soil compacting; tests; frost heave; soil mechanics; soil moisture; compressive properties; foundations

-118-

AN - 32001876
TI - Evaluating the stability of foundations built in frost heaving ground, allowing for additional normal pressures.
OTI - Otsenka ustoychivosti fundamentov, zalozhennykh v puchinistykh gruntakh s uchetom dopolnitel'nykh normal'nykh davlenii
AU - Lititskii, V.M.
SO - Geograficheskoe obshchestvo SSSR. Zabaikal'skii filial. Zapiski, 1970-Vol.44, p.29-32, In Russian.
DT - J (JOURNAL ARTICLE)
LA - rus
IT - design; buildings; foundations; frost heave

DFFE

-119-

AN - 32001865
TI - Cable trenches in permafrost
OTI - Kabel'naia kanalizatsiia v vechnomerzlykh gruntakh
AU - Bolichenko, V.I.
SO - 56p., In Russian with English table of contents enclosed. 9
refs., Moscow, Energiia, 1971
DT - MON (MONOGRAPH)
LA - rus
IT - trenching; ground ice; earthwork; frost heave; transmission
lines; power lines; underground cables

-120-

AN - 32001737
TI - Foundation construction problems in Transbaikai
OTI - Problemy fundamentostroeniia v Zabaikal'e
AU - Sal'nikov, P.I.
SO - Geograficheskoe obshchestvo SSSR. Zabaikal'skii filial.
Zapiski, 1969-Vol.29, p.42-52, In Russian. 6 refs.
DT - J (JOURNAL ARTICLE)
LA - rus
IT - foundations; permafrost beneath structures; frost heave;
permafrost hydrology; earthquakes

-121-

AN - 32001732
TI - Construction of buildings and structures on frozen ground
OTI - Stroitel'stvo zdaniil i sooruzhenii na merzlykh gruntakh
OS - Geograficheskoe obshchestvo SSSR. Zabaikal'skii filial
SO - Its Zapiski, Vol.29, 222p., In Russian. For selected papers see
32-1733 through 32-1756. Refs. passim., Chita, 1969
DT - MON (MONOGRAPH)
LA - rus
IT - buildings; foundations; cryogenic processes; frost heave;
permafrost beneath buildings

-122-

AN - 32001639
TI - Computer simulation of freezing soil; development and validation
using experimental data
AU - Sheppard, M.I.
SO - 171p., Ph.D. thesis. Photo copy available from the University of
Guelph., University of Guelph, 1977
DT - MON (MONOGRAPH)
LA - eng
IT - models; computerized simulation; soil temperature; experimental
data; soil freezing; mass balance; heat balance; frost heave;
soil moisture; thermal properties

DFFE

-123-

AN - 32001560
 TI - Increasing the stability of drain pipes by local reinforcement of roadbeds
 OTI - Povyshenie ustoychivosti vodopropusknykh trub posredstvom nestnogo armirovaniia zemliannogo polotna
 AU - Podval'nyi, R.E.; Kaznacheeva, E.F.
 SO - Moscow. Vsesoiuznyi dorozhnyi nauchno-issledovatel'skii institut. Trudy, 1976-Vol.91, p.128-131, In Russian. 2 refs.
 DT - J (JOURNAL ARTICLE)
 LA - rus
 IT - deformation; countermeasures; roadbeds; frost penetration; drainage; pipe laying; frost heave

-124-

AN - 32001559
 TI - Stabilizing weak mineral ground beneath embankments during winter construction
 OTI - Obespechenie ustoychivosti slabykh mineral'nykh gruntov v osnovanii nasypi pri zimnem stroitel'stve
 AU - Ievlev, V.M.
 SO - Moscow. Vsesoiuznyi dorozhnyi nauchno-issledovatel'skii institut. Trudy, 1976-Vol.91, p.125-127, In Russian.
 DT - J (JOURNAL ARTICLE)
 LA - rus
 IT - cold weather construction; embankments; soil compacting; roadbeds; frost heave; fines; sands

-125-

AN - 32001502
 TI - Influence of permeability of unfrozen soil on frost heave
 OTI - Tojō ni oyobosu mitcketsudo nai no dosui teiko no eikyo; tokuni cryoku no chisai bai
 AU - Takashi, T.; Masuda, M.; Yamamoto, H.
 SO - Seppyō, Mar. 1976-38(1). p.1-10, In Japanese with English summary. 3 refs.
 DT - J (JOURNAL ARTICLE)
 LA - jap, eng
 IT - analysis (mathematics); soil moisture migration; frost heave; stresses

659

-126-

- AN - 32001484
TI - Frost heave associated with different cryogenic structures,
allowing for settlement
OTI - Moroznoe puchenie grunta pri razlichnykh kriogennykh teksturakh s
uchetom ego usadki
AU - Shevchenko, L.V.; Lapshin, V.IA.
SO - Merzlotnye issledovaniia, 1977-Vol.16, p.188-194, In Russian. 15
refs.
DT - J (JOURNAL ARTICLE)
LA - rus
IT - low temperature tests; laboratory techniques; permafrost
structure; ground ice; frost heave; settlement (structural);
clays; sampling; frozen fines

-127-

- AN - 32001470
TI - Seasonal heaving and settlement of rocks in the lower course of
the Yenisey River
DTI - Sezonnoe puchenie i osadka porod v nizov'iax r. Enisei
AU - Zamolotchikova, S.A.
SO - Merzlotnye issledovaniia, 1977-Vol.16, p.65-72, In Russian. 11
refs.
DT - J (JOURNAL ARTICLE)
LA - rus
IT - ussr -yenisey river; permafrost beneath rivers; frost heave;
active layer; ground thawing; settlement (structural); frost
penetration; soil moisture migration

-128-

- AN - 32001372
TI - Palsa-type frost mounds
OTI - Pagorki mrozowe typu palsa
AU - Jahn, A.
SO - Towarzystwo Naukowe w Toruniu. Studia. Section C: Geographia et
geologia, 1976-8(4/6), p.123-139, In Polish with English summary.
37 refs.
DT - J (JOURNAL ARTICLE)
LA - pol, eng
IT - frost heave; thermokarst; pingos; discontinuous permafrost;
hummocks
ST - Palsas

DFFE

-129-

AN - 32001127
 TI - Peat deformation under laboratory and field conditions and its statistical analysis
 OTI - Opredelenie deformativnykh svoystv torfa v polevykh i laboratornykh usloviyakh i ikh statisticheskii analiz
 AU - Bronin, V.N.; Tikhomirova, L.K.
 SO - Leningrad. Inzhenerno-stroitel'nyi institut. Nauchnye trudy, 1973-No.78, p.64-67, In Russian. 4 refs.
 DT - J (JOURNAL ARTICLE)
 LA - rus
 IT - compressive strength; test equipment; statistical data; foundations; frost heave; swamps; peat; compacting

-130-

AN - 32001123
 TI - Forecasting soil moisture migration and frost heave
 OTI - K prognozu migratsii vlagi i moroznogo pucheniia gruntov
 AU - Karlov, V.D.
 SO - Leningrad. Inzhenerno-stroitel'nyi institut. Nauchnye trudy, 1973-No.78, p.43-48, In Russian. 5 refs.
 DT - J (JOURNAL ARTICLE)
 LA - rus
 IT - analysis (mathematics); soil freezing; frost penetration; soil moisture migration; frost heave

-131-

AN - 32001117
 TI - Soil mechanics, bases and foundations
 OTI - Mekhanika gruntov, osnovaniia i fundamenty
 AU - Dalmatov, B.I., ED
 SO - Leningrad. Inzhenerno-stroitel'nyi institut. Nauchnye trudy, 1973-No.78, 95p., In Russian. For selected papers see 32-1118 through 32-1128., Leningrad, 1973
 DT - MON (MONOGRAPH)
 LA - rus
 IT - analysis (mathematics); soil mechanics; frozen fines; frost heave; foundations; buildings; ground ice; frost penetration; soil moisture migration

-132-

AN - 32001014
 TI - Frost and glacially deformed bedrock on Somerset Island, Northwest Territories
 AU - Kerr, J.W.
 SO - Canada. Geological Survey. Paper, Oct. 1977-77-10, p.75-77, 3 refs.
 DT - PA (PAPER)

LA - eng
IT - canada -northwest territories -somerset island; frost heave;
geologic structures

-133-

AN - 32001008
TI - Report of activities, part C
OS - Canada. Geological Survey
SO - 115p., For selected individual papers see 32-1009 through
32-1015., Ottawa, 1977
DT - R (REPORT)
LA - eng
IT - percussion drilling; ground ice; frost heave; minerals; shoreline
modification; climate; marine biology

-134-

AN - 32000679
TI - Frost action in soils: theories, criteria, instruments, results
DTI - Frost i jord: teorier, kriterier, udstyr, resultater
AU - Christensen, E.; Palmqvist, K.
SO - Denmark. Tekniske højskole. Institutet for vejbygning,
trafikteknik og byplanlægning. Rapport No.4. Eksamensarbejde,
187p., In Danish. 35 refs., Lyngby, 1976
DT - MON (MONOGRAPH)
LA - dan
IT - measuring instruments; theories; frost action; frost heave; soil
freezing; frozen ground thermodynamics; capillarity

-135-

AN - 32000487
TI - Thermal and mechanical interaction between frozen ground and
engineering structures
DTI - Teplovoe i mekhanicheskoe vzaimodeistvie inzhenernykh sooruzhenii
s merzlymi gruntami
AU - Dubina, M.M.; Krasovitskii, B.A.; Lozovskii, A.S.; Popov, F.S.
SO - 341p., In Russian. 142 refs., Novosibirsk, 1977
DT - MON (MONOGRAPH)
LA - rus
IT - active layer; mathematical models; underground facilities;
permafrost thermal properties; heat transfer; mass transfer;
ground ice; frost heave

DFFE

-136-

AN - 32000467
 TI - Patterned ground on lake shores and bottoms, central subarctic Quebec
 OTI - Cryosols avec friage sur rivage et fond de lacs, Quebec central subarctique
 AU - Dionne, J.-C.
 SO - Revue de geographie de Montreal, 1974-28(4), p.323-342, In French with English and Russian summaries. Refs. p.340-342.
 DT - J (JOURNAL ARTICLE)
 LA - fre, eng, rus
 IT - patterned ground; lakes; frost heave; freeze thaw cycles

-137-

AN - 32000400
 TI - Priorities for basic research on permafrost
 OS - National Research Council. Committee on Polar Research
 SO - Quaternary research, Mar. 1975-5(1), p.125-150, For previously issued report see 23-3179.
 DT - J (JOURNAL ARTICLE)
 LA - eng
 IT - ecology; research projects; rheology; thermal regime; permafrost; active layer; frozen ground; soil formation; frost heave; patterned ground; slope processes

-138-

AN - 32000395
 TI - Frost creep and gelifluction features: a review
 AU - Benedict, J.B.
 SO - Quaternary research, Mar. 1976-6(1), p.55-76, 82 refs.
 DT - J (JOURNAL ARTICLE)
 LA - eng
 IT - fossil ice; paleoclimatology; soil moisture; frost action; soil creep; cryogenic slope processes; solifluction; frost heave; frozen ground; landforms

-139-

AN - 32000380
 TI - Water flow induced by soil freezing
 AU - Arvidson, W.D.; Morgenstern, N.R.
 SO - Canadian geotechnical journal, May 1977-14(2), p.237-245, In English with French summary. 14 refs.
 DT - J (JOURNAL ARTICLE)
 LA - eng, fre
 IT - soil freezing; soil moisture migration; frost heave

663

-140-

AN - 32000298
TI - Frost-heave potential of silty sands
AU - Sherif, M.A.; Ishibashi, I.; Ding, W.
SO - International Symposium on Cold Regions Engineering, 2nd,
Fairbanks, Aug. 12-14, 1976, Proceedings, p.239-251, 4 refs.,
Fairbanks, University of Alaska, Cold Regions Engineers
Professional Association, 1977
DT - PA (PAPER)
LA - eng
IT - frozen sand; frost heave; laboratory techniques; temperature
effects

-141-

AN - 32000270
TI - Solving the problems of linear heat and mass transfer in the
ground
OTI - K resheniiu odnomernoi zadachi teplo- i massoobmena v gruntakh
AU - Balyshv, O.A.
SO - Proizvodstvennyi i nauchno-issledovatel'skii institut po
inzhenernym izyskaniyam v stroitel'stve. Trudy, 1974-Vol.44,
p.90-98, In Russian. 2 refs.
DT - J (JOURNAL ARTICLE)
LA - rus
IT - analysis (mathematics); cryogenic processes; frost heave; soil
freezing; soil moisture migration; frost penetration; heat
transfer; mass transfer

-142-

AN - 32000267
TI - Relationship between frost heave and ice segregation in freezing
ground
OTI - O korreliativnoi svyazi mezhdu pucheniem i l'dovydeleniem v
promerzaiushchikh gruntakh
AU - Orlov, V.O.
SO - Proizvodstvennyi i nauchno-issledovatel'skii institut po
inzhenernym izyskaniyam v stroitel'stve. Trudy, 1974-Vol.44,
p.44-61, In Russian. 20 refs.
DT - J (JOURNAL ARTICLE)
LA - rus
IT - cryogenic processes; soil freezing; fines; soil moisture
migration; frost penetration; frost heave

-143-

AN - 32000172
 TI - How and why of cooling Arctic gas pipelines--Part 1
 AU - King, G.
 SO - Pipeline and gas journal, Sep. 1977-204(11), p.58-59, 72, 74
 DT - J (JOURNAL ARTICLE)
 LA - eng
 IT - frost heave; permafrost preservation; gas pipelines; fluid flow; cooling; heat transfer

-144-

AN - 32000153
 TI - Effect of frost heaving on the foundation bed and foundation during the construction period
 AU - Kiselev, M.F.; Chubarova, N.P.
 SO - Soil mechanics and foundation engineering, Jan.-Feb. 1977 (Pub. July 77)-14(1), p.31-35, Translated from Osnovaniia, fundamenty i mekhanika gruntov, 4 refs.
 DT - J (JOURNAL ARTICLE)
 LA - eng, rus
 IT - buildings; bearing strength; foundations; building codes; frost heave; clay soils; frost protection; ground ice; ground thawing

-145-

AN - 31004372
 TI - Designing substations for frost heave areas
 DTI - Ob opyte proektirovaniia podstantsii v raionakh rasprostraneniia puchinyistyykh gruntov
 AU - Filatov, A.M.
 SO - Energeticheskoe stroitel'stvo, 1976-9(183), p.62-65, In Russian. 5 refs.
 DT - J (JOURNAL ARTICLE)
 LA - rus
 IT - design; electric power plants; permafrost beneath buildings; frost heave

-146-

AN - 31004152
 TI - Susceptibility of soils to frost damage
 DTI - Jordarters telefarlighet
 AU - Saetersdal, R.
 SO - Norges teknisk-naturvitenskapelige forskningsrad og Statens vegvesens Utvalg for frost i jord. Publikasjoner, Nov. 1976-Nr. 17, p.123-152, 82 refs. In Norwegian.
 DT - J (JOURNAL ARTICLE)
 LA - nor
 IT - frozen ground mechanics; frost resistance; analysis (mathematics); soil freezing; frost action; freeze thaw cycles;

frost heave

-147-

AN - 31004148
TI - Problems encountered in the freezing of soils. Research activities
OTI - Problemer ved frysing av jord. Forskningsaktivitet
AU - Saetersdal, R.
SO - Norges teknisk-naturvitenskapelige forskningsrad og Statens vegvesens Utvalg for frost i jord. Publikasjoner, Nov. 1976-Nr. 17, p. 11-21, 83 refs. In Norwegian.
DT - J (JOURNAL ARTICLE)
LA - nor
IT - research projects; norway; frost action; soil freezing; frost heave; frost penetration

-148-

AN - 31004130
TI - Electric power lines in Yakutia
OTI - Lini elektroporedachi v Iakutii
AU - Argunov, L.I.
SO - 184p., In Russian with abridged English table of contents enclosed. 44 refs., Yakutsk, Yakutskoe knizhnoe izd-vo, 1976
DT - MON (MONOGRAPH)
LA - rus
IT - permafrost; ussr -yakutia; economic development; electric power plants; power line supports; power lines; frost heave; thermokarst

-149-

AN - 31003894
TI - Foundations on frost-heaving ground
OTI - Ustroistvo fundamentov v usloviakh puchiniistykh gruntov
AU - Tolkahev, N.A.
SO - Zhilishchnoe stroitel'stvo, Mar. 1977-No.3, p. 18-21, In Russian. 6 refs.
DT - J (JOURNAL ARTICLE)
LA - rus
IT - foundations; soil freezing; frost penetration; soil moisture migration; frost heave

-150-

- AN - 31003769
TI - Moisture content of freezing ground at the beginning of heave
OTI - O vlazhnosti nachala pucheniia gruntov pri promerzani
AU - Nevecheria, V.L.; Chistotinov, L.V.
SO - Vsesoluznyi nauchno-issledovatel'skii institut gidrogeologii i inzhenernoi geologii. Trudy, Fiziko-geologicheskie protsessy v promerzaiushchikh i protaivaiushchikh porodakh (Physical and geological processes in freezing and thawing rocks) Edited by L.V. Chistotinov, #974-Vol.70, p.24-30. In Russian. 11 refs.
DT - PA (PAPER)
LA - rus
IT - analysis (mathematics); soil freezing; frost penetration; soil moisture migration; frost heave

-151-

- AN - 31003766
TI - Physical and geological processes in freezing and thawing rocks
OTI - Fiziko-geologicheskie protsessy v promerzaiushchikh i protaivaiushchikh porodakh
AU - Chistotinov, L.V., ED
SO - Vsesoluznyi nauchno-issledovatel'skii institut gidrogeologii i inzhenernoi geologii. Trudy, 1974-Vol.70, 79p., In Russian. For individual papers see 31-3767 through 31-3775. Refs. passim.
DT - MON (MONOGRAPH)
LA - rus
IT - frozen fines; cryogenic processes; frost penetration; soil moisture; ice growth; ground ice; frost heave; ground thawing; thermokarst; permafrost thermal properties; human factors

-152-

- AN - 31003752
TI - Density and strength of dams of earth materials
AU - Vutsel', V.I.
SO - Hydrotechnical construction, Sep. 1976-No.9, p.904-908. Translated from Gidrotekhnicheskoe stroitel'stvo. 10 refs.
DT - J (JOURNAL ARTICLE)
LA - eng, rus
IT - hydraulic structures; earth dams; construction materials; freeze thaw cycles; frost heave; soil strength; gravel; sands

DFFE

-153-

AN - 31003596
TI - Evaluating and obtaining local stability of slopes in swelling ground
OTI - Otsenka i obespechenie mestnoi ustoiichivosti otkosov v nabukhalushchikh gruntakh
AU - Peshkov, P.G.; Nevecheria, M.A.; Gol'makov, V.N.
SO - Moscow. Vsesoiuznyi dorozhnyi nauchno-issledovatel'skii institut. Trudy, 1974-Vol.75, p.44-50, In Russian.
DT - J (JOURNAL ARTICLE)
LA - rus
IT - analysis (mathematics); dams; embankments; slope stability; frozen fines; freeze thaw cycles; soil moisture migration; settlement (structural); frost heave

-154-

AN - 31003510
TI - Relations between the chemical composition and the heave amount of powder materials
AU - Horiguchi, K.
SO - Low temperature science (Teton kagaku). Series A Physical sciences, 1976-No.34, p.245-247, In Japanese. 5 refs.
DT - J (JOURNAL ARTICLE)
LA - jap
IT - chemical composition; frost heave; frozen fines

-155-

AN - 31003300
TI - Evaporation from foundations of large structures built on permafrost and prediction of moisture in such foundations
AU - Zolotar', I.A.
SO - Heat transfer: Soviet research, Mar.-Apr. 1976-8(2), p.92-116, 13 refs.
DT - J (JOURNAL ARTICLE)
LA - eng, rus
IT - soil moisture migration; permafrost hydrology; frost heave
ST - Permafrost bases

-156-

AN - 31003212
TI - Structure and morphology of minerogenic palsas in Northern Norway
AU - Ahman, R.
SO - Biuletyn peryglacjalny, 1976-No.26, p.25-31, 22 refs.
DT - J (JOURNAL ARTICLE)
LA - eng
IT - swamps; cryogenic formations; peat; frost heave; soil moisture migration; ice growth; ice structure
ST - Palsas

DFFE

-157-

AN - 31003211
 TI - Seasonal thawing of a palsa at Enontekiö, Finnish Lapland, in 1974
 AU - Seppälä, M.
 SO - Biuletyn peryglacjalny, 1976-No.26, p.17-24, 23 refs.
 DT - J (JOURNAL ARTICLE)
 LA - eng
 IT - peat; swamps; frost heave; cryogenic formations; ice growth; active layer; soil moisture migration
 ST - Palsas

-158-

AN - 31003161
 TI - Accounting for water absorption of hard foam plastics when establishing thermal insulation thickness for roadbeds
 OTI - Ob uchete osobennostei vodopogloshcheniya zhestkikh penoplastov pri naznacheniі toishchiny teploizolatsionnykh sloev v dorozhnykh odezhdakh
 AU - Estimsetov, E.Sh.
 SO - Moscow. Avtomobil'no-dorozhnyi institut. Trudy, 1975-Vol.94, p.54-60, In Russian.
 DT - J (JOURNAL ARTICLE)
 LA - rus
 IT - roadbeds; frost heave; thermal insulation; cellular plastics

-159-

AN - 31003156
 TI - Designing draining layers for the case of unstable water movement and seepage in the capillary zone
 OTI - Raschet dreniruiushchikh sloev dlia sluchaia neustanovivshegosia dvizheniya i fil'tratsii vody v kapillarnoi zone
 AU - Tulaev, A.IA.
 SO - Moscow. Avtomobil'no-dorozhnyi institut. Trudy, 1975-Vol.94, p.4-27, In Russian.
 DT - J (JOURNAL ARTICLE)
 LA - rus
 IT - frost heave; roadbeds; embankments; drainage; soil moisture migration; frost penetration; capillarity

-160-

AN - 31003115
 TI - Frost-heaving pressures
 AU - Hoekstra, P.; Chamberlain, E.; Frate, T.
 SO - Highway research record, REPT. NO. MP 580, 1965-No.101, p.28-38, 16 refs. Microform No. SIP 24409.
 DT - J (JOURNAL ARTICLE)
 LA - eng
 IT - ice water interface; soil moisture; frost heave; soil pressure;

669

DFFE

- frost action; soil mechanics; soil freezing
- AB - Considerable pressure develops on freezing a saturated soil in an open system from the top down. The pressure is the result of the surface energy of a curved ice-water interface. The curvature of the interface is necessary for ice to proliferate through the soil pores and is related to the pore size distribution of the soil. The test chamber used is designed to minimize the friction of the soil with the wall. An accurate control of heat removal is obtained by thermoelectric cooling. A load cell placed on top of the sample is used to measure the pressure developed and at the same time prevents heaving of the sample. Measurement of the pressure on a layered sample shows that the pressure develops at the freezing front. Results on several soils indicate that each soil develops a characteristic maximum pressure. For each soil used, the water content vs tension curve is given and the maximum pressure is related to this curve. (Auth.)

-161-

- AN - 31003080
- TI - Ground behavior due to freezing and thawing
- AU - Morgenstern, N.R.
- SO - Canada. Environmental Protection Service. Economic and technical review reports, Symposium on Utilities Delivery in Arctic Regions, March 16-18, 1976, Edmonton, Alberta, Canada, Jan. 1977-EPS 3-WP-77-1, p.201-206, 12 refs.
- DT - PA (PAPER)
- LA - eng
- IT - soil freezing; ground thawing; frozen ground settling; thermal conductivity; frost heave

-162-

- AN - 31003054
- TI - New look at permafrost completions
- AU - Goodman, M.A.
- SO - Petroleum engineer international, Apr. 1977-49(4), p.21-22, 24, 26, 30
- DT - J (JOURNAL ARTICLE)
- LA - eng
- IT - ground thawing; well casings; settlement (structural); frost heave; soil pressure

-163-

- AN - 31003052
- TI - Current field measurements concerning the nature and rate of periglacial processes
- AU - French, H.M.
- SO - Biuletyn peryglacjalny, 1976-No.25, p.79-91, 59 refs.
- DT - J (JOURNAL ARTICLE)
- LA - eng

670

670

670

IT - periglacial processes; bibliographies; cryogenic processes;
alpine land forms; patterned ground; alpine soils; frost heave;
ground ice

-164-

AN - 31003042
TI - Migration pingos in the northeast European USSR and West Siberia
OTI - Migratsionnye bugry puchenii severo-vostoka evropeiskoi chasti
SSSR i Zapadnoi Sibiri
AU - Evseev, V.P.
SO - Problemy kriolitologii. 1976-Vol.5, p.95-159, In Russian. 41
refs.
DT - J (JOURNAL ARTICLE)
LA - rus
IT - swamps; peat; ground ice; pingos; frost heave; soil moisture
migration; ice growth; ice structure; ice composition; impurities

-165-

AN - 31003014
TI - Covers preventing frost heave of foundations
OTI - Primenenie protivopuchinnoi obolochki pri sooruzhenii fundamentov
AU - Sobolev, G.I.; Chernyshov, I.U.G.
SO - Transportnoe stroitel'stvo, Nov. 1976-No.11, p.51-52, In Russian.
DT - J (JOURNAL ARTICLE)
LA - rus
IT - foundations; frost heave; plastics; polymers; films; lubricants

-166-

AN - 31002949
TI - Tunnel lining performance under frost heave conditions
OTI - Rabota konstruktsii tunnel'nykh obdelok v usloviakh proiavlennii
moroznogo pucheniia gruntov
AU - Slavin, E.E.; Protasov, N.N.; Myshkina, G.P.
SO - Novosibirsk. Institut inzhenerov zheleznodorozhnogo transporta.
Trudy, 1974-Vol.157, p.140-144, In Russian. 3 refs.
DT - J (JOURNAL ARTICLE)
LA - rus
IT - clay soils; soil moisture migration; tunnels; frost heave;
fracturing
ST - Tunnel liners

-167-

AN - 31002792
TI - Methods of preventing frost heave of closed irrigation systems in non-chernozem regions
OTI - Effektivnye sposoby predokhraneniia zakrytykh orositel'nykh sistem ot razrusheniia moroznym pucheniem (v usloviakh nechernozem'ia)
AU - Sokolov, V.M.; Ulitskii, V.M.
SO - Leningrad. Inzhenerno-stroitel'nyi institut. Nauchnye trudy, 1976-No.112, p.64-70. In Russian. 3 refs.
DT - J (JOURNAL ARTICLE)
LA - rus
IT - equipment; frozen fines; frost heave; soil moisture migration; frost penetration; drainage
ST - Irrigation systems

-168-

AN - 31002791
TI - Determining the conditions favoring self-drying of sand fills during ground freezing
OTI - Metodika opredeleniia uslovia samoosusheniia peschanykh zasypok pri promerzanii gruntov
AU - Dalmatov, B.I.; Malysheva, E.F.
SO - Leningrad. Inzhenerno-stroitel'nyi institut. Nauchnye trudy, 1976-No.112, p.59-64. In Russian. 3 refs.
DT - J (JOURNAL ARTICLE)
LA - rus
IT - buildings; foundations; frost penetration; frost heave
ST - Sand bases

-169-

AN - 31002717
TI - Protection against frost damage Part VI: floors laid directly on ground, with reduced foundation depth
AU - Torgerson, P.
SO - U.S. Army Cold Regions Research and Engineering Laboratory. REPT. NO. TL 486, Oct. 1975, 50p., Translation of Norges teknisk-naturvitenskapelige forskningsrad. Utvalg for frost i jord. Sikring mot teleskader, p.67-93, 1975
DT - R (REPORT)
LA - eng, nor
IT - floors; frost protection; frost heave; heat transfer; insulation
AB - This report presents research activities conducted in Norway on floors laid directly on ground, with reduced foundation depths. The Building Code of Norway has recently changed allowing this type of construction therefore research in special test houses using this type of floor was initiated. This report describes these test houses and presents information on heat flow, floor temperatures, damp-proofing and frost-proofing.

DFFE

-170-

AN - 31002494
TI - Features of soil water in freezing ground
AU - Kinoshita, S.
SO - Colloquium on Water in Planetary Regoliths, Hanover, N.H., Oct.
5-7, 1976. Proceedings, p.5-8, Hanover, N.H., U.S. Army Cold
Regions Research and Engineering Laboratory, 1977
DT - PA (PAPER)
LA - eng
IT - frost heave; water table; compressive strength; soil freezing;
soil moisture; soil temperature

-171-

AN - 31002470
TI - Heave of silty sands
AU - Sherif, M.A.; Ishibashi, I.; Ding, W.-W.
SO - American Society of Civil Engineers. Geotechnical Engineering
Division. Journal, Mar. 1977-103(GT3), p.185-195, 4 refs.
DT - J (JOURNAL ARTICLE)
LA - eng
IT - experimental data; sands; frost heave; temperature effects

-172-

AN - 31002446
TI - Optimal depth of power-line support sinking into permafrost in
the Lenz-Amga interfluv, Yakutia
OTI - K voprosu o optimal'nom zaglublennii opor LEP na vechnomerzlykh
gruntakh v raionakh Leno-Amginskogo mezhdurech'ia Iakutskoi ASSR
AU - Argunov, L.E.; Olesov, I.U.I.
SO - Vsesoiuznoe nauchno-tekhnicheskoe soveshchanie problemy
energetiki Krainego Severa, Yakutsk, Siberia, 1974. Sbornik
dokladov. Pt.4. Energosnabzhenie sel'skogo khoziaistva Severa
(All-Union conference on power engineering in the Far North, 1st,
Yakutsk, Siberia, 1974. Papers. Pt.4: Power supply to
agricultural establishments of the North), p.67-74, In Russian.
2 refs., Yakutsk, Akademiia nauk SSSR, Iakutskii filial, 1975.
DT - PA (PAPER)
LA - rus
IT - construction; permafrost; power line supports; frost heave

-173-

AN - 31002321
TI - Hydraulic piping--theoretical and experimental findings
AU - Kalin, M.
SO - Canadian geotechnical journal, Feb. 1977-14(1), p.107-124, 31
refs. In English with French summary.
DT - J (JOURNAL ARTICLE)
LA - eng, fre

IT - frost heave; hydraulics; ground water; safety; water flow; erosion

-174-

AN - 31002318.
TI - Application of pressuremeter test results in deformation analysis
AU - Burgess, N.; Eisenstein, Z.
SO - Canadian geotechnical journal, Feb. 1977-14(1), p.64-75, 16 refs.
In English with French summary.
DT - J (JOURNAL ARTICLE)
LA - eng, fre
IT - frost heave; settlement (structural); deformation; foundations;
soil structure
ST - Pressure tests

-175-

AN - 31002276
TI - Controlling frost heaving of ponderosa pine seedlings in Arizona
AU - Heldmann, L.J.; Thorud, D.B.
SO - U.S. Rocky Mountain Forest and Range Experiment Station, Fort
Collins, Colorado. U.S. Forest Service research paper, Oct.
1976-RM-172, 12p., 14 refs.
DT - R (REPORT)
LA - eng
IT - soil freezing; ice lenses; frost heave; trees (plants);
protection; seasonal freeze thaw
ST - Environmental protection

-176-

AN - 31002243
TI - Performance of gas line inlets into buildings on heaving ground
in Chita city
OTI - Issledovanie raboty vvodov gazoprovodov v zdanila v puchinistyykh
gruntakh g. Chity
AU - Albaut, G.N.
SO - Geograficheskoe obshchestvo SSSR. Zabaikal'skii filial.
Zapiski, 1975-Vol. 104, p.147-151, In Russian.
DT - PA (PAPER)
LA - rus
IT - permafrost structure; ground ice; frost heave; buildings;
underground facilities; gas pipelines

-177-

AN - 31002237
TI - Causes and prevention of building deformations in Yakutsk
OTI - Prichiny deformatsii zdaniy v raione Iakutskaya i ikh
preduprezhdenie
AU - Ushkalov, V.P.
SO - Geograficheskoe obshchestvo SSSR. Zabaikal'skii filial.
Zapiski, 1975-Vol. 104, p.101-109, In Russian.
DT - PA (PAPER)
LA - rus
IT - frozen fines; buildings; frost heave; foundations; deformation;
settlement (structural); permafrost beneath buildings

-178-

AN - 31002234
TI - Calculating frost heave of freezing ground
OTI - K raschetnoi otsenke pucheniya promerzavushchikh gruntov
AU - Ershov, E.D.; Shevchenko, L.V.; Lebedenko, I.U.
SO - Geograficheskoe obshchestvo SSSR. Zabaikal'skii filial.
Zapiski, 1975-Vol. 104, p.74-80, In Russian. 8 refs.
DT - PA (PAPER)
LA - rus
IT - snow cover effect; soil freezing; frost penetration; frost heave;
soil moisture migration; heat transfer; fines

-179-

AN - 31002232
TI - Frost heave effect on municipal gas lines in Chita
OTI - Issledovanie vozdeystviya moroznogo pucheniya grunta na
gazoprovody v usloviyakh goroda Chity
AU - Smolich, S.V.; Leiko, L.I.
SO - Geograficheskoe obshchestvo SSSR. Zabaikal'skii filial.
Zapiski, 1975-Vol. 104, p.58-63, In Russian.
DT - PA (PAPER)
LA - rus
IT - ussr -chita; gas pipelines; frost heave; ground ice; ice growth
ST - Permafrost beneath pipelines

-180-

AN - 31002173
TI - Ways of increasing the strength of roadbeds
OTI - Kak povysit' prochnost' zemliannogo polotna
AU - Chelyshkin, N.D.
SO - Lesnaya promyshlennost', June 1976-No.6, p.23-24, In Russian.
DT - J (JOURNAL ARTICLE)
LA - rus
IT - roadbeds; freeze thaw cycles; frost penetration; swamps;
embankments; frost heave; waterproofing; frozen fines; drainage

-181-

AN - 31002090
 TI - Frost heave in Tomakomai (1974-1975)
 AU - Kinoshita, S.; Suzuki, Y.; Horiguchi, K.; Fukuda, M.; Inoue, M.;
 Takeda, K.
 SO - Low temperature science (Teion kagaku). Series A Physical
 sciences. Data report, 1975-No.33, p.77-83. In Japanese.
 DT - R (REPORT)
 LA - jap
 IT - Japan -tomakomai; frost heave; frost penetration; water content

-182-

AN - 31002081
 TI - Frost heave during winter construction of a building in Ottawa,
 Canada
 AU - Burn, K.N.; Beach, R.K.
 SO - International Symposium on Frost Action in Soils, Lulea, Sweden,
 Feb. 1977. Proceedings, Vol.1, p.185-194, 11 refs., University
 of Lulea, 1977
 DT - PA (PAPER)
 LA - eng
 IT - buildings; construction; frost heave

-183-

AN - 31002070
 TI - Dependence of frost heaving on load application--preliminary
 results
 AU - Penner, E.; Ueda, T.
 SO - International Symposium on Frost Action in Soils, Lulea, Sweden,
 Feb. 1977. Proceedings, Vol.1, p.92-101, 3 refs., University of
 Lulea, 1977
 DT - PA (PAPER)
 LA - fre
 IT - soil freezing; frost heave; loads (forces); test equipment

-184-

AN - 31002068
 TI - Frost heave character in freezing of powder materials
 AU - Horiguchi, K.
 SO - International Symposium on Frost Action in Soils, Lulea, Sweden,
 Feb. 1977. Proceedings, Vol.1, p.67-75, 5 refs., University of
 Lulea, 1977
 DT - PA (PAPER)
 LA - fre
 IT - frost resistance; frost heave; porous materials
 ST - Powder (particles)

676

76

DFFE

-185-

AN - 31002066
TI - Thermodynamic description of the ice lensing process
AU - Keinonen, L.S.
SO - International Symposium on Frost Action in Soils, Lulea, Sweden, Feb. 1977. Proceedings, Vol.1, p.54-58, 1 ref., University of Lulea, 1977
DT - PA (PAPER)
LA - fre
IT - frost heave; temperature effects; soil pressure; frozen ground thermodynamics; ground water; unfrozen water content; ice lenses

-186-

AN - 31002065
TI - Thermodynamic conditions for ice accumulation in freezing soils
AU - Williams, P.J.
SO - International Symposium on Frost Action in Soils, Lulea, Sweden, Feb. 1977. Proceedings, Vol.1, p.42-53, 12 refs., University of Lulea, 1977
DT - PA (PAPER)
LA - fre
IT - soil moisture migration; ground ice; unfrozen water content; frozen ground thermodynamics; frost heave

-187-

AN - 31002064
TI - Preliminary comparison of simulated and observed water redistribution in soils freezing under laboratory and field conditions
AU - Kay, B.D.; Sheppard, M.I.; Loch, J.P.G.
SO - International Symposium on Frost Action in Soils, Lulea, Sweden, Feb. 1977. Proceedings, Vol.1, p.29-41, 21 refs., University of Lulea, 1977
DT - PA (PAPER)
LA - fre
IT - heat transfer; soil moisture migration; soil freezing; ground ice; frost heave; models

-188-

AN - 31002062
TI - Proceedings, Vol.1 [International Symposium on Frost Action in Soils, Lulea, Sweden, Feb. 1977]
SO - 215p., For individual papers see 31-2063 through 31-2083., University of Lulea, 1977
DT - MON (MONOGRAPH)
LA - eng
IT - meetings; soil moisture migration; ice formation; soil freezing; frost heave; freeze thaw cycles; construction

677

DFFE

-189-

AN - 31002051
TI - Climatology of a needle ice event: an experiment in simulation
climatology
AU - Outcalt, S.I.
SO - Archiv fur Meteorologie, Geophysik und Bioklimatologie. Ser. B,
1971-19(3), p.325-338, 10 refs.
DT - J (JOURNAL ARTICLE)
LA - eng
IT - ice needles; ice crystal growth; frost heave; computerized
simulation; models; surface temperature; freeze thaw cycles;
climatic factors; ground water

-190-

AN - 31002026
TI - Caen frost station, 4th experiment, geotechnical and thermal
aspects
OTI - La Station de gel de Caen, quatrieme experimentation, aspect
geotechnique
AU - Canlard, L.; Dupas, A.; Bertouille, H.
SO - 90p., In French. 11 refs., Paris, Laboratoire central des ponts
et chaussees, 1975
DT - R (REPORT)
LA - fre
IT - research projects; frozen ground mechanics; soil freezing; soil
temperature; frost penetration; frost heave; mathematical models

-191-

AN - 31001990
TI - Macroscopic interpretation of frozen soil texture as a function
of freezing rate
AU - McGaw, R.
SO - REPT. NO. MP 727, 22p., Prepared for Symposium on Frost Action on
Roads, Oslo, Norway, Oct.1-3, 1973, Session 3. 7 refs.
Unpublished manuscript., 1974
DT - PA (PAPER)
LA - eng
IT - heat balance; water content; freeze thaw cycles; frozen ground
physics; soil texture; freezing indexes; frost heave
AB - A schematic model of frozen soil texture has been described, and
certain parameters relating to the manner in which frozen texture
is physically developed have been defined. Two primary
variables, the heave ratio and the textural ratio, have been
derived and discussed in relation to freezing and thawing. The
former is a measure of surface heaving, of water content gain,
and of heat balance. The latter is a measure of the structural
arrangement in a frozen soil. Both provide information on the
probable stability of the thawed soil. It would be useful to be
able to delineate the influence of these variables in
experimental data presently available. As demonstrated,

678

DFFE

graphical representations of data such as were presented in Fig. 2 lend themselves to this purpose and provide a means of summarizing information on frozen texture.

-192-

AN - 31001915
TI - Numeric results of coupled heat-mass flow during freezing and thawing
AU - Taylor, G.S.; Luthin, J.M.
SO - Conference on Soil-Water Problems in Cold Regions, 2nd, Edmonton, Sep. 1976, Proceedings, p.155-172, 21 refs., 1976
DT - PA (PAPER)
LA - eng
IT - heat flux; mass flow; computerized simulation; soil freezing; ground thawing; water flow; conductivity; frost heave; models

-193-

AN - 31001911
TI - Galerkin finite element analog of frost heave
AU - Guymon, G.L.; Berg, R.L.
SO - Conference on Soil-Water Problems in Cold Regions, 2nd, Edmonton, Sep. 1976, Proceedings, REPT. NO. MP 898, p.111-113, 3 refs., 1976
DT - PA (PAPER)
LA - eng
IT - frost heave; mathematical models

-194-

AN - 31001910
TI - Grain size as a basis for frost susceptibility criteria
AU - Penner, E.
SO - Conference on Soil-Water Problems in Cold Regions, 2nd, Edmonton, Sep. 1976, Proceedings, p.103-109, 8 refs., 1976
DT - PA (PAPER)
LA - eng
IT - Frost resistance; ice lenses; frost heave

-195-

AN - 31001902
TI - Proceedings [Conference on Soil-Water Problems in Cold Regions, 2nd, Edmonton, Sep. 1976]
SO - 185p., For individual papers see 31-1903 through 31-1916., 1976
DT - MON (MONOGRAPH)
LA - eng
IT - meetings; snow water content; ground water; heat transfer; frost heave; unfrozen water content; ice lenses

679

DFFE

-196-

AN - 31001842
TI - Detailed studies of frost action in soils
AU - Rix, H.H.
SO - 178p., M.S. thesis. Refs. p.153-155. Microfilm from University of Alberta Library, Edmonton, Canada., Edmonton, University of Alberta, Oct. 1959
DT - MON (MONOGRAPH)
LA - eng
IT - ice lenses; soil temperature; measuring instruments; soil pressure; frozen ground; frost heave; frost action
ST - Piezometers; Fore pressure

-197-

AN - 31001665
TI - Shear strength characteristics of a silty clay subjected to freezing and thawing
AU - Yao, L.Y.-C.
SO - 187p., Ph.D. thesis. Refs. p.182-187., Ithaca, N.Y., Cornell University, 1964
DT - MON (MONOGRAPH)
LA - eng
IT - soil mechanics; test equipment; subgrade soils; frost heave; freeze thaw tests; shear strength; frost action; clay soils

-198-

AN - 31001355
TI - Process for the prevention of frost heaves in fine-grained soils
AU - Roth, W.
SO - U.S. Patent Office. Patent, Dec. 16, 1975, 6 col., 5 refs.
DT - P (PATENT)
LA - eng
IT - frost heave; frozen fines; countermeasures

-199-

AN - 31001348
TI - Method and system for providing an ice slab while preventing undue freeze penetration below
AU - MacCracken, C.D.
SO - U.S. Patent Office. Patent, Oct. 7, 1975, 18 col., 9 refs.
DT - P (PATENT)
LA - eng
IT - soil moisture; antifreezes; ice rinks; frost penetration; frost heave; ground ice

089

DFFE

-200-

- AN - 31001264
 TI - Designing power plants for the Far North
 OTI - Nekotorye osobennosti proektirovaniia energeticheskikh ob"ektov na Kraĭnem Severe
 AU - Khokhl'ov, V.A.
 SO - Vsesoiuznoe nauchno-tekhnicheskoe soveshchanie Problemy energetiki Kraĭnego Severa, 1st, Yakutsk, Siberia, 1974 Sbornik dokladov. Pt.2: Fiziko-tekhnicheskie i ekonomicheskie problemy elektro- i teplosnabzheniia Severa (All-Union conference on power engineering in the Far North, 1st, Yakutsk, Siberia, 1974. Papers. Pt. 2: Physics, technology and economics of heat and electric power supply to the North), p.136-146, In Russian. 13 refs., Yakutsk, Akademiia nauk SSSR, IAKutskii filial, :975
 DT - PA (PAPER)
 LA - rus
 IT - design; permafrost; snowdrifts; electric power plants; ground ice; frost heave

-201-

- AN - 31001248
 TI - Methodical instructions for field and laboratory determination of moisture transfer parameters for fine grained ground
 OTI - Metodicheskie ukazaniia po polevomu i laboratornomu opredeleniiu parametrov protsessa v agglomeratsii v dispersnykh gruntakh
 AU - Ershov, E.D.; Cheverev, V.G.
 SO - 124p., In Russian with English table of contents enclosed. 30 refs., MGU, 1974
 DT - MON (MONOGRAPH)
 LA - rus
 IT - mass transfer; frost penetration; clay soils; frozen fines; ground thawing; soil moisture migration; capillary ice; frost heave

-202-

- AN - 31001137
 TI - Permafrost
 AU - Fewe, T.L.
 SO - McGraw-Hill Yearbook of Science and Technology, 1975 review and 1976 preview, p.33-47, New York, McGraw-Hill Inc., 1976
 DT - PA (PAPER)
 LA - eng
 IT - ground thawing; frost heave; ice wedges; solar radiation; civil engineering; construction; pipelines; permafrost thickness; permafrost distribution; permafrost origin; permafrost thermal properties; soil temperature

DFFE

-203-

- AN - 31000876
TI - Peculiarities in the course of settling and frost heaving processes in freezing soils of different composition and properties
OTI - Osobennosti protokanii protsessa usadki i pucheniia v promerzaiushchikh gruntakh razlichnogo sostava i svoistv
AU - Ershov, E.D.; Shevchenko, L.V.; Lebedenko, I.U.P.
SO - Merzlotnye issledovaniia, 1976-Vol.15, p.226-236, In Russian. 8 refs.
DT - J (JOURNAL ARTICLE)
LA - rus
IT - freeze thaw cycles; cryogenic structures; tests; laboratory techniques; cryogenic processes; soil freezing; frost penetration; frost heave; settlement (structural); soil moisture migration

-204-

- AN - 31000867
TI - Engineering and geological investigations of cryogenic structure of bedrock hydraulic construction
OTI - K metodike inzhenerno-geologicheskogo izuchenii kriogennogo stroeniia skal'nykh porod dlia tselei gidrotekhnicheskogo stroitel'stva
AU - Krivonogova, N.F.
SO - Merzlotnye issledovaniia, 1976-Vol.15, p.150-159, In Russian. 7 refs.
DT - J (JOURNAL ARTICLE)
LA - rus
IT - hydraulic structures; frozen rocks; ground ice; permafrost structure; frost heave; fracturing

-205-

- AN - 31000866
TI - Types of ground ice formation in bedrock in relation to engineering and geological properties
OTI - Analiz tipov i doobrazovaniia v skal'nykh porodakh pri ikh inzhenerno-geologicheskoi kharakteristike
AU - Krivonogova, N.F.
SO - Merzlotnye issledovaniia, 1976-Vol.15, p.147-149, In Russian. 1 ref.
DT - J (JOURNAL ARTICLE)
LA - rus
IT - frost penetration; frost heave; ground ice; ice formation
ST - Bedrock; Ice cement; Segregated ice; Injected ice; Sublimation ice

682

DFFE

-206-

- AN - 31000856
 TI - Solving a self-modeling problem of heat- and moisture transfer in freezing fines when the law governing surface level variations is given
 OTI - Avtomodel'noe reshenie zadachi teplo- i vlagoobmena v promerzaiushchikh tonkodispersnykh prodakh pri zadannom zakone izmeneniia urovnia poverkhnosti
 AU - Melamed, V.G.
 SO - Merzlotnye issledovaniia, 1976-Vol. 15, p.37-44, In Russian. 4 refs.
 DT - J (JOURNAL ARTICLE)
 LA - rus
 IT - mathematical models; frozen fines; frost penetration; frost heave; heat transfer; soil moisture migration

-207-

- AN - 31000590
 TI - Nonsorted circles--a comparison of arctic and alpine forms
 OTI - Nonsorted circles--ein Vergleich zwischen arktischen und alpinen Formen
 AU - Fitze, P.
 SO - Geographica helvetica, 1975-30(2), p.75-82, In German. 13 refs.
 DT - J (JOURNAL ARTICLE)
 LA - ger
 IT - arctic topography; alpine land forms; frost heave; cryogenic formations

-208-

- AN - 31000155
 TI - Subdividing the Ukrainian SSR into regions according to frost heave conditions and frost penetration, for determining the depth of foundation embedding for agricultural structures
 OTI - Raionirovaniie territorii USSR po usloviyam pucheniia i promerzaniia gruntov s tochki zreniia glubiny zalozeniia fundamentov sel'skokhoziaistvennykh sooruzhenii
 AU - Andreeva, T.P.; Fursa, V.I.; Smirnova, N.V.; Skliaruk, N.P.
 SO - Osnovaniia i fundamenty, 1976-No.9, p.6-10, In Russian.
 DT - J (JOURNAL ARTICLE)
 LA - rus
 IT - design; mapping; foundations; frost heave; frost penetration

DFFE

-209-

AN - 30004512
TI - Frost heave of tree seedlings: a literature review of causes and possible control
AU - Heidemann, L.C.
SO - U.S. Rocky Mountain Forest and Range Experiment Station, Fort Collins, Colorado. U.S. Forest Service general technical report, Jan. 1976-RM-21, 10p., 39 refs.
DT - R (REPORT)
LA - eng
IT - frost heave; trees (plants); soil moisture migration; supercooling

-210-

AN - 30004489
TI - Relation between frost-heave amplitude and soil water content in unidirectional soil freezing--Part I
AU - Tanuma, K.
SO - Canada. Defence Research Board. Translation, Sep. 1968-T98J, 4p. + 6 figs.. For Japanese original see 23-2754. 2 refs.
DT - O (OTHER)
LA - eng
IT - soil freezing; frost heave; soil moisture

-211-

AN - 30003897
TI - Concerning the paper of A.M. Pchelintsev "Dependence of the tangential forces of frost heaving of foundations on the depth of freezing in the ground"
SO - Soil mechanics and foundation engineering, Mar. 1976-12(5), p.334-335, Translation of Osnovaniia, fundamenty i mekhanika gruntov, No.5, Sep.-Oct. 1975, p.33-34. 2 refs. The editors present the views of B.I. Dalmatov and V.O. Orlov disputing the views of Pchelintsev.
DT - J (JOURNAL ARTICLE)
LA - eng, rus
IT - frost heave; foundations; frost penetration; soil mechanics

-212-

AN - 30003896
TI - Dependence of the tangential forces of frost heaving of foundations on the depth of freezing in the ground
AU - Pchelintsev, A.M.
SO - Soil mechanics and foundation engineering, Mar. 1976-12(5), p.331-333, Translation of Osnovaniia, fundamenty i mekhanika gruntov, No.5, Sep.-Oct. 1975, p.32-33. 4 refs.
DT - J (JOURNAL ARTICLE)
LA - eng, rus
IT - frost heave; frozen ground mechanics; foundations

684

DFFE

-213-

AN - 30003820
TI - Frost heave and heaving pressure measurements in colliery shales
AU - Kettle, R.J.; Williams, R.I.T.
SO - Canadian geotechnical journal, May 1976-13(2), p.127-133, In English with French summary. 21 refs.
DT - J (JOURNAL ARTICLE)
LA - eng, fre
IT - frost heave; soil pressure; thermoelectric effects; artificial freezing
ST - Shales

-214-

AN - 30003783
TI - Investigation of frost penetration into coarse-grained water-saturated ground
OTI - Issledovanie promerzanila krupnozernistykh vodonasyschennykh gruntov
AU - Lapshin, V.I.A.; Shvets, V.B.; Iurganov, M.M.
SO - Sverdlovsk: Ural'skii politekhnicheskii institut. Trudy, 1974-No.227, p.200-203, In Russian.
DT - J (JOURNAL ARTICLE)
LA - rus
IT - soil freezing; frozen gravel; frozen sand; frost penetration; frost heave

-215-

AN - 30003426
TI - Experimental study on the influence of freezing speed upon frost heave ratio of soil under constant effective stress
AU - Takashi, T.; Masuda, M.; Yamamoto, H.
SO - Seppyo, June 1974-36(2), p.1-20, In Japanese with English summary. 20 refs.
DT - J (JOURNAL ARTICLE)
LA - jap, eng
IT - freezing indexes; analysis (mathematics); experimentation; soil freezing; frost heave; frozen ground hydrology; tensile stress

-216-

AN - 30003333
TI - Water and salt redistribution in freezing soils
AU - Sheeran, D.E.; Yong, R.N.
SO - Conference on soil-water problems in cold regions, Calgary, Alberta, Canada, May 6-7, 1975, Proceedings, p.58-69, 7 refs., 1975
DT - PA (PAPER)
LA - eng
IT - soil chemistry; soil freezing; frost heave; soil moisture

migration; brines

-217-

AN - 30003332
TI - Some geotechnical observations on the role of surcharge pressure
in soil freezing
AU - McRoberts, E.C.; Nixon, J.F.
SO - Conference on soil-water problems in cold regions, Calgary,
Alberta, Canada, May 6-7, 1975, Proceedings, p.42-57, 16 refs.,
1975
DT - PA (PAPER)
LA - eng
IT - frost heave; soil moisture migration; water pressure; frozen
ground mechanics

-218-

AN - 30003247
TI - Method has to vary with conditions to prevent frost heave in
buried lines
SO - Oilweek, Feb. 23, 1976-27(2), p.13
DT - J (JOURNAL ARTICLE)
LA - eng
IT - pipelines; subsurface structures; frost heave

-219-

AN - 30003201
TI - Forecasting of roadbed freezing
OTI - Prognozirovaniye merzlotnykh iavlenii v zemlianom polotne
AU - Brzhezitskii, B.F.
SO - Avtomobil'nye dorogi, Oct. 1975-No.10, p.24-25, In Russian. 3
refs.
DT - J (JOURNAL ARTICLE)
LA - rus
IT - design criteria; frost heave; thermal regime; subgrades; soil
freezing; frost forecasting; roadbeds; seasonal freeze thaw;
ground thawing

-220-

AN - 30003168
TI - Frost bulb growth overriding factor as scientific experts clash
on technique
SO - Oilweek, Oct. 27, 1975-26(37), p.12-13
DT - J (JOURNAL ARTICLE)
LA - eng
IT - ground water; gas pipelines; frost heave; discontinuous permafrost
ST - Investigative panels

DFFE

-221-

AN - 30003144
TI - Can paludification be stopped in taiga
OTI - Можно ли остановить заболачивание тайги?
AU - Kriuchkov, V.V.
SO - Priroda, 1975-No.2, p.32-93, In Russian. 6 refs.
DT - J (JOURNAL ARTICLE)
LA - rus
IT - peat; mosses; soil freezing; frost heave; taiga vegetation;
swamps; countermeasures; permafrost heat balance; forest
ecosystems

-222-

AN - 30003127
TI - Subdivision of lands according to the intensity of frost heave
processes
OTI - К методике районирования территории по интенсивности
проявления процессов пучинообразования в грунтах
AU - Nevecheria, V.L.
SO - Moscow. Vsesoluznyi nauchno-issledovatel'skii institut
gidrogeologii i inzhenernoi geologii. Trudy, 1973-Vyp.62,
p.21-27, 7 refs. In Russian.
DT - J (JOURNAL ARTICLE)
LA - rus
IT - buildings; deformation; frost heave; foundations; soil moisture
migration; frost penetration; mapping

-223-

AN - 30003058
TI - Frame-shaped field assembly for determining tangential frost
heave forces acting on foundations
OTI - Polevaia ustanovka ramnogo tipa dlia opredeleniia kasatel'nykh
sil moroznogo vypuchivaniia fundamentov
AU - Pchelintsev, A.M.
SO - Moscow. Nauchno-issledovatel'skii institut osnovanii i
podzemnykh sooruzhenii. Sbornik, 1974-No.64, p.167-173, In
Russian. 12 refs.
DT - J (JOURNAL ARTICLE)
LA - rus
IT - stresses; measuring instruments; foundations; frost heave

-224-

AN - 30003057
TI - Using the water-repellant silicon-organic fluid GKZh-11 for preventing frost heave of ground (Laboratory investigations)
OTI - Primenenie gidrofobnoi kremniorganicheskoi zhidkosti GKZh-11 protiv pucheniia gruntov (laboratornye issledovaniia)
AU - Derbeneva, M.M.
SO - Moscow. Nauchno-issledovatel'skii institut osnovanii i podzemnykh sooruzhenii. Sbornik, 1974-No.64, p.157-166, In Russian. 2 refs.
DT - J (JOURNAL ARTICLE)
LA - rus
IT - countermeasures; soil freezing; ice formation; frost heave

-225-

AN - 30003052
TI - Formation of contact zones between ground and foundation surfaces
OTI - Formirovanie zony kontakta mezhdu gruntom i poverkhnost'iu fundamenta
AU - Prazdnikova, G.L.
SO - Moscow. Nauchno-issledovatel'skii institut osnovanii i podzemnykh sooruzhenii. Sbornik, 1974-No.64, p.115-123, In Russian. 5 refs.
DT - J (JOURNAL ARTICLE)
LA - rus
IT - buildings; foundations; soil freezing; frost heave

-226-

AN - 30003051
TI - Chemical substances and compounds for preventing frost heave of fine-grained soils
OTI - Primenenie nekotorykh khimicheskikh veshchestv i soedinenii dlia protivopuchinnoi stabilizatsii tonkodispersnykh gruntov
AU - Desiak, V.S.
SO - Moscow. Nauchno-issledovatel'skii institut osnovanii i podzemnykh sooruzhenii. Sbornik, 1974-No.64, p.107-114, In Russian. 5 refs.
DT - J (JOURNAL ARTICLE)
LA - rus
IT - admixtures; clay soils; frozen fines; frost heave; soil stabilization

DFFE

-227-

AN - 30003048
TI - Surface area of soils in the seasonally thawing layer of the Vorkuta area
OTI - O dispersnosti gruntov sezonnootataivalushchego sloia v raione Vorkuty
AU - Ivanov, I.A.
SO - Moscow. Nauchno-issledovatel'skii institut osnovanii i podzemnykh sooruzhenii. Sbornik, 1974-No.64, p.85-91, In Russian. 9 refs.
DT - J (JOURNAL ARTICLE)
LA - rus
IT - dispersions; frost heave; forecasting; ussr -vorkuta river; frozen fines; seasonal freeze thaw; active layer
ST - Surface area

-228-

AN - 30003046
TI - Nature of spontaneous electrical potentials occurring during the freezing of ground
OTI - K voprosu o prirode estestvennykh elektricheskikh potentsialov, voznikavushchikh pri promerzanii gruntov
AU - Iarkin, I.G.
SO - Moscow. Nauchno-issledovatel'skii institut osnovanii i podzemnykh sooruzhenii. Sbornik, 1974-No.64, p.59-81, In Russian. 15 refs.
DT - J (JOURNAL ARTICLE)
LA - rus
IT - phase transformations; clays; soil freezing; frost heave; soil moisture migration; frozen fines; electric charge; electric potential; water films

-229-

AN - 30003045
TI - Theory of water migration and heaving of ground during freezing
OTI - Teoriia migratsii vody i puchenia gruntov pri promerzanii
AU - Tiutiunov, I.A.
SO - Moscow. Nauchno-issledovatel'skii institut osnovanii i podzemnykh sooruzhenii. Sbornik, 1974-No.64, p.22-58, In Russian. 63 refs.
DT - J (JOURNAL ARTICLE)
LA - rus
IT - soil freezing; soil moisture migration; frost penetration; frost heave

689

DFFE

-230-

AN - 30003043
TI - Physico-chemical processes in freezing ground and ways of controlling them
OTI - Fiziko-khimicheskie protsessy v promerzaiushchikh gruntakh i sposoby upravleniya imi
SO - Moscow. Nauchno-issledovatel'skii institut osnovanii i podzemnykh sooruzhenii. Sbornik, 1974-No.64, 214p., In Russian with English table of contents enclosed.. For individual papers see 30-3044 through 30-3060.
DT - J (JOURNAL ARTICLE)
LA - rus
IT - soil freezing; soil moisture migration; frost penetration; ice formation; ground ice; frozen fines; frost heave; snow compaction

-231-

AN - 30002976
TI - Tree ring record of soil movements on permafrost
AU - Zoltai, S.C.
SO - Arctic and alpine research, Fall 1975-7(4), p.331-340, 28 refs.
DT - J (JOURNAL ARTICLE)
LA - eng
IT - cryoturbation; frost heave; air temperature; precipitation (meteorology); permafrost mass transfer; soil mechanics; hummocks; trees (plants)

-232-

AN - 30002944
TI - Development of the phenomenological theory of interaction between freezing and heaving ground and the lateral vertical surface of a foundation
OTI - K postroeniui fenomenologicheskoi teorii vzaimodeistviia promerzaiushchego puchinistogo grunta s bokovoi vertikal'noi poverkhnost'iu fundamenta
AU - Turenko, I.I.
SO - Leningrad. Inzhenerno-stroitel'nyi institut. Sbornik trudov, 1973-Vol.73, p.102-117, In Russian. 15 refs.
DT - J (JOURNAL ARTICLE)
LA - rus
IT - design; buildings; foundations; frost heave

069

DFFE

-233-

AN - 30002937
TI - Preventing frost-heave of lightly loaded foundations by foam-plastic insulation of bearing ground
OTI - Uteplenie gruntov penoplastami kak sredstvo bor'by s moroznym vypuchivaniem malonagruzhennykh fundamentov sooruzhenii
AU - Pal'kin, I.U.S.; Kuleshov, A.P.
SO - Novosibirsk. Institut inzhenerov zheleznodorozhnogo transporta. Trudy, 1971-Vol.123, p.187-196, In Russian. 4 refs.
DT - J (JOURNAL ARTICLE)
LA - rus
IT - frost heave; frost protection; thermal insulation; plastics; foundations

-234-

AN - 30002934
TI - Frost heave and the state of stress of a freezing layer of ground, no loads acting on its surface
OTI - Osobennosti moroznogo pucheniia i napriazhennoe sostoiianie promerzatushchego sloia grunta so svobodnoi ot nagruзки poverkhnosti
AU - Puskov, V.I.
SO - Novosibirsk. Institut inzhenerov zheleznodorozhnogo transporta. Trudy, 1971-Vol.123, p.147-158, In Russian. 12 refs.
DT - J (JOURNAL ARTICLE)
LA - rus
IT - stress analysis; fines; soil freezing; frost penetration; frost heave

-235-

AN - 30002932
TI - Engineering geology, bearing-grounds and foundation design
OTI - Voprosy inzhenernoi geologii, osnovanii i fundamentov
SO - Novosibirsk. Institut inzhenerov zheleznodorozhnogo transporta. Trudy, 1971-Vol.123, 226p., In Russian. For selected papers see 30-2933 through 30-2938. Refs. passim.
DT - MON (MONOGRAPH)
LA - rus
IT - design; permafrost structure; ground ice; mapping; electrical prospecting; foundations; frost heave; thermal insulation

691

DFFE

-236-

AN - 30002904
TI - Geocryological conditions of the central Siberian Uvaly
OTI - Geokriologicheskie uslovia tsentral'noi chasti Sibirskikh Uvalov
AU - Shamanova, I.I.
SO - Akademiia nauk SSSR. Izvestiia. Seriia geograficheskaiia,
July-Aug. 1975-No.4, p.109-116, In Russian. 2 refs.
DT - J (JOURNAL ARTICLE)
LA - rus
IT - soil freezing; geomorphology; frost heave; cryogenic relief;
permafrost distribution; soils; geocryology

-237-

AN - 30002902
TI - Tests of the concept of secondary frost heaving
AU - Loch, J.P.G.; Miller, R.D.
SO - Soil Science Society of America: Proceedings, Nov.-Dec.
1975-39(6), p.1036-1041, 20 refs.
DT - J (JOURNAL ARTICLE)
LA - eng
IT - soil colloids; water transport; tests; frost heave; frozen ground
mechanics; soil freezing; ice formation; ice lenses

-238-

AN - 30002876
TI - Secondary heaving: experiments and analysis of frost heaving
pressure in soils
AU - Loch, J.P.G.
SO - 113p., Ph.D. thesis. For abstract see Dissertation abstracts
international, Sec.B, Dec. 1975, p.2557., Ithaca, N.Y., Cornell
University, 1975
DT - MON (MONOGRAPH)
LA - eng
IT - ice pressure; temperature effects; models; frost heave; soil
freezing; frozen ground hydrology; ice water interface

-239-

AN - 30002793
TI - Frost-heaving soils and their effect on structures
OTI - Moroznoe pucheniie gruntov i vozdeistvie ego na sooruzheniia
AU - Dalmatov, B.I.
SO - Soveshchanie-seminar po obmenu opytom stroitel'stva v surovyykh
klimaticheskikh usloviakh, 6, Krasnoyarsk, 1970
(Conference-seminar on the exchange of experience in construction
under severe climatic conditions, 6th, Krasnoyarsk, 1970),
1970-5(1), p.102-122, In Russian. 16 refs.
DT - PA (PAPER)
LA - rus

DFFE

IT - buildings; foundations; frost heave; frozen fines; clay soils;
frost penetration

-240-

AN - 30002791

TI - Calculating frost heave forces acting in the foundation bottom plane

OTI - O formirovani v ploskosti podoshvy fundamentov sil moroznogo vypuchivaniia i metodike ikh rascheta

AU - Puskov, V.I.

SO - Soveshchanie-seminar po obmenu opytom stroitel'stva v surovyykh klimaticheskikh usloviakh, 6, Krasnoyarsk, 1970
(Conference-seminar on the exchange of experience in construction under severe climatic conditions, 6th, Krasnoyarsk, 1970),
1970-5(1), p.82-93, In Russian. 11 refs.

DT - PA (PAPER)

LA - rus

IT - stresses; buildings; design; foundations; frost heave

-241-

AN - 30002790

TI - Intensity of the residual heave of unloaded structures

OTI - Ob ostatochnom puchenii nenagruzhennykh konstruktsii i ego velichine

AU - Dement'ev, A.I.

SO - Soveshchanie-seminar po obmenu opytom stroitel'stva v surovyykh klimaticheskikh usloviakh, 6, Krasnoyarsk, 1970
(Conference-seminar on the exchange of experience in construction under severe climatic conditions, 6th, Krasnoyarsk, 1970),
1970-5(1), p.77-81, In Russian.

DT - PA (PAPER)

LA - rus

IT - experimental data; piers; frozen fines; frost heave

-242-

AN - 30002789

TI - Decreasing the action of shear stresses caused by frost heave on experimental foundations in Vorkuta by polymer coatings

OTI - Umen'shenie kasatel'nykh sil pucheniia opytnykh fundamentov v Vorkute s pomoshch'yu polimernykh pokrytii

AU - Konnova, O.S.; Sadovskii, A.V.

SO - Soveshchanie-seminar po obmenu opytom stroitel'stva v surovyykh klimaticheskikh usloviakh, 6, Krasnoyarsk, 1970
(Conference-seminar on the exchange of experience in construction under severe climatic conditions, 6th, Krasnoyarsk, 1970),
1970-5(1), p.69-76, In Russian. 1 ref.

DT - PA (PAPER)

LA - rus

IT - frost heave; foundations; polymers; protective coatings; resins

DFFE

-243-

AN - 30002788
TI - Effect of the side-plane slope of a pier on the stability of pier foundations in heaving ground
OTI - Issledovanie vliianiia naklona granel na ustoiichivost' stolbchatykh fundamentov v puchinistykh gruntakh
AU - Petrov, B.G.
SO - Soveshchanie-seminar po obmenu opytom stroitel'stva v surovyykh klimaticheskikh usloviyakh, 6, Krasnoyarsk, 1970
(Conference-seminar on the exchange of experience in construction under severe climatic conditions, 6th, Krasnoyarsk, 1970), 1970-5(1), p.63-68, In Russian. 1 ref.
DT - PA (PAPER)
LA - rus
IT - design; foundations; piers; frost heave

-244-

AN - 30002787
TI - Establishing foundation embedding depth in frost-heaving ground
OTI - Vybory glubiny zalozeniya fundamentov pri puchinistykh gruntakh
AU - Orlov, V.O.
SO - Soveshchanie-seminar po obmenu opytom stroitel'stva v surovyykh klimaticheskikh usloviyakh, 6, Krasnoyarsk, 1970
(Conference-seminar on the exchange of experience in construction under severe climatic conditions, 6th, Krasnoyarsk, 1970), 1970-5(1), p.55-62, In Russian. 2 refs.
DT - PA (PAPER)
LA - rus
IT - design; buildings; foundations; frost heave

-245-

AN - 30002786
TI - Review of the principles of foundation design for frost-heave and its improvement
OTI - Obzor printsipov rascheta moroznogo vypuchivaniia fundamentov i predlozheniia po ikh sovershenstvovaniu
AU - Sarkisian, R.M.; Orlov, V.O.
SO - Soveshchanie-seminar po obmenu opytom stroitel'stva v surovyykh klimaticheskikh usloviyakh, 6, Krasnoyarsk, 1970
(Conference-seminar on the exchange of experience in construction under severe climatic conditions, 6th, Krasnoyarsk, 1970), 1970-5(1), p.44-54, In Russian. 23 refs.
DT - PA (PAPER)
LA - rus
IT - design; buildings; foundations; frost heave

DFFE

-246-

AN - 30002785
 TI - Frost heave countermeasures practiced in construction
 OTI - Protivopuchilnye meropriyatia v stroitel'stve
 AU - Kronik, I.A.
 SO - Soveshchanie-seminar po obmenu opytom stroitel'stva v surovykh klimaticheskikh usloviakh, 6, Krasnoyarsk, 1970
 (Conference-seminar on the exchange of experience in construction under severe climatic conditions, 6th, Krasnoyarsk, 1970), 1970-5(1), p.38-43, In Russian.
 DT - PA (PAPER)
 LA - rus
 IT - buildings; frost heave; foundations; soil stabilization

-247-

AN - 30002784
 TI - Freezing and heave of coarse clastics with clay fill
 OTI - Osobennosti promerzaniya i moroznogo pucheniya krupnooblomochnykh gruntov s glinistym zapolnitelem
 AU - Shalagin, E.P.; Shvets, V.B.
 SO - Soveshchanie-seminar po obmenu opytom stroitel'stva v surovykh klimaticheskikh usloviakh, 6, Krasnoyarsk, 1970
 (Conference-seminar on the exchange of experience in construction under severe climatic conditions, 6th, Krasnoyarsk, 1970), 1970-5(1), p.25-37, In Russian. 3 refs.
 DT - PA (PAPER)
 LA - rus
 IT - frozen fines; frozen gravel; clay soils; frost penetration; frost heave

-248-

AN - 30002783
 TI - Studying frost heave of eluvial soils under laboratory conditions
 OTI - Issledovanie pucheniya eluvial'nykh gruntov v laboratornykh usloviakh
 AU - Lapshin, V.IA.; Mel'nikov, B.N.; Shvets, V.B.
 SO - Soveshchanie-seminar po obmenu opytom stroitel'stva v surovykh klimaticheskikh usloviakh, 6, Krasnoyarsk, 1970
 (Conference-seminar on the exchange of experience in construction under severe climatic conditions, 6th, Krasnoyarsk, 1970), 1970-5(1), p.15-24, In Russian. 5 refs.
 DT - PA (PAPER)
 LA - rus
 IT - models; clay soils; frozen fines; soil moisture migration; frost heave

DFFE

-249-

- AN - 30002782
 TI - Frost heave problem in hydraulic engineering and complex countermeasures
 DTI - Problema moroznogo pucheniia gruntov v gidrotekhnike i kompleksnye protivopuchinnnye meropriiatiia
 AU - Tsytoich, N.A.; Kronik, I.A.
 SO - Soveshchanie-seminar po obmenu opytom stroitel'stva v surovyykh klimaticheskikh usloviakh, 6, Krasnoyarsk, 1970
 (Conference-seminar on the exchange of experience in construction under severe climatic conditions, 6th, Krasnoyarsk, 1970), 1970-5(1), p.5-14, In Russian. 13 refs.
 DT - PA (PAPER)
 LA - rus
 IT - countermeasures; slope processes; dams; slope stability; frost heave

-250-

- AN - 30002781
 TI - Sixth Conference-Seminar on the Exchange of Experience in Construction under Severe Climatic Conditions. Proceedings. Vol.5, No.1 [Soveshchanie-seminar po obmenu opytom stroitel'stva v surovyykh klimaticheskikh usloviakh, 6, Krasnoyarsk, 1970]
 SO - 124p., In Russian. For individual papers see 30-2782 through 30-2793. Refs. passim., Krasnoyarsk, 1970
 DT - MON (MONOGRAPH)
 LA - rus
 IT - stress analysis; design; frost heave; foundations; active layer; permafrost beneath buildings; frozen sand; frozen gravel; frozen fines

-251-

- AN - 30002630
 TI - Zonality of permafrost distribution and forecasts of engineering geocryological phenomena
 DTI - Zonal'nost' rasprostraneniia tolshchi mnogolethemerzlykh porod i prognoz inzhenerno-geokriologicheskikh iavlenii
 AU - Bobov, N.G.
 SO - Moscow. Vsesoiuznyi nauchno-issledovatel'skii institut gidrogeologii i inzhenernoi geologii. Trudy, 1971 -Vol.42, p.91-101, In Russian. Refs. p.99-101
 DT - J (JOURNAL ARTICLE)
 LA - rus
 IT - permafrost distribution; ground ice; permafrost structure; active layer; frost heave; permafrost transformation; maps; permafrost thickness

969

DFFE

-252-

AN - 30002595
TI - Stabilization of the upper roadbed
OTI - Ukreplenie verkhnei chasti zemlianogo polotna
AU - Vasil'ev, I.U.M.
SO - Avtomobil'nye dorogi, Sep. 1975-No.9, p.18-19, In Russian.
DT - J (JOURNAL ARTICLE)
LA - rus
IT - roadbeds; freeze thaw cycles; soil moisture migration; frozen
fines; soil stabilization; cements; frost heave

-253-

AN - 30002531
TI - Construction of agricultural structures (greenhouses) on heaving
soils
AU - Kiselev, M.F.; Saforov, V.S.; Chubarova, N.P.
SO - Soil mechanics and foundation engineering, May-June 1975 (Pub.
Nov. 75)-12(3), p.154-157, Translated from Osnovaniia, fundamenty
i mekhanika gruntov. 3 refs.
DT - J (JOURNAL ARTICLE)
LA - eng, rus
IT - design; prefabrication; soil freezing; frost heave; soil moisture
migration; frost penetration; foundations; buildings

-254-

AN - 30002514
TI - Regularities governing the distribution of migration frost mounds
in northern West Siberia and the Pechora Plain
OTI - K voprosu o zakonomernostiakh rasprostraneniia migratsionnykh
bugrov puchenii na severe Zapadnoi Sibiri i Pechorskoi
nizmennosti
AU - Evseev, V.P.
SO - Prirodnye uslovia Zapadnoi Sibiri, 1975-Vol.5, p.216-227, In
Russian. 11 refs.
DT - J (JOURNAL ARTICLE)
LA - rus
IT - frost heave; ice formation; ice growth; forest tundra; taiga
terrain; cryogenic relief; pingos

-255-

AN - 30002388
TI - Mackenzie Valley inquiry--Berger inquiry resumes hearings
SO - Oilweek, Oct. 20, 1975-26(36), p.7-8
DT - J (JOURNAL ARTICLE)
LA - eng
IT - gas pipelines; permafrost preservation; frost heave
ST - Public hearings

DFFE

-256-

AN - 30002266
TI - Frost-heave uplift forces on foundations
AU - Penner, E.
SO - National Research Council, Canada. Division of Building Research. Research paper, International CIB/RILEM Symposium on Moisture Problems in Buildings, 2nd. Rotterdam, Sept. 10-12, 1974, 1974-No.635, 10p., In English with French summary. 5 refs.
DT - PA (PAPER)
LA - eng, fre
IT - frost heave; foundations; ice lenses; buildings; structural changes

-257-

AN - 30002175
TI - Mechanics of roadbeds
OTI - Mekhanika zemliannogo polotna
AU - Leonovich, I.I.; Vyrko, N.P.
SO - 230p., In Russian with abridged English table of contents enclosed. 172 refs., Minsk, Nauka i tekhnika, 1975
DT - MON (MONOGRAPH)
LA - rus
IT - settlement (structural); design; swamps; roadbeds; frost penetration; frost heave; freeze thaw cycles; slope stability

-258-

AN - 30002165
TI - Frost-susceptibility criteria
AU - Jessberger, H.L.
SO - Highway research record, 1973-No.429, p.40-46, 18 refs.
DT - J (JOURNAL ARTICLE)
LA - eng
IT - particle size distribution; ground thawing; bearing capacity; frost action; frost penetration; frost heave; frozen ground thermodynamics; phase transformations

-259-

AN - 30002029
TI - New basement wall designs for below-grade living space
AU - Elmroth, A.; Hogland, I.
SO - National Research Council, Canada. Technical translation, 1975-No.TT-1801, 44p., Translation of Nya kallaryttervaggar ger bostadsklimat under mark, Stockholm, Bygghogskolan, 1971.
DT - R (REPORT)
LA - eng, swe
IT - frost heave; residential buildings; insulation; soil moisture migration
ST - Basements

DFFE

-260-

AN - 30002025
TI - Foundation movements
AU - Crawford, C.B.
SO - Canadian building digest, April 1972-No.148, 4p.
DT - J (JOURNAL ARTICLE)
LA - eng
IT - frost heave; foundations; settlement (structural)

-261-

AN - 30002023
TI - Study of frost heaving and water suction caused by frost on the freezing of fine wet soils
DTI - Etude du gonflement et de l'aspiration d'eau engendres par le gel lors de la congelation des sols fins humides
AU - Aguirre-Puente, J.; Khastou, B.; Chalhoub, M.
SO - France. Centre national de la recherche scientifique. Laboratoire d'aerothermique. Publication, International Congress of Refrigeration, XIIth. Proceedings, Washington, D.C., 1971. Vol.1, 1971-No.450, p.759-764, In French with English summary. Includes discussion 6 refs.
DT - PA (PAPER)
LA - fre, eng
IT - soil freezing; frost heave; freezing points; water pressure

-262-

AN - 30001943
TI - Factors affecting the heaving of subgrade soils at freezing
AU - Vasil'ev, I.U.M.
SO - Norges teknisk-naturvitenskapelige forskningsrad og Statens vegvesens Utvalg for frost i jord Publikasjoner, Dec. 1973-No.12, p.17-18, 2 refs.
DT - J (JOURNAL ARTICLE)
LA - eng
IT - soil composition; density (mass/volume); moisture content; soil temperature; air temperature; subgrade soils; frost heave; soil freezing; ground water

-263-

AN - 30001942
TI - Moisture content and frost heaving of highway subgrade soils
AU - Korsunskii, M.B.; Galvoronskii, V.N.; Rossovskii, P.D.
SO - Norges teknisk-naturvitenskapelige forskningsrad og Statens vegvesens Utvalg for frost i jord. Publikasjoner, Dec. 1973-No.12, p.13-16, 2 refs.
DT - J (JOURNAL ARTICLE)
LA - eng
IT - density (mass/volume); soil temperature; subgrade soils;

roadbeds; moisture content; frost heave

-264-

- AN - 30001578
- TI - Significance of forests in water preservation and environment protection. Proceedings of the conference [Vsesoluznaia nauchnaia konferentsiia po vodookhranno-zashchitnomu znacheniiu lesa, Vladivostok, 1974]
- DTI - Vodookhranno-zashchitnoe znachenie lesa. Materialy konferentsii
- SO - 200p., In Russian., Vladivostok., 1974
- DT - MON (MONOGRAPH)
- LA - rus
- IT - forestry; frost heave; forest soils; snow cover distribution; taiga soils; snow water equivalent; soil formation; soil temperature; landscape types

-265-

- AN - 30001575
- TI - Forest canopy effect on soil heave during first autumn frosts
- DTI - O vliianii lesa na protsessy pucheniiia pochvy v period osennikh zamorozkov
- AU - Moskaev, A.P.
- SO - Vladivostok. Dal'nevostochnyi nauchnyi tsentr. Trudy, 1973-Vol.12, p.116-118, In Russian.
- DT - J (JOURNAL ARTICLE)
- LA - rus
- IT - soil temperature; forest soils; frost penetration; frost heave; forest canopy

-266-

- AN - 30001574
- TI - Hydroclimatic investigations in the forests of the Soviet Far East
- DTI - Gidroklimaticheskie issledovaniia v lesakh Sovetskogo Dal'nego Vostoka
- SO - Vladivostok. Dal'nevostochnyi nauchnyi tsentr. Trudy, 1973-Vol.12, 183p., In Russian. For selected papers see 30-1575 through 30-1577. Refs. passim.
- DT - MON (MONOGRAPH)
- LA - rus
- IT - forest soils; frost penetration; frost heave; forest canopy; snow accumulation; snow cover distribution; protective vegetation

-267-

AN - 30001401
TI - Improving the repeatability of frost heave tests
AU - Jones, R.H.; Hurt, K.G.
SO - Highways and road construction, July/Aug. 1975-43(1787-8),
p.8-11, 13, 10 refs.
DT - J (JOURNAL ARTICLE)
LA - eng
IT - frost heave; subgrades; frost resistance; laboratory techniques

-268-

AN - 30001352
TI - Soil properties and behaviour
AU - Yong, R.N.; Warkentin, B.P.
SO - Developments in geotechnical engineering, No.5, 449p. (Pertinent
p.382-419), Refs. p.431-439., Amsterdam, Elsevier Scientific
Publishing Company, 1975
DT - MON (MONOGRAPH)
LA - eng
IT - thermal factors; unfrozen water content; ice lenses; permafrost;
frozen ground physics; soil freezing; frost penetration; frost
heave; ice erosion

-269-

AN - 30001219
TI - Susceptibility to frost heaving of soils at selected sites along
the Liard River Valley, determined by pore pressure measurements
AU - Riddle, J.A.
SO - Task Force on Northern Oil Development. Environmental-Social
Committee. Report, Apr. 1973-No.73-3, p.465-511, 4 refs.
DT - PA (PAPER)
LA - eng
IT - canada -northwest territories -liard river; frost heave; arctic
soils; soil tests

-270-

AN - 30001208
TI - Hydrologic aspects of northern pipelines development
OS - Canada. Water Resources Branch. Glaciology Division
SO - Task Force on Northern Oil Development. Environmental-Social
Committee. Report, Apr. 1973-No.73-3, 664p., Numerous refs.
passim.
DT - MON (MONOGRAPH)
LA - eng
IT - rivers; canada -northwest territories -mackenzie district; ice
jams; frost heave; hydrology; environments; arctic vegetation;
pipelines

DFFE

-271-

AN - 30001117
TI - Stress on mine shaft supports by cryogenic heave
OTI - O nagruzkakh na krep' shakhtnykh stvolov ot sil kriogenogo pucheniia
AU - Mel'nikov, D.I.; Reva, V.N.
SO - Fiziko-tekhnicheskie problemy razrabotki poleznykh iskopaemykh, Jan.-Feb. 1975-No.1, p.15-21, In Russian. 9 refs.
DT - J (JOURNAL ARTICLE)
LA - rus
IT - mine shafts; frost heave

-272-

AN - 30001095
TI - Processes of soil movement in turf-banked solifluction lobes, Okstindan, northern Norway
AU - Harris, C.
SO - Institute of British Geographers. Special publication, July 1972-No.4, p.155-174, 13 refs. French and German summaries.
DT - PA (PAPER)
LA - eng, fre, ger
IT - norway; soil creep; frost heave; soil moisture; solifluction; slope processes

-273-

AN - 30000973
TI - Thermal regime of ground during study of its frost heaving properties under laboratory conditions
OTI - Temperaturnyi rezhim grunta pri issledovanii ego puchinistykh svoistv v laboratornykh usloviakh
AU - Ereemeev, M.A.; Zolotar', A.I.
SO - Fundamenty sbornykh, sborno-razbornykh i peredvizhnykh zdanii na vechnomerzlykh gruntakh (Foundations for sectional, collapsible and mobile residential buildings in permafrost), p.37-47, In Russian. 2 refs., Leningrad, 1973
DT - MON (MONOGRAPH)
LA - rus
IT - residential buildings; laboratory techniques; computerized simulation; foundations; frost heave; permafrost beneath buildings; frost penetration; models

702

DFFE

-274-

AN - 30000910
 TI - Frost heave of soil as an ecological factor in Picea jessoensis forests
 OTI - Moroznoe puchenie pochvy kak ekologicheskii faktor v lesakh iz ell alanskoi
 AU - Kalinichenko, E.P.; Moskaev, A.P.
 SO - Ekologiya, Mar.-Apr. 1975-No.2, p.28-36, In Russian. 16 refs.
 DT - J (JOURNAL ARTICLE)
 LA - rus
 IT - damage; forest soils; soil moisture migration; frost penetration; frost heave
 ST - Tree roots

-275-

AN - 30000890
 TI - Foundations for buildings and structures. Construction rules and practical standards
 OTI - Osnovaniya zdaniy i sooruzheniy. Stroitel'nye normy i pravila
 OS - Russia. Gosudarstvennyi komitet po delam stroitel'stva
 SO - Stroitel'nye normy i pravila, 1975-2(15), 64p., In Russian.
 DT - J (JOURNAL ARTICLE)
 LA - rus
 IT - settlement (structural); ground thawing; buildings; foundations; footings; power line supports; frost heave

-276-

AN - 30000553
 TI - Compacting loess soils in southern West Siberia
 OTI - Uplotnenie lessovykh gruntov luga Zapadnoi Sibiri
 AU - Nikitenko, F.A.; Arz'ev, V.S.; Matsenko, V.V.
 SO - Vsesoiuzhnoe soveshchanie po zakrepleniiu i uplotneniiu gruntov v stroitel'stve, 8, Kiev, 1974, Materialy (All-Union Conference on Ground Stabilization and Compacting, 8th., Kiev, 1974, Proceedings), p.325-327, In Russian., Kiev, Budivel'nyk, 1974
 DT - PA (PAPER)
 LA - rus
 IT - cold weather construction; fines; frost penetration; loess; soil compacting; frost heave

-277-

AN - 30000401
 TI - Influence of the composition of coarse-clastic grounds on their physical and mechanical properties
 OTI - Vliyanie sostava krupnooblochnykh gruntov na ikh fiziko-mekhanicheskie svoystva
 AU - Dobrov, E.M.; Kamenetskaya, L.B.; Ivanova, T.M.
 SO - Moscow. Vsesoiuznyi dorozhnyi nauchno-issledovatel'skii

DFFE

institut. Trudy, 1972-Vol.60, p.107-128, In Russian. 4 refs.
 DT - J (JOURNAL ARTICLE)
 LA - rus
 IT - tests; shear strength; bearing strength; gravel; sands; fines;
 seasonal freeze thaw; frost heave

-278-

AN - 30000324
 TI - Structure of frost heaved soil and velocity of compressive waves
 AU - Fukuda, M.; Inoue, M.
 SO - Low temperature science (Teion kagaku). Series A Physical
 sciences, 1974-Vol.32, p.283-286, In Japanese. 4 refs.
 DT - J (JOURNAL ARTICLE)
 LA - jap
 IT - frozen ground; frost heave; ultrasonic tests; soil structure

-279-

AN - 30000319
 TI - Frost heave in Tomakomai (1973-1974)
 AU - Kinoshita, S.; Suzuki, Y.; Horiguchi, K.; Fukuda, M.; Inoue, M.
 SO - Low temperature science (Teion kagaku). Series A Physical
 sciences, 1974-Vol.32, p.251-260, In Japanese with English
 summary. 15 refs.
 DT - J (JOURNAL ARTICLE)
 LA - jap, eng
 IT - frost heave; soil moisture; water table; soil pressure

-280-

AN - 30000019
 TI - Construction on frost heaving and weak ground in the North
 OTI - Stroitel'stvo v usloviakh puchiniy i slabikh gruntov Severa
 AU - Ushkalov, V.P.
 SO - 44p., In Russian with abridged English table of contents
 enclosed. 26 refs., Novosibirsk, Nauka, 1974
 DT - MON (MONOGRAPH)
 LA - rus
 IT - design; buildings; permafrost; ussr -yakutia; foundations; frozen
 fines; clay soils; frost penetration; frost heave

-281-

AN - 29003917
 TI - Use of the freezing soil stress system to evaluate the frost
 susceptibility of soils
 AU - Olsen, J.M.; Wissa, A.E.Z.; Martin, T.
 SO - Massachusetts Institute of Technology. Department of Civil
 Engineering, Report, May 1974-R74-32, 118p.
 DT - R (REPORT)

DFFE

LA - eng
IT - soil freezing; frost heave; test equipment; stresses

-282-

AN - 29003779
TI - Heat and moisture transfer in seasonally freezing ground of roadbeds
OTI - O perenose tepla i vlagi v sezonnopromerzaiushchikh gruntakh zemliannogo polotna avtomobil'nykh dorog
AU - Lukina, V.A.; Uvarov, B.V.
SO - Russia. Ministerstvo vysshego i srednego spetsial'nogo obrazovaniia. Izvestiia vysshikh uchebnykh zavedenii. Lesnoi zhurnal, 1974-17(4), p.51-58, In Russian. 10 refs.
DT - J (JOURNAL ARTICLE)
LA - rus
IT - heat transfer; analysis (mathematics); roadbeds; freeze thaw cycles; frost heave; soil moisture migration

-283-

AN - 29003640
TI - Performance of foundations built on pillows of coarse-grained ground
OTI - Analiz uslovii raboty fundamentov na podushkakh iz krupnozernistogo grunta
AU - Kudriavtsev, A.N.; Zavarukhin, A.P.
SO - Irkutsk. Politekhnikheskii institut. Trudy, 1972-Vol.78, p.56-61, In Russian. 5 refs.
DT - J (JOURNAL ARTICLE)
LA - rus
IT - bearing ground; sands; gravel; buildings; foundations; frost heave; seasonal freeze thaw; soil moisture migration

-284-

AN - 29003459
TI - Inexpensive chest for conducting frost-heaving experiments
AU - Heidmann, L.J.
SO - U.S. Rocky Mountain Forest and Range Experiment Station, Fort Collins, Colorado. U.S. Forest Service research note, July 1974-No.RM-269, 4p., 8 refs.
DT - R (REPORT)
LA - eng
IT - tests; artificial freezing; frozen ground; frost heave; laboratory techniques

705

OFFE

-285-

AN - 29003317
TI - Cryogenic, cryo-diagenetic and diagenetic relief of the central areas of northwestern Siberia
OTI - Merzlotnyi, merzlotno-diageneticheskii i diageneticheskii rel'ef tsentral'nykh raionov severa Zapadnoi Sibiri
AU - Kostiaev, A.G.; Kopylov, I.F.
SO - Problemy kriolitologii, 1974-Vol.4, p.209-243, In Russian. Refs. p. 241-243
DT - MON (MONOGRAPH)
LA - rus
IT - frost heave; polygonal topography; thermokarst; cryogenic processes; patterned ground; frost shattering; ice veins
ST - Submarine permafrost

-286-

AN - 29003302
TI - Forecasting deformation of bearing ground beneath buildings on gravel beds
OTI - Prognozirovaniye deformatsii osnovanii pod zdaniami na podsypkakh
AU - Tishin, V.G.
SO - Stroitel'stvo truboprovodov, Jan. 1975-No.1, p.23, In Russian.
DT - J (JOURNAL ARTICLE)
LA - rus
IT - analysis (mathematics); buildings; foundations; frost heave; frost penetration

-287-

AN - 29003179
TI - Priorities for basic research on permafrost
OS - National Research Council. Committee on Polar Research
SO - 53p., Washington, D.C., National Academy of Sciences, 1974
DT - MON (MONOGRAPH)
LA - eng
IT - thermal regime; rheology; permafrost; active layer; frozen ground; ecology; research projects; soil formation; frost heave; patterned ground; slope processes

-288-

AN - 29003171
TI - Pore water expulsion during freezing
AU - McRoberts, E.C.; Morgenstern, N.R.
SO - Canadian geotechnical journal, Feb. 1975-12(1), p.130-141, In English with French summary. 15 refs.
DT - J (JOURNAL ARTICLE)
LA - eng, fre
IT - soil freezing; water pressure; frost heave; soil moisture migration

DFFE

-289-

AN - 29003156
 TI - Study of needle ice events at Vancouver, Canada, 1961-1968
 AU - Outcalt, S.I.
 SO - 135p., Ph.D. thesis. Refs. p.119-124. No microfiche available.,
 Vancouver, University of British Columbia, April 1970
 DT - MON (MONOGRAPH)
 LA - eng
 IT - surface temperature ground water; models; climatic factors; ice
 needles; ice crystal growth; frost heave; freeze thaw cycles

-290-

AN - 29003149
 TI - Standard values of specific values of specific tangential forces
 of frost heaving of soils
 AU - Kiselev, M.F.; Orlov, V.O.
 SO - Soil mechanics and foundation engineering, May-June 1974 (Publ.
 Nov. 74)-11(3), p.207-214, Translated from Osnovaniia, fundamenti
 i mekhanika gruntov. 19 refs. Includes comments by V.O. Orlov.
 DT - J (JOURNAL ARTICLE)
 LA - eng
 IT - shear stress design; foundations; frost heave

-291-

AN - 29003148
 TI - Thermal effect of buildings on the tangential forces of frost
 heaving of foundations
 AU - Pushkov, V.I.
 SO - Soil mechanics and foundation engineering, May-June 1974 (Publ.
 Nov. 74)-11(3), p.180-183, Translated from Osnovaniia, fundamenti
 i mekhanika gruntov. 1 refs.
 DT - J (JOURNAL ARTICLE)
 LA - eng, rus
 IT - foundations; frost heave; soil freezing; frost penetration; soil
 moisture migration; ice formation

-292-

AN - 29003147
 TI - Experimental investigations of the effect of frost heaving on
 shallow low-loaded foundations
 AU - Shterenfel'd, N.S.
 SO - Soil mechanics and foundation engineering, May-June 1974 (Publ.
 Nov. 74)-11(3), p.155-160, Translated from Osnovaniia, fundamenti
 i mekhanika gruntov. 4 refs.
 DT - J (JOURNAL ARTICLE)
 LA - eng
 IT - settlement (structural); foundations; frost heave; ground thawing

-293-

AN - 29003141
 TI - Engineering and geological consequences of perennial freezing of rocks in the northeastern USSR
 OTI - Inzhenerno-geologicheskie posledstviya mnogoletnego promerzaniya porod na Severo-Vostoke
 AU - Gol'dtman, V.G.
 SO - Magadan. Vsesoiuznyi nauchno-issledovatel'skii institut zolota i redkikh metallov. Trudy, Merzlotovedenie (Geocryology), 1972-32(3), p.64-79, In Russian. 22 refs.
 DT - J (JOURNAL ARTICLE)
 LA - rus
 IT - permafrost hydrology; ground water; soil moisture migration; heat transfer; frost penetration; ground ice; frost shattering; frost heave; subpermafrost ground water; taliks

-294-

AN - 29003130
 TI - Influence of frost heave on the ground freezing process
 OTI - K voprosu o vliyanii pucheniya na protsess promerzaniya grunta
 AU - Khain, V.IA.
 SO - Voprosy geotekhniki, 1972-Vol. 20, p.159-166, In Russian. 4 refs.
 DT - J (JOURNAL ARTICLE)
 LA - rus
 IT - heat transfer; mass transfer; analysis (mathematics); soil freezing; frost heave; ground ice; ice formation; frost penetration; soil moisture migration

-295-

AN - 29003046
 TI - Design of tunnel lining for frost heave
 OTI - Staticheskii raschet tunnel'nykh obdelok na deistvie sil moroznogo pucheniya grunta
 AU - Slavin, B.E.; Myshkina, G.P.
 SO - Soveshchanie-seminar po obmenu opytom stroitel'stva v surovyykh klimaticheskikh usloviyakh, 6, Krasnoyarsk, 1970 (Conference-seminar on the exchange of experience in construction under severe climatic conditions, 6th, Krasnoyarsk, 1970), 1970-7(4), p.38-46, In Russian. 7 refs.
 DT - PA (PAPER)
 LA - rus
 IT - design; frost heave; tunnels; linings

DFFE

-296-

AN - 29003045
TI - Designing bridge pier foundations for frost heave
OTI - Osobennosti rascheta na vypuchivanie fundamentov opor mostov
AU - Glotov, N.M.; Peretrukhin, N.A.
SO - Soveshchanie-seminar po obmenu opytom stroitel'stva v surovyykh klimaticheskikh usloviyakh, 6, Krasnoyarsk, 1970
(Conference-seminar on the exchange of experience in construction under severe climatic conditions, 6th, Krasnoyarsk, 1970),
1970-7(4), p.33-37, In Russian. 3 refs.
DT - PA (PAPER)
LA - rus
IT - design; bridges; frost heave

-297-

AN - 29002854
TI - Freezing processes at the bottom of permafrost, Tuktoyaktuk Peninsula area, District of Mackenzie (107 C)
AU - Mackay, J.R.
SO - Canada. Geological Survey. Paper, 1975-75-1, Part A, p.471-474, 4 refs.
DT - J (JOURNAL ARTICLE)
LA - eng
IT - permafrost thermal properties; unfrozen water content; frost heave
ST - Drained lake basins

-298-

AN - 29002696
TI - Using morainal soil for roadbed for the Leningrad-Murmansk highway
OTI - Vozvedenie zemliannogo polcna iz morennykh gruntov na doroge Leningrad-Murmansk
AU - Tsukanov, G.
SO - Avtomobil'nye dorogi, Nov., 1974-No.11, 3-4, In Russian.
DT - J (JOURNAL ARTICLE)
LA - rus
IT - slope stability; cold weather construction; roadbeds; earthwork; soil moisture migration; frost penetration; frost heave; soil compacting

-299-

AN - 29002636
TI - Arctic soils
AU - Rieger, S.
SO - Arctic and Alpine environments, edited by J.D. Ives and R.G. Barry, p.749-769, Numerous refs., London, Methuen and Co., 1974
DT - PA (PAPER)
LA - eng
IT - arctic soils; active layer; thaw depth; frost heave; soil

classification

-300-

AN - 29002458
TI - Model for the freezing of water in a dispersed medium
AU - Vignes, M.; Dijkema, K.M.
SO - Journal of colloid and interface science, Nov. 1974-49(2),
p.165-172, 20 refs.
DT - J (JOURNAL ARTICLE)
LA - eng
IT - capillary ice; ice growth; frost heave; laboratory techniques

-301-

AN - 29002311
TI - Frost heave and soil settlement in the active layer of the
Lena-Vilyuy Interfluv
OTI - Puchenie i osadka porod sloia sezonnogo ottaivaniia na
Lena-Viliuiskom vodorazdele
AU - Zamolotchikova, S.A.
SO - Merzlotnye issledovaniia, 1974-Vol. 14, p.148-153, In Russian. 6
refs.
DT - J (JOURNAL ARTICLE)
LA - rus
IT - active layer; frost heave; seasonal freeze thaw; soil moisture
migration; frost penetration

-302-

AN - 29002235
TI - Calculation and experimental study of the thermal effect of a
building on its seasonally freezing bearing ground (Bibliographic
review)
OTI - Raschet i eksperimental'noe issledovanie teplovogo vliianiia
zdanii na sezonno-promerzaiushchee gruntovoe osnovanie
(Informatsionnyi obzor)
AU - Stanov, V.I.; Kotiukov, D.A.
SO - 105p., In Russian with English table of contents enclosed. 31
refs., Moscow, 1968
DT - MON (MONOGRAPH)
LA - rus
IT - frozen ground temperature; buildings; foundations; frost heave;
seasonal freeze thaw; frost penetration

DFFE

-303-

AN - 29002181
 TI - Formation of pingos in the Mackenzie Delta, N.W.T.
 OTI - Zur Entstehung der Pingos im Mackenzie Delta, N.W.T.
 AU - Bleich, K.E.
 SO - Polarforschung, 1974-44(1), p.60-66. In German with English summary.
 DT - J (JOURNAL ARTICLE)
 LA - ger, eng
 IT - meltwater; geomorphology; frost heave; canada -northwest territories -mackenzie river; pingos; ice cracks; icebound lakes

-304-

AN - 29002069
 TI - Loads on underground pipe due to frost penetration
 AU - Monie, W.D.; Clark, C.M.
 SO - American Water Works Association. Journal, June 1974-66(6), p.353-358
 DT - J (JOURNAL ARTICLE)
 LA - eng
 IT - water pipelines; soil mechanics; frost penetration; frost heave
 ST - Underground pipelines

-305-

AN - 29001925
 TI - Crack repair settlement investigation Contract DACD85-70-C-0063 maintain primary runway Elmendorf AFB, Alaska
 OS - U.S. Army Engineer District, Alaska
 SO - Various pagings, Includes an addendum to the basic report plus correspondence., 1970
 DT - R (REPORT)
 LA - eng
 IT - runways; maintenance; frost heave; cracks; subgrade maintenance

-306-

AN - 29001759
 TI - Designing thermal insulation for electrically heated floors of refrigerators
 OTI - K proektirovaniu teploizolitsii elektroobogrevaemykh polov kholodil'nikov
 AU - Gindolan, A.G.; Duranov, E.F.; Khodyreva, V.T.
 SO - Promyshlennoe stroitel'stvo, July 1974-No.7, p.33-37. In Russian. 9 refs.
 DT - J (JOURNAL ARTICLE)
 LA - rus
 IT - countermeasures; refrigerating; floors; thermal insulation; frost heave

DFFE

-307-

AN - 29001636
 TI - Reduction of frost heave by surcharge stress
 AU - Aitken, G.W.
 SO - U.S. Army Cold Regions Research and Engineering Laboratory, REPT.
 NO. TR 184, Aug. 1974, 24p., 10 refs.
 DT - R (REPORT)
 LA - eng
 IT - soil mechanics; frost heave; measuring instruments; static loads
 AB - The results of a six-year field test program conducted near Fairbanks, Alaska, to investigate the reduction in frost heave obtained by applying a surcharge stress on the soil are presented. Seasonal heaves of 25-ft-square test sections with nominal surcharge loads of 2, 4, 6, and 8 psi were compared with heaves at adjacent unloaded sections. The test sections were on a silt soil in an area where permafrost existed at about a 7-ft depth. Results showed that only a small surcharge load was needed to cause significant reductions in heave. Data are included that indicate that heave reduction was achieved by minimizing groundwater migration. A method for correlating field and laboratory rate-of-heave data is suggested.

-308-

AN - 29001471
 TI - Moisture content of thawed soil at the freezing boundary
 OTI - O vlazhnosti talogo grunta na granitse promerzaniia
 AU - Zhestkova, T.N.; Shur, I.U.L.
 SO - Moscow. Universitet. Vestnik. Seriya 4 Geologiya, July-Aug. 1974-No.4, p.69-73, In Russian. 7 refs.
 DT - J (JOURNAL ARTICLE)
 LA - rus
 IT - soil freezing; clay soils; soil moisture migration; frost penetration; frost heave

-309-

AN - 29001337
 TI - Striations oriented parallel to slope as an evidence of cryoturbation
 OTI - Cryoturbations en forme de stries enracinees paralleles a la pente
 AU - Collard, M.
 SO - Biuletyn peryglacjalny, 1973-No.22, p.323-327, In French. 7 refs.
 DT - J (JOURNAL ARTICLE)
 LA - fre
 IT - cryoturbation; cryogenic soils; frost heave; solifluction; periglacial mass movement

712

DFFE

-310-

AN - 29001334
 TI - Comed-hummocky peatbogs of the northern taiga in Western Siberia
 AU - Ehpollanskaia, N.A.; Evseev, V.P.
 SO - Biuletyn peryglacjalny, 1973 -No.22, p.271-283, 12 refs.
 DT - J (JOURNAL ARTICLE)
 LA - eng
 IT - thixotropy; swamps; taiga vegetation; frozen fines; peat; frost heave
 ST - Palsas

-311-

AN - 29001280
 TI - Thermokarst phenomena and landforms due to frost heaving in central Yakutia
 AU - Solov'ev, P.A.
 SO - Biuletyn peryglacjalny, International Symposium on Periglacial Phenomena and Paleogeography of the Pleistocene, Yakutsk-Moscow, 1969 (Part I), 1973-No.23, p.135-155, 6 refs.
 DT - J (JOURNAL ARTICLE)
 LA - eng
 IT - thermokarst development; permafrost structure; frost heave; cryogenic formations; alassy

-312-

AN - 29001278
 TI - Results of tests on frost action in soil
 OTI - Resultats d'expériences sur l'action du gel dans le sol
 AU - Pissart, A.
 SO - Biuletyn peryglacjalny, International Symposium on Periglacial Phenomena and Paleogeography of the Pleistocene, Yakutsk-Moscow, 1969 (Part I), 1973-No.23, p.101-113, In French with English summary, 9 refs.
 DT - J (JOURNAL ARTICLE)
 LA - eng, fre, eng
 IT - frost action; soil freezing; frost heave; frozen ground mechanics

-313-

AN - 29001262
 TI - Frost susceptibility of soils using heave pressure measurements
 AU - Shrestha, B.B.
 SO - 142p., M. Sc. thesis. Numerous refs. No microfiche available., Cambridge, Massachusetts Institute of Technology, 1971
 DT - MON (MONOGRAPH)
 LA - eng
 IT - frost resistance; frost heave; soil pressure; soil temperature; temperature gradients

DFFE

-314-

AN - 29001219
 TI - Frost heave problem in relation to building linear structures in West Siberia
 OTI - K voprosu pucheniia grunta v svyazi so stroitel'stvom lineinykh sooruzhenii na territorii Zapadnoi Sibiri
 AU - Smirnov, V.V.
 SO - Prirodnye uslovia Zapadnoi Sibiri, Vyp.4 (Natural conditions in West Siberia, Vol.4) Edited by A.I. Popov, p.116-124, In Russian, 5 refs., Moscow, Universitet, 1973
 DT - PA (PAPER)
 LA - rus
 IT - models; trenching; frozen fines; pipelines; ground ice; frost heave
 ST - Conduits

-315-

AN - 29001166
 TI - Laboratory formation of extrusion features by multicyclic freeze-thaw in soils
 AU - Corte, A.E.
 SO - Centre de geomorphologie de Caen. Bulletin, May-Nov. 1972-No. 13-15, p.157-182, 13 refs. Discussion.
 ET - PA (PAPER)
 LA - eng, fre
 IT - soil freezing; freeze thaw tests; frost heave

-316-

AN - 29001164
 TI - Growth and development of perturbations on the soil surface due to the repetition of freezing and thawing
 AU - Corte, A.E.; Higashi, A.
 SO - Centre de geomorphologie de Caen. Bulletin, May-Nov. 1972-No. 13-15, p.117-129, With French summary. 4 refs.
 DT - PA (PAPER)
 LA - eng, fre
 IT - models; frozen ground mechanics; frost heave

-317-

AN - 29001008
 TI - Frost susceptibility of Massachusetts soils--evaluation of rapid frost susceptibility tests
 AU - Martin, R.T.; Wissa, A.E.Z.
 SO - Massachusetts Institute of Technology. Department of Civil Engineering. Research report, March 1973-R73-60, 256p.
 DT - R (REPORT)
 LA - eng
 IT - laboratory techniques; soil tests; soil freezing; frost heave;

DFFE

soil pressure; water pressure

-318-

AN - 29000971
 TI - Uplift forces on foundations in frost heaving soils
 AU - Penner, E.
 SO - Canadian geotechnical journal, Aug. 1974-11(3), p.323-338, 14 refs.
 DT - J (JOURNAL ARTICLE)
 LA - eng
 IT - foundations; frost heave

-319-

AN - 29000952
 TI - Manual for determining physical, thermal and mechanical characteristics of frozen soil
 OTI - Rukovodstvo po opredeleniiu fizicheskikh, teplofizicheskikh i mekhanicheskikh kharakteristik merzlykh gruntov
 OS - Proizvodstvennyi i nauchno-issledovatel'skii institut po inzhenernym izyskaniyam v stroitel'stve
 SO - 91p., In Russian with English table of contents enclosed., Moscow, 1973
 DT - MON (MONOGRAPH)
 LA - rus
 IT - mechanical tests; laboratory techniques; compressive properties; shear strength; ground ice; frozen ground analysis; frozen ground temperature; samplers; frost heave; ground thawing

-320-

AN - 29000914
 TI - Freezing test for evaluating relative frost susceptibility of various soils
 AU - Kaplan, C.W.
 SO - U.S. Army Cold Regions Research and Engineering Laboratory, REPT. NO. TR 250, June 1974, 36p., 14 refs.
 DT - R (REPORT)
 LA - eng
 IT - test equipment; low temperature tests; frozen ground mechanics; frost heave; frost resistance
 AB - This report presents a description of the equipment and procedures used in the laboratory test of the relative frost susceptibility of different soils on Corps of Engineers construction projects and includes typical results of freezing tests of natural soils. The test utilizes a slow unidirectional freezing of a 6-in. high, remolded or undisturbed soil specimen with water available at the base (open system). The heaving rate measured during the test is used as the basis for classification of the frost susceptibility potential of the soil. This type of test, which measures heaving rate, is considered most versatile

and adaptable for evaluating the effects of numerous soil parameters on frost heave.

-321-

AN - 29000878
TI - Electrochemical method of preventing frost heave of ground
OTI - Elektrokhimicheskii metod profilaktiki moroznogo pucheniia gruntov
AU - Fridman, O.M.; Ibragimov, K.K.; Chernykh, V.D.
SO - 28p., In Russian with English table of contents enclosed. 18
refs., Leningrad, 1971
DT - MON (MONOGRAPH)
LA - rus
IT - frost heave; ground ice; ice growth; frost penetration; soil
moisture migration; frost protection

-322-

AN - 29000845
TI - Water migration in the soil during the frost heaving
AU - Kinoshita, S.
SO - Norges teknisk-naturvitenskapelige forskningsrad og Statens
vegvesens Utvalg for frost i jord. Publikasjoner, Sept.
1973-No. 11, p.37-40
DT - J (JOURNAL ARTICLE)
LA - eng
IT - frost heave; soil moisture migration; frozen ground hydrology

-323-

AN - 29000844
TI - Study of the mechanism of frost heave and stabilization by the
use of deflocculating agents
AU - Denalp, A.
SO - Norges teknisk-naturvitenskapelige forskningsrad og Statens
vegvesens Utvalg for frost i jord. Publikasjoner, Sept.
1973-No. 11, p.15-30, 30 refs.
DT - J (JOURNAL ARTICLE)
LA - eng
IT - sodium tripolyphosphate; frost heave; soil stabilization; frost
penetration; soil moisture migration; porosity

-324-

AN - 29000653
TI - Ground swelling by frost prevention
AU - Fridman, O.M.; Ibragimov, K.K.; Sedlukha, G.A.
SO - Soviet inventions illustrated. Section 3 Mechanical and general,
1974-V(22), p.U9
DT - P (PATENT)
LA - eng, rus

DFFE

IT - soil dehydration; frost heave; electric equipment

-325-

AN - 29000471
 TI - On the thermal expansion of frozen soil (preliminary report)
 AU - Horiguchi, K.
 SO - Low temperature science (Teion kagaku). Series A Physical sciences, 1973-No.31, p.295-298, In Japanese. Ref.
 DT - J (JOURNAL ARTICLE)
 LA - jap
 IT - frozen ground thermodynamics; frost heave

-326-

AN - 29000463
 TI - Theoretical study on the heaving force of freezing soil
 AU - Yoshida, Z.
 SO - Low temperature science (Teion kagaku). Series A Physical sciences, 1973-No.31, p.231-244, In Japanese with English summary. 4 refs.
 DT - J (JOURNAL ARTICLE)
 LA - jap, eng
 IT - frost heave; soil freezing; stresses

-327-

AN - 29000172
 TI - Foundations for light buildings on treated bases
 OTI - Fundamenty pod malonagruzhennye zdaniya na zaranee podgotovlennom osnovanii
 AU - Zhulin, V.IA.
 SO - Osnovaniya, fundamenty i podzemnye sooruzheniya, 1973-No.62, p.139-144, In Russian. 13 refs.
 DT - J (JOURNAL ARTICLE)
 LA - rus
 IT - countermeasures; design; buildings; foundations; seasonal freeze thaw; frost heave

-328-

AN - 29000128
 TI - Seasonal frost heave and frost penetration measurements in the Indian Peaks region of the Colorado Front Range
 AU - Fahey, B.D.
 SO - Arctic and alpine research, Winter 1974-6(1), p.63-70, 31 refs.
 DT - J (JOURNAL ARTICLE)
 LA - eng
 IT - seasonal variations; measurement; frost heave; frost penetration

DFFE

-329-

- AN - 29000059
TI - Design of large-panel buildings for complicated geologic conditions
OTI - Proektirovanie krupnopanel'nykh zdaniy dlya slozhnykh geologicheskikh usloviy
AU - Sergeev, D.D.
SO - 159p.. In Russian with English table of contents enclosed., Moscow, Stroizdat, 1973
DT - MON (MONOGRAPH)
LA - rus
IT - buildings; foundations; permafrost beneath buildings; frost heave; ground thawing; settlement (structural)

-330-

- AN - 29000049
TI - Investigation of tangential forces of frost heave
AU - Petrov, B.G.
SO - Soil mechanics and foundation engineering, Sept.-Oct. 1973-10(5), p.313-315, 6 refs.
DT - J (JOURNAL ARTICLE)
LA - eng, rus
IT - stresses; experimentation; frost heave; soil pressure; foundations; frost penetration

-331-

- AN - 29000026
TI - Protecting bearing ground from freezing
OTI - Zashchita osnovaniya ot promerzaniya
AU - Okon, I.; Mil'ner, E.
SO - Na stroikakh Rossii, Oct. 1972-No.10, p.48-49, In Russian.
DT - J (JOURNAL ARTICLE)
LA - rus
IT - frost heave; soil freezing; frost protection; artificial thawing; winter concreting; foundations

-332-

- AN - 28004278
TI - Designing land-reclamation systems for seasonal freeze-thaw conditions
OTI - Proektirovanie meliorativnykh sistem v usloviakh sezonnogo promerzaniya gruntov
AU - Bishof, E.A.; Zhigalev, I.U.P.
SO - Gidrotekhnika i melioratsiya, Dec. 1973-No.12, p.6-11, In Russian. 9 refs.
DT - J (JOURNAL ARTICLE)
LA - rus
IT - pipelines; swamps; drainage; seasonal freeze thaw; active layer;

718

surface drainage; frost heave

-333-

AN - 28004218
TI - Hydrothermal movements of soil near the lower Angara River
OTI - Gidrotermicheskie dvizheniya gruntov v nizhnem Priangar'ie
AU - Volloshnikov, V.A.
SO - Iuzhnaia taiga Priangar'ia (Southern taiga in the Angara River region); p.166-218, In Russian with French summary. 45 refs., Leningrad, Nauka, 1969
DT - PA (PAPER)
LA - rus, fre
IT - ground ice; taiga soils; seasonal freeze thaw; cryogenic processes; discontinuous permafrost; permafrost hydrology; cryogenic relief; frost heave

-334-

AN - 28004103
TI - Performance of shallow mat-footings of electric substations built on frost-heaving ground
OTI - Nekotorye rezul'taty issledovaniia raboty nezaglubennykh fundamentov podstantsii na puchinykh gruntakh
AU - Shterenfel'd, N.S.
SO - Energeticheskoe stroitel'stvo, 1973-No.2, p.68-72, In Russian. 7 refs.
DT - J (JOURNAL ARTICLE)
LA - rus
IT - design; foundations; frost heave; frost penetration

-335-

AN - 28003918
TI - Quantitative analysis of freeze-thaw cycles, frost heave cycles, and frost penetration in the Front Range of the Rocky Mountains, Boulder County, Colorado
AU - Fahey, B.D.
SO - 329p., Ph. D. Thesis. See also 28-668., Boulder, University of Colorado, 1971
DT - MON (MONOGRAPH)
LA - eng
IT - freeze thaw cycles; frost heave; diurnal variations; frost penetration; seasonal variations

OFFE

-336-

- AN - 28003542
 TI - Some results concerning frost heaving and their application to soil classification according to frost susceptibility
 OTI - Quelques resultats concernant le gonflement au gel et leur application au classement des sols selon leur degre de gelivite
 AU - Aguirre-Puente, J.; Dupas, A.; Philippe, A.
 SO - Laboratoire central des ponts et chaussees. Bulletin de liaison des laboratoires routiers: Ponts et chaussees, Nov.-Dec. 1973-No.68 (supplement), p.23-29, In French with English, German, Spanish and Russian summaries (p.40-55). 7 refs.
 DT - J (JOURNAL ARTICLE)
 LA - fre, eng, ger, spa, rus
 IT - frost heave; soil classification; frost resistance

-337-

- AN - 28003452
 TI - Frost penetration in sandy soil
 AU - Janson, L.-E.
 SO - 165p., Refs. p.155-165, Goteborg, Sweden, Elanders Boktryckeri, 1963
 DT - MON (MONOGRAPH)
 LA - eng
 IT - frost penetration; sands; soil moisture; porosity; frost heave; laboratory techniques

-338-

- AN - 28003374
 TI - Construction of large-panel residential buildings on water-saturated clayey soil in Novosibirsk
 OTI - Stroitel'stvo krupnopanel'nykh zhilykh domov na vodonasyshchennykh glinistykh gruntakh v Novosibirske
 AU - Charushkin, I.G.; Shaevich, I.A.E.
 SO - Vsesoiuznoe soveshchanie po stroitel'stvu na slabykh vodonasyshchennykh glinistykh gruntakh, Materialy (All-Union conference on construction on weak, water-saturated clay, Proceedings), p.322-325, In Russian., Tallin, 1965
 DT - PA (PAPER)
 LA - rus
 IT - permafrost preservation; residential buildings; permafrost beneath buildings; clay soils; frost heave

720

DFFE

-339-

- AN - 28003319
 TI - Nature of ground freezing and the use of high-molecular compounds to prevent frost heave
 OTI - Priroda smerzaemosti gruntov i primeneniye vysokomolekuliarnykh soedinenii v bor'be s vypuchivaniem fundamentov
 AU - Tiutiunov, I.A.; Pchelintsev, A.M.
 SO - Stroitel'stvo v rayonakh Vostochnoi Sibiri i Krainego Severa, 1969-Vol.14, p.127-143, In Russian. 8 refs.
 DT - J (JOURNAL ARTICLE)
 LA - rus
 IT - countermeasures; soil freezing; soil moisture migration; frost penetration; permafrost beneath buildings; foundations; frost heave; polymers

-340-

- AN - 28003275
 TI - Waterproofing of soil for frost-heave prevention
 OTI - Gidrofobizatsiya gruntov v tseliakh bor'by s silami puchenija
 AU - Kriukov, G.N.
 SO - Vsesoiuznaya konferentsiya-seminar po obobshcheniyu opyta proektirovaniya, stroitel'stva i ekspluatatsii sistem vodosnabzheniya i kanalizatsii v rayonakh Vostochnoi Sibiri i Krainego Severa, Tiumen', 1968 (All-Union conference-seminar on design, construction and operation of water supply and sewage systems in East Siberia and the Far North, Tiumen', 1968), p.126-135, In Russian., Leningrad, 1968
 DT - PA (PAPER)
 LA - rus
 IT - soils; waterproofing; soil freezing; soil moisture migration; frost heave

-341-

- AN - 28003231
 TI - Deformation of hydraulic structures at the Kabansk channel in the Buryat ASSR
 OTI - Deformatsii sooruzhenii Kabanskogo ograditel'nogo kanala v Buriatskoi ASSR
 AU - Iakhtenfel'd, I.P.
 SO - Moscow, Institut inzhenerov vodnogo khoziaistva. Nauchnye zapiski, 1968-33(2), P.84-89, In Russian. 1 ref.
 DT - J (JOURNAL ARTICLE)
 LA - rus
 IT - hydraulic structures; channels (waterways); slope stability; concretes; prefabrication; permafrost beneath rivers; active layer; frost heave; rafts

DFFE

-342-

- AN - 28003192
 TI - Salt weathering processes in the Mcurdo Dry Valley regions of South Victoria Land, Antarctica
 AU - Johnston, J.H.
 SO - New Zealand journal of geology and geophysics, July 1973-16(2), p.221-224, 13 refs.
 IS - AB VOL. 7 ITEM 13335
 DT - J (JOURNAL ARTICLE)
 LA - eng
 CC - *E (GEOLOGICAL SCIENCES)
 IT - geomorphology; geochemistry; antarctica -taylor valley; weathering; frost heave
 AB - The salt weathering and frost heaving processes leading to the disintegration of granite bedrock in the Taylor Dry Valley, South Victoria Land, Antarctica, have been investigated. The weathering appears to be mainly physical with only relatively small amounts of chemical weathering taking place. (Auth.)

-343-

- AN - 28003176
 TI - Critical velocity of freezing front in fine-grained porous media
 OTI - Kriticheskaya skorost' fronta zamorazhivaniya poristykh sred tonkoi granulatsii
 AU - Aguirre-Puente, J.; Dupas, A.
 SO - Vsesoiuznoe soveshchanie po teplo- i massoobmenu. Teplo- i massopereenos, 1972-Vol.9(1), p.121-145, In Russian. 11 refs.
 DT - PA (PAPER)
 LA - rus, eng
 IT - mathematical models; frozen ground temperature; measuring instruments; frost heave; experimentation; laboratory techniques; soil freezing; soil moisture migration; frost penetration

-344-

- AN - 28003064
 TI - Geocryology. Textbook for students of structural engineering. Part I
 OTI - Geokriologiya (Merzlotovedenie). Metodicheskoe posobie dlia studentov stroitel'noi spetsial'nosti. Chast' pervaya
 AU - Fetisov, V.G.
 SO - 114p., In Russian with English table of contents enclosed. 47 refs., Khabarovsk, 1968
 DT - MON (MONOGRAPH)
 LA - rus
 IT - frozen rocks; classifications; permafrost distribution; permafrost structure; active layer; seasonal freeze thaw; permafrost hydrology; cryogenic processes; thermokarst; solifluction; naleds; frost heave; engineering geology; civil engineering

722

DFFE

-345-

- AN - 28003004
TI - Evaluation of the intensity of ground heave during freezing
OTI - Otsenka puchinistosti gruntov pri zamerzanii
AU - Vasil'ev, I.U.M.
SO - Voprosy proektirovaniia i sooruzheniia zemliianogo polotna avtomobil'nykh dorog (Design and construction of rights-of-way for roads) Trudy SOIUZDORNII Vol.37, p.147-155, In Russian. 4 refs., Balashikha, 1970
DT - PA (PAPER)
LA - rus
IT - analysis (mathematics): frost heave; soil moisture migration; heat transfer; mass transfer; frost penetration

-346-

- AN - 28003002
TI - Stabilizing embankment slopes by earth treated with mineral and organic sizing materials
OTI - Ukreplenie otkosov zemliianogo polotna avtomobil'nykh dorog gruntom, obrabotannym mineral'nymi i organicheskimi vliashushchimi
AU - Kazarnovskii, V.D.; L'vovich, I.U.M.; Vel'makina, N.I.; Pokrovskaia, N.A.; Liberman, M.A.; Tserpin'sh, T.M.; Liniser, A.V.; Bolshtianskii M.P.; Anisimov, P.V.; Semenov, V.A.
SO - Voprosy proektirovaniia i sooruzheniia zemliianogo polotna avtomobil'nykh dorog (Design and construction of rights-of-way for roads) Trudy SOIUZDORNII Vol.37, p.61-92, In Russian., Balashikha, 1970
DT - PA (PAPER)
LA - rus
IT - embankments; slope stability; soil stabilization; cements; freeze thaw cycles; frost heave

-347-

- AN - 28002947
TI - Reduction of frost heaving by tetraalkylammonium ions
AU - Kay, B.D.; Scott, W.S.
SO - Canadian journal of soil science, Nov. 1973-53(4), p.421-427, With French summary. 14 refs.
DT - J (JOURNAL ARTICLE)
LA - eng, fre
IT - hydraulics; soil moisture migration; frost heave; soil freezing; frost resistance
ST - Tetraalkylammonium ions

723

DFFE

-348-

AN - 28002910
TI - Frost insulation
OTI - Frostisolering
AU - Bergschold, B.; Jansson, I.
SO - Lantbrukshogskolan. Institutionen for lantbrukets byggnadsteknik. Handlingar, 1969-No.112, 66p., In Swedish. 23 refs.
DT - R (REPORT)
LA - swe
IT - air temperature; buildings; frost heave; frost penetration; thermal insulation; foundations

-349-

AN - 28002853
TI - Experimental method of classifying soils according to the extent to which they break up on freezing
AU - Aguirre-Puente, J.; Dupas, A.; Philippe, A.
SO - U.S. Army Cold Regions Research and Engineering Laboratory, REPT. NO. TL 392, Aug. 1973, 22p., For French original see 28-2069. 19 refs.
DT - J (JOURNAL ARTICLE)
LA - eng, fre
IT - soil freezing; plastic deformation; frost penetration; frost heave; ground water; equipment
AB - An experimental method, based upon a test of swelling upon freezing, permits relative classification of different soils with respect to one another according to a parameter brought to light by fundamental studies of swelling upon freezing, which is the slope of the straight line curve of swelling as a function of the square root of the frost index. An experimental installation was developed for this purpose, with which relative classification of eight soils covering a wide range in their extent of breaking up on freezing was accomplished. The studies have the objectives, in a first phase, of establishing an operating procedure, and in a second phase, relative classification of the greatest possible number of soils.

-350-

AN - 28002623
TI - Studying moisture regime of heavy impervious soils
OTI - Issledovanie rezhima vlazhnosti tiazhelykh slabopronitsaemykh pochv
AU - Rudol, A.U.
SO - Minsk. Belorusskii nauchno-issledovatel'skii institut melioratsii i vodnogo khoziaistva. Trudy, 1973-Vol.21, p.34-44, In Russian. 8 refs.
DT - J (JOURNAL ARTICLE)
LA - rus
IT - clay soils; permeability; soil moisture migration; settlement

(structural); frost penetration; frost heave

-351-

AN - 28002562
TI - Effect of initial density on ice separation in freezing ground
OTI - Vliianie plotnosti na l'dovydelenie promerzaiushchikh gruntov
AU - Zhestkova, T.N.
SO - Merzlotnye issledovaniia, 1973-Vol.13, p.205-211, In Russian. 3
refs.
DT - J (JOURNAL ARTICLE)
LA - rus
IT - frozen fines; clay soils; density (mass/volume); soil moisture
migration; ice formation; frost heave

-352-

AN - 28002561
TI - Variation of humidity and physical properties of ground due to
compacting under immediate loading
OTI - Izmenenie vodno-fizicheskikh svoistv gruntov pri uplotnenii ikh
kratkovremennymi nagruzkami
AU - Ershov, E.D.; Ananian, A.A.; Dontsova, L.P.
SO - Merzlotnye issledovaniia, 1973-Vol.13, p.199-204, In Russian. 9
refs.
DT - J (JOURNAL ARTICLE)
LA - rus
IT - clay soils; soil compacting; soil moisture migration; frost
penetration; frost heave; ground ice; frozen fines; bearing
strength

-353-

AN - 23002560
TI - Approximate calculation of mean effective radius of capillary
pores in ground
OTI - Priblizhennyi metod rascheta srednego effektivnogo radiusa por
(kapilliarov) grunta
AU - Ershov, E.D.; Cheverev, V.G.
SO - Merzlotnye issledovaniia, 1973-Vol.13, p.195-198, In Russian. 9
refs.
DT - J (JOURNAL ARTICLE)
LA - rus
IT - analysis (mathematics); frost heave; soils; capillarity; porosity

-354-

AN - 28002557
TI - Dependence of the moisture-transfer coefficients of water-unsaturated ground on its moisture content, grain size and density
DTI - Zavisimost' koëffitsientov vlagoperenosa vodonenasyshchennykh gruntov ot ikh vlazhnosti, granulometricheskogo sostava i plotnosti
AU - Kudriavtsev, V.A.; Ershov, E.D.; Cheverev, V.G.
SO - Merzlotnye issledovaniia, 1973-Vol.13, p.176-182, In Russian. 6 refs.
DT - J (JOURNAL ARTICLE)
LA - rus
IT - frost heave; fines; grain size; soil moisture migration; capillarity

-355-

AN - 28002550
TI - Possibility of studying heat and moisture transfer in freezing fines using a linear solution of the problem of frost penetration with moisture migration
DTI - K voprosu o vezmozhnosti issledovaniia teplo- i vlagoobmena v promerzaiushchikh tonkodispersnykh porodakh s pomoshch'iu linearnizovannogo resheniia zadachi promerzaniia s migratsiei vlagi
AU - Melamed, V.G.; Medvedev, A.V.
SO - Merzlotnye issledovaniia, 1973-Vol.13, p.135-141, In Russian. 4 refs.
DT - J (JOURNAL ARTICLE)
LA - rus
IT - heat transfer; mass transfer; soil freezing; soil moisture migration; frozen fines; frost penetration; mathematical models; frost heave

-356-

AN - 28002549
TI - Mathematical model for solving the problem of freezing fines, allowing for frost heave and ice formation on the ground surface
DTI - Avtomodel'noe reshenie zadachi o promerzaniit tonkodispersnykh porod s uchetom puchenii i l'dobrazovaniia na poverkhnosti grunta
AU - Melamed, V.G.; Medvedev, A.V.
SO - Merzlotnye issledovaniia, 1973-Vol.13, p.116-134, In Russian. 9 refs.
DT - J (JOURNAL ARTICLE)
LA - rus
IT - frozen fines; soil moisture migration; frost penetration; mathematical models; computer applications

DFFE

-357-

AN - 28002341
TI - Designing foundations with anchor plates on thawing bases,
subject to tangential frost-heave forces
OTI - Raschet fundamentov s ankernoi plitoi na talom osnovanii,
podverzhennykh deistviu kasatel'nykh sil moroznogo vypuchivaniia
AU - Puskov, V.I.
SO - Novosibirsk. Institut inzhenerov zheleznodorozhnogo transporta.
Trudy, 1969-Vol.90, p.120-130, In Russian. 11 refs.
DT - J (JOURNAL ARTICLE)
LA - rus
IT - frost heave; foundations; deformation; stress analysis

-358-

AN - 28002340
TI - Regional norms and the methods of studying tangential forces
causing frost heave of foundations
OTI - O regional'nom normirovanii i metodakh issledovaniia kasatel'nykh
sil moroznogo vypuchivaniia fundamentov
AU - Puskov, V.I.
SO - Novosibirsk. Institut inzhenerov zheleznodorozhnogo transporta.
Trudy, 1969-Vol.90, p.109-119, In Russian. 16 refs.
DT - J (JOURNAL ARTICLE)
LA - rus
IT - stress analysis; foundations; deformation; frost heave

-359-

AN - 28002122
TI - Salt migration and frost heaving of salt treated soils in view of
freezing and thawing
AU - Yong, R.N.; Sheeran, D.E.; Janiga, P.V.
SO - Symposium on Frost Action on Roads, Oslo, Norway, Oct. 1-3, 1973,
Vol.2, p.439-450, 11 refs., Paris, Organisation for Economic
Co-operation and Development, 1973
DT - PA (PAPER)
LA - eng
IT - Frost heave; salting; frost protection; subgrade maintenance;
freeze thaw cycles

-360-

AN - 28002117
TI - Frost properties of cement stabilized bases and subbases
AU - Balduzzi, F.
SO - Symposium on Frost Action on Roads, Oslo, Norway, Oct. 1-3, 1973,
Vol.2, p.355-376, 4 refs., Paris, Organisation for Economic
Co-operation and Development, 1973
DT - PA (PAPER)
LA - eng

727

DFFE

IT - frost protection; soil cement; subgrade preparation; bearing capacity; frost heave; frost resistance

-361-

AN - 28002097
TI - Frost heaving pressures in particulate materials
AU - Penner, E.
SO - Symposium on Frost Action on Roads, Oslo, Norway, Oct. 1-3, 1973, Vol. 1, p.379-385, 15 refs., Paris, Organisation for Economic Co-operation and Development, 1973
DT - PA (PAPER)
LA - eng
IT - frost heave; particle size distribution; soil texture; frost forecasting; ice lenses

-362-

AN - 28002096
TI - Freezing mechanism and pressure condition at the freezing front
AU - Saetersdal, R.
SO - Symposium on Frost Action on Roads, Oslo, Norway, Oct. 1-3, 1973, Vol. 1, p.365-373, Paris, Organisation for Economic Co-operation and Development, 1973
DT - PA (PAPER)
LA - eng
IT - soil freezing; frost forecasting; frost heave; soil mechanics

-363-

AN - 28002092
TI - Physical basis of the growth of ice lenses in soils
AU - Keinonen, L.
SO - Symposium on Frost Action on Roads, Oslo, Norway, Oct. 1-3, 1973, Vol. 1, p.311-316, Ref., Paris, Organisation for Economic Co-operation and Development, 1973
DT - PA (PAPER)
LA - eng
IT - ice lenses; ice formation; ice structure; soil freezing; molecular structure; frost heave; freezing points

-364-

AN - 28002090
TI - Evaluation of the frost cracking of soils according to different interpretations of measurements
OTI - Evaluation de la gellivite des sols par differentes interpretations des mesures
AU - Gorle, D.
SO - Symposium on Frost Action on Roads, Oslo, Norway, Oct. 1-3, 1973, Vol. 1, p.279-293, In French. 10 refs., Paris, Organisation for

OFFE

Economic Co-operation and Development, 1973

- DT - PA (PAPER)
LA - fre
IT - moisture content; soil moisture; frost shattering; soil freezing;
frost heave

-365-

- AN - 28002089
TI - Results of frost heaving and their application to soil
classification according to the degree of frost cracking
OTI - Quelques resultats concernant le gonflement au gel et leur
application au classement des sols selon leur degre de gellivite
AU - Aguirre-Puente, J.; Dupas, A.; Philippe, A.
SO - Symposium on Frost Action on Roads, Oslo, Norway, Oct. 1-3, 1973,
Vol.1, p.267-278, In French. 7 refs., Paris, Organisation for
Economic Co-operation and Development, 1973
DT - PA (PAPER)
LA - fre
IT - soil classification; frost heave; frost shattering; frozen ground
mechanics

-366-

- AN - 28002088
TI - Frost heave susceptibility research
AU - Obermeier, S.F.
SO - Symposium on Frost Action on Roads, Oslo, Norway, Oct. 1-3, 1973,
Vol.1, p.251-266, 12 refs., Paris, Organisation for Economic
Co-operation and Development, 1973
DT - PA (PAPER)
LA - eng
IT - frost heave; frost forecasting; stress analysis

-367-

- AN - 28002086
TI - Theory and experience regarding frost penetration and frost
heaving
AU - Knutson, A.F.
SO - Symposium on Frost Action on Roads, Oslo, Norway, Oct. 1-3, 1973,
Vol.1, p.223-234, 9 refs., Paris, Organisation for Economic
Co-operation and Development, 1973
DT - PA (PAPER)
LA - eng
IT - analysis (mathematics); frost penetration; frost heave; frost
resistance; roadbeds; thermal insulation

DFFE

-368-

AN - 28002070
 TI - Critical rate of advance of the frost front in fine porous media
 OTI - Vitesse critique du front de congelation dans des milieux poreux fins
 AU - Aguirre-Puente, J.; Dupas, A.
 SO - Laboratoire central des ponts et chaussées. Bulletin de liaison des laboratoires routiers: Ponts et chaussées, Sept.-Oct. 1972-No.61, p.145-154, In French with English, Russian and Spanish summaries. 11 refs.
 DT - J (JOURNAL ARTICLE)
 LA - fre, eng, rus, spa
 IT - soil freezing; soil texture; frost heave; frost resistance

-369-

AN - 28002052
 TI - Methods of studying frost heave of soil under laboratory conditions
 OTI - K voprosu o metodike issledovaniia moroznogo pucheniia gruntov v laboratornykh usloviakh
 AU - Karpov, V.M.
 SO - Osnovaniia, fundamenti i mekhanika gruntov. Doklady na XIX nauchnoi konferentsii (Nineteenth scientific conference on soil mechanics and foundation engineering), p.9-12, In Russian., Leningrad, 1961
 DT - PA (PAPER)
 LA - rus
 IT - soil freezing; frost heave; low temperature tests; test equipment

-370-

AN - 28001909
 TI - Peculiarities of handling tall spoil banks at quarries in the North
 OTI - Osobennosti ekspluatatsii vysokikh otvalov na kar'erakh Severa
 AU - Ovodenko, B.K.; Usynin, V.I.; Eremin, G.M.; Romanov, O.V.; Lebedev, V.K.
 SO - Problemy razrabotki mestorozhdenii poleznykh iskopaemykh Severa (Development of mineral resources of the North), p.144-148, In Russian., Leningrad, 1972
 DT - PA (PAPER)
 LA - rus
 IT - mining; frost heave; slope processes; cryogenic processes

-371-

- AN - 28001890
TI - Frost susceptibility of soils used for building hydraulic structures in the Far North
OTI - K voprosu o morozoopasnosti gruntov, ispol'zuemykh v gidrotekhnicheskoy stroitel'stve na Krainem Severe
AU - Kronik, I.A.
SO - Moscow. Inzhenerno-stroitel'nyi institut. Sbornik trudov, 1973-No.115, p.159-167. In Russian. 6 refs.
DT - J (JOURNAL ARTICLE)
LA - rus
IT - construction materials; classification; earth dams; frost heave; frost resistance

-372-

- AN - 28001879
TI - Mechanical properties and thermal expansion of frozen ground in relation to earth dam construction in Yakutia
OTI - Rezul'taty issledovaniia mekhanicheskikh svoistv i temperatur'nogo rasshireniia merzlykh gruntov v svyazi so stroitel'stvom zemlianykh plotin v Tsentral'noi Iakutii
AU - Sheshin, I.U.B.
SO - Moscow. Vsesoiuznyi nauchno-issledovatel'skii institut gidrogeologii i inzhenernoi geologii. Trudy, 1973-Vol.55, p.95-101. In Russian. 4 refs.
DT - J (JOURNAL ARTICLE)
LA - rus
IT - earth dams; frost heave; fracturing; frozen ground compression; frozen ground extension; frozen ground strength

-373-

- AN - 28001878
TI - Theoretical and experimental studies of thermal stresses and deformations of earth dams in winter
OTI - Teoreticheskie i eksperimental'nye issledovaniia temperaturnykh napriazhenii i deformatsii v zemlianykh plotinakh v zimnii period
AU - Grechishchev, S.E.; Sheshin, I.U.B.
SO - Moscow. Vsesoiuznyi nauchno-issledovatel'skii institut gidrogeologii i inzhenernoi geologii. Trudy, 1973-Vol.55, p.77-94. In Russian. 4 refs.
DT - J (JOURNAL ARTICLE)
LA - rus
IT - stress analysis; earth dams; frost penetration; frost heave; deformation

DFFE

-374-

- AN - 28001872
TI - Effect of moisture and freezing on the strength of rocks surrounding underground excavations
OTI - Vliianie uvlazhneniia i promerzaniia na prochnost' gornykh porod vokrug podzemnykh vyrabotok
AU - Zil'berbord, A.F.
SO - Moscow. Vsesoiuznyi nauchno-issledovatel'skii institut gidrogeologii i inzhenernoi geologii. Trudy, 1973-Vol.55, p.15-26, In Russian. 13 refs.
DT - J (JOURNAL ARTICLE)
LA - rus
IT - soil moisture migration; frost penetration; ground ice; underground storage; cold storage; frozen ground strength; frost heave

-375-

- AN - 28001830
TI - Designing bases for power-line supports
OTI - Proektirovanie fundamentov opor lini elektropperedach
AU - Bukharin, E.M.; Gablita, I.U.A.; Levin, L.E.
SO - 215p. (Pertinent p.74-111), In Russian. 60 refs., Moscow, Energiia, 1971
DT - MON (MONOGRAPH)
LA - rus
IT - design; power line supports; foundations; swamps; permafrost thermal properties; frost heave; frozen fines; soil moisture migration

-376-

- AN - 28001822
TI - Some factors affecting the rates and processes of periglacial mass movements
AU - Harris, C.
SO - Geografiska annaler. Series A. Physical geography, 1973-55A(1), p.24-28, 11 refs.
DT - J (JOURNAL ARTICLE)
LA - eng
IT - periglacial mass movement; soil creep; frost heave; soil moisture; cryogenic slope processes; slope orientation

DFFE

-377-

AN - 28001693
TI - Frost heaving pressures
AU - Hoekstra, P.
SO - Copenhagen. Polyteknisk laereanstalt. Laboratoriet for elektromagnetisk feltteori. Report, REPT. NO. MP 704, Sept. 1971-R 110, 19p., 18 refs.
DT - R (REPORT)
LA - eng
IT - soil freezing; frost heave; soil moisture migration; water content; soil pressure

-378-

AN - 28001665
TI - Correlation between frost heave and movements in the foundation walls of one-family houses: Effect of ground insulation using mineral wool
OTI - Samband mellan tjalning och rorelser hos grundmurar i smahus: Inverkan av markisolering med mineralull
AU - Fyrhake, L.
SO - Stockholm. Statens Institut for Byggnadforskning. Rapport, 1973-R20, 26p., In Swedish with English summary. 2 refs.
DT - J (JOURNAL ARTICLE)
LA - swe, eng
IT - frost heave; settlement (structural); foundations; insulation
ST - Mineral wool

-379-

AN - 28001612
TI - On ground interbeddings in ice hummocks of naleds
AU - Nekrasov, I.A.
SO - U.S. Army Cold Regions Research and Engineering Laboratory, Siberian naleds, April 1973, p.192-196, Translation of Naledi Sibiri, Moscow, Nauka, 1969.
DT - J (JOURNAL ARTICLE)
LA - eng, rus
IT - naleds; taliks; ice accretion; ice structure; impurities; frost heave

-380-

AN - 28001611
TI - On explosion of hydrolaccoliths in southern part of Chitinskaya oblast
AU - Bgomolov, N.S.; Skliarevskaya, A.N.
SO - U.S. Army Cold Regions Research and Engineering Laboratory, Siberian naleds, April 1973, p.187-191, Translation of Naledi Sibiri, Moscow, Nauka, 1969.
DT - J (JOURNAL ARTICLE)

DFFE

LA - eng, rus
 IT - naleds; pingos; ice lenses; ice growth; frost heave; ice composition; water chemistry

-381-

AN - 28001582
 TI - Movement of frozen soil undergoing variations in sub-zero temperatures; results of dilatometric measurements
 OTI - Mouvements de sols geles subissant des variations de temperature sous 0; resultats de mesures dilatometriques
 AU - Pissart, A.J.G.
 SO - International Geographical Congress, 22nd, Montreal, 1972. Papers. Edited by W.P. Adams and F.M. Helleiner, 1972-Vol.1, p.124-126, In French. 3 refs.
 DT - PA (PAPER)
 LA - fre
 IT - cryogenic slope processes; frost heave; solifluction; flow rate

-382-

AN - 28001571
 TI - Cryopedimentation: an important type of slope development in cold environment
 AU - Demek, J.
 SO - International Geographical Congress, 22nd, Montreal, 1972. Papers. Edited by W.P. Adams and F.M. Helleiner, 1972-Vol.1, p.15-17, 5 refs.
 DT - PA (PAPER)
 LA - eng
 IT - arctic topography; periglacial processes; cryogenic slope processes; frost weathering; frost heave; altiplanation

-383-

AN - 28001421
 TI - Frost heave and the rapid frost heave test
 AU - Zoller, J.H.
 SO - Public roads, Sept. 1973-37(6), p.211-220, 39 refs.
 DT - J (JOURNAL ARTICLE)
 LA - eng
 IT - soil freezing; soil composition; soil chemistry; frozen ground hydrology; frost heave; test equipment; soil tests

DFFE

-384-

AN - 28001384
 TI - Comparison of the T.R.R.L. and C.R.R.E.L. tests for the frost susceptibility of soils
 AU - Sutherland, H.B.; Gaskin, P.N.
 SO - Canadian geotechnical journal, Aug. 1973-10(3), p.553-557, In English with French summary. 12 refs.
 DT - J (JOURNAL ARTICLE)
 LA - eng, fre
 IT - soil freezing; frost resistance; low temperature tests; soil tests; frost heave

-385-

AN - 28001269
 TI - Hydrophobic lime increases the stability of roadbeds
 OTI - Gidrofobnaya izvest' spsobstvuet ustoychivosti zemliannogo polotna
 AU - Gerasimenko, V.G.
 SO - Avtomobil'nye dorogi, June 1973-No.6, p.7, In Russian.
 DT - J (JOURNAL ARTICLE)
 LA - rus
 IT - roadbeds; soil stabilization; cements; liming; frost heave

-386-

AN - 28001241
 TI - Some aspects of permafrost growth, Mackenzie Delta area, N.W.T. (107 B, C, D)
 AU - Mackay, J.R.
 SO - Canada. Geological Survey. Paper, April-Oct. 1972-73(1-Part A), p.232-233, Ref.
 DT - J (JOURNAL ARTICLE)
 LA - eng
 IT - Canada - northwest territories - Mackenzie river; permafrost beneath lakes; permafrost distribution; pingos; frost heave; active layer; permafrost physics

-387-

AN - 28001193
 TI - Cryogenic phenomena in hydraulic structures built of earth
 OTI - Kriogennyye yavleniya v zemliannykh gidrotekhnicheskikh sooruzheniyakh
 AU - Kronik, I.A.A.
 SO - International Conference on Permafrost, 2nd, Yakutsk, 1973, 1973-Vol.7, p.240-243, In Russian. 7 refs.
 DT - PA (PAPER)
 LA - rus
 IT - earth dams; cryogenic processes; frost heave; ice melting; frost shattering; solifluction; naleds

DFFE

-388-

AN - 28001187
TI - Design values of specific, tangential, frost-heave forces
OTI - Znachenia udel'nykh kasatel'nykh sil pucheniia gruntov
AU - Kiselev, M.F.
SO - International Conference on Permafrost, 2nd, Yakutsk, 1973,
1973-Vol.7, p.214-218, In Russian.
DT - PA (PAPER)
LA - rus
IT - design; stress analysis; cryogenic processes; frost heave;
foundations

-389-

AN - 28001168
TI - Interaction between frost-susceptible ground and single
foundations
OTI - Issledovanie vzaimodelstvia puchinistogo grunta s odinochnymi
fundamentami
AU - Peretrukhin, N.A.; Dubnov, I.U.D.; Merenkov, N.D.
SO - International Conference on Permafrost, 2nd, Yakutsk, 1973,
1973-Vol.7, p.96-102, In Russian. 7 refs.
DT - PA (PAPER)
LA - rus
IT - laboratory techniques; foundations; permafrost beneath buildings;
frost heave; soil moisture migration; models

-390-

AN - 28001167
TI - Interaction between freezing, frost-susceptible ground and
foundations
OTI - Vzaimodelstvie promerzaiushchikh puchinistykh gruntov s
fundamentami
AU - Dalmatov, B.I.; Karlov, V.D.; Turenko, I.I.; Ulitskii, V.M.;
Kharlab, V.D.
SO - International Conference on Permafrost, 2nd, Yakutsk, 1973,
1973-Vol.7, p.89-96, In Russian. 9 refs.
DT - PA (PAPER)
LA - rus
IT - frozen fines; clays; frost heave; permafrost beneath buildings;
foundations

736

DFFE

-391-

- AN - 28001156
 TI - Engineering-geocryological conditions and the principles of construction in the Magadan region
 OTI - Inzhenerno-geokriologicheskie uslovia i printsipy stroitel'stva v Magadanskoi oblasti
 AU - Gol'dtman, V.G.
 SO - International Conference on Permafrost, 2nd, Yakutsk, 1973, 1973-Vol.7, p.5-10, In Russian. 7 refs.
 DT - PA (PAPER)
 LA - rus
 IT - permafrost distribution; lithology; alluvium; frost heave; ground thawing; settlement (structural)
 ST - Permafrost construction

-392-

- AN - 28001090
 TI - Freeze-thaw effect on the structure, composition and properties of cohesive soils
 OTI - Vliianie promerzaniia i ottaivaniia na stroenie, sostav i svoistva svlaznykh gruntov
 AU - Tlutiunov, L.A.; Averochkina, M.V.; Titov, A.V.
 SO - International Conference on Permafrost, 2nd, Yakutsk, 1973, 1973-Vol.4, p.98-104, In Russian. 6 refs.
 DT - PA (PAPER)
 LA - rus
 IT - frozen fines; ground thawing; loess; bearing strength; cryogenic processes; soil formation; clay minerals; frost heave; soil moisture migration; ground ice; ice growth

-393-

- AN - 28001087
 TI - Regularities governing frost-heave of freezing ground
 OTI - Nekotorye zakonomernosti sushcheniia promerzatushchikh gruntov
 AU - Orlov, V.O.
 SO - International Conference on Permafrost, 2nd, Yakutsk, 1973, 1973-Vol.4, p.86-89, In Russian. 2 refs.
 DT - PA (PAPER)
 LA - rus
 IT - cryogenic processes; frost heave; frozen fines; soil moisture migration; phase transformations; ground ice; ice growth

OFFE

-394-

AN - 28001084
TI - Effect of coagulants on frost heave intensity in clayey and sandy loams of the Far East
OTI - Vliianie veshchestv-koagulyatorov na velichinu moroznogo pucheniia dal'nevostochnykh supešei i suglinkov
AU - Voroshilov, G.D.
SD - International Conference on Permafrost, 2nd, Yakutsk, 1973, 1973-Vol.4, p.74-78, In Russian.
DT - PA (PAPER)
LA - rus
IT - clay soils; loams; frost penetration; frost heave; soil moisture migration; flow control; coagulation

-395-

AN - 28001076
TI - Mechanism of lenticular ice formation in streams and in ground
OTI - Mekhanizm formirovaniia linozoidnogo l'da v vodotokakh i gruntakh
AU - Utkin, B.V.
SD - International Conference on Permafrost, 2nd, Yakutsk, 1973, 1973-Vol.3, p.93-95, In Russian.
DT - PA (PAPER)
LA - rus
IT - thixotropy; ice lenses; pingos; ice growth; alimentation; frozen fines; frost heave

-396-

AN - 28001045
TI - Migratory frost-heave hummocks
OTI - Migratsionnye bugry pucheniia
AU - Evseev, V.P.
SD - International Conference on Permafrost, 2nd, Yakutsk, 1973, 1973-Vol.2, p.93-102, In Russian. 3 refs.
DT - PA (PAPER)
LA - rus
IT - cryogenic formations; cryogenic processes; pingos
ST - Palsas

-397-

AN - 28001026
TI - Studying cryogenic structure and frost heave of freezing fines with the aid of computers
OTI - Issledovanie kriogennogo stroeniia i pucheniia pri promerzaniia tonkodispersnykh porod s pomoshch'iu ETsVM
AU - Melamed, V.G.; Medvedev, A.V.
SD - International Conference on Permafrost, 2nd, Yakutsk, 1973, 1973-Vol.1, p.81-85, In Russian.
DT - PA (PAPER)

DFFE

LA - rus
 IT - frozen fines; frost penetration; ground ice; ice growth; frost heave; computer applications

-398-

AN - 28001023
 TI - Soil water migration during frost heave
 OTI - Migratsiia vody v grunte pri puchenii
 AU - Kinoshita, S.
 SO - International Conference on Permafrost, 2nd, Yakutsk, 1973, 1973-Vol.1, p.68-72, In Russian. 2 refs.
 DT - PA (PAPER)
 LA - rus
 IT - frost heave; ice lenses; ice growth; soil moisture migration

-399-

AN - 28001013
 TI - Second International Conference on Permafrost, papers and reports [International Conference on Permafrost, 2nd, Yakutsk, 1973]
 OTI - Vtoraja mezhdunarodnaya konferentsiia po merzlotovedeniiu doklady i soobshcheniia
 SO - 7 vols., In Russian. Numerous references. For individual papers see 28-1014 through 28-1198., Yakutskoe knizh. izd-vo., 1973
 DT - MDN (MONOGRAPH)
 LA - rus
 IT - meetings; permafrost origin; permafrost thermal cycles; active layer; frozen ground mechanics; frozen ground chemistry; frost heave; frozen fines; ground ice; heat balance; phase transformations; soil moisture migration; permafrost hydrology
 AB - Vol.1 Thermophysical processes of cryolithozone formation and development. Vol.2 Regional geocryology. Vol.3 Origin, composition and structure of perennially frozen rocks and ground ice. Vol.4 Physics, chemistry and mechanics of frozen rocks and ice. Vol.5 Ground water in the cryolithosphere. Vol.6 Fundamentals of geocryological survey and predictions. Vol.7 Control of cryogenic processes in permafrost regions during their development.

-400-

AN - 28000925
 TI - Foundations in frost susceptible grounds
 OTI - Fundamenty v puchinistykh gruntakh
 AU - Simagin, V.G.
 SO - 102p., In Russian. 33 refs., Petrozavodsk, Karelia, 1973
 DT - MON (MONOGRAPH)
 LA - rus
 IT - frozen fines; soil moisture migration; frost penetration; frost heave; foundations; footings

739

DFFE

-401-

AN - 28000842
TI - Some aspects of surficial salt treatment for attenuation of frost heaving
AU - Yong, R.N.; Osler, J.C.; Janiga, P.V.
SO - Permafrost: North American contribution to the Second International Conference, p.426-432, 10 refs., Washington, D.C., National Academy of Sciences, 1973
DT - PA (PAPER)
LA - eng
IT - ice lenses; soil moisture migration; frost penetration; ice growth; frost heave; salting

-402-

AN - 28000840
TI - Pore water and heaving pressures developed in partially frozen soils
AU - Sutherland, H.B.; Gaskin, P.N.
SO - Permafrost: North American contribution to the Second International Conference, p.409-419, 19 refs., Washington, D.C., National Academy of Sciences, 1973
DT - PA (PAPER)
LA - eng
IT - stress analysis; ice lenses; ice growth; frost heave; soil moisture migration; frost penetration

-403-

AN - 28000836
TI - Experimental pressure studies of frost heave mechanisms and the growth-fusion behavior of ice
AU - Radd, F.J.; Oertle, D.H.
SO - Permafrost: North American contribution to the Second International Conference, p.377-384, 21 refs., Washington, D.C., National Academy of Sciences, 1973
DT - PA (PAPER)
LA - eng
IT - test equipment; laboratory techniques; frozen fines; ground ice; ice lenses; ice growth; ice accretion; frost heave

-404-

AN - 28000668
TI - Analysis of diurnal freeze-thaw and frost-heave cycles in the Indian Peaks region of the Colorado Front Range
AU - Fahey, B.D.
SO - Arctic and alpine research, Summer 1973-5(3, Pt.1), p.269-281, 24 refs.
DT - J (JOURNAL ARTICLE)
LA - eng

DFFE

IT - diurnal variations; freeze thaw cycles; frost heave; measuring instruments

-405-

AN - 28000163
TI - Soil mechanics in foundation engineering
AU - Wilun, Z.; Starzewski, K.
SO - 2 Vols., 164 refs. Relevant pages Vol.1:p.6-8 Vol.2:p.133-148, 1972., London, Intertext Books, 1972
DT - MON (MONOGRAPH)
LA - eng
IT - soil mechanics; frost heave; frost protection; foundations; soil moisture

-406-

AN - 28000108
TI - Effect of clay soil freezing on the stability of a right-of-way
OTI - Vliianie zamerzaniya g'iristyykh gruntov na ustoychivost' zemliannogo polotna
AU - Snitko, N.K.
SO - Avtomobil'nye dorogi, March 1973-No.3, p.25-26, In Russian.
DT - J (JOURNAL ARTICLE)
LA - rus
IT - clay soils; soil moisture migration; soil freezing; frost heave; roadbeds

-407-

AN - 27003094
TI - Anti-swelling pillow
AU - Gritsyk, V.I.; Kharlamov, I.U.T.; Karmanov, V.V.
SO - Soviet inventions illustrated. Section 3 Mechanical and general, Feb. 1973, p.E5-E6
DT - P (PATENT)
LA - eng, rus
IT - subgrades; frost heave; countermeasures

-408-

AN - 27002971
TI - Up-heaved blocks: a curious feature of the instability in the tundra
AU - Price, L.W.
SO - Icefield ranges research project. Scientific results, 1972-Vol.3, p.177-181, 15 refs.
DT - J (JOURNAL ARTICLE)
LA - eng
IT - slope processes; tundra soils; frost heave; frozen ground physics; freeze thaw cycles; solifluction

741

DFFE

-409-

AN - 27002882
TI - Frost heave in Tomakomai (1971-1972)
AU - Kinoshita, S.; Suzuki, Y.; Horiguchi, K.; Tanuma, K.
SO - Low temperature science (Teton kagaku). Series A Physical sciences, 1972-No.30, p.203-210, In Japanese with English summary. 3 refs.
DT - J (JOURNAL ARTICLE)
LA - jap, eng
IT - frost heave; measuring instruments; electrical resistivity; soil moisture migration; freezing points

-410-

AN - 27002881
TI - Experiments on heaving force of freezing soil
AU - Kinoshita, S.
SO - Low temperature science (Teton kagaku). Series A Physical sciences, 1972-No.30, p.191-201, In Japanese with English summary. 6 refs.
DT - J (JOURNAL ARTICLE)
LA - jap, eng
IT - frost heave; soil freezing; frozen ground thermodynamics; soil pressure; water pressure

-411-

AN - 27002822
TI - Formation of beds of ground ice
AU - Bobov, N.G.
SO - Soviet geography: review and translation, June 1970-11(6), p.456-463, For Russian original see 25-342.
DT - J (JOURNAL ARTICLE)
LA - eng, rus
IT - ice physics; permafrost physics; active layer; thermokarsk development; pingos; ground ice; ice composition; frost heave

-412-

AN - 27002380
TI - Land under refrigeration
AU - James, P.
SO - Geographical magazine, Sept. 1972-44(12), p.853-857
IS - AB VOL. 6 ITEM 11935
DT - J (JOURNAL ARTICLE)
LA - eng
CC - *E (GEOLOGICAL SCIENCES); F (ICE AND SNOW)
IT - pedology-cryopedology; patterned ground; permafrost; geomorphology; ice; snow; periglacial processes; geomorphology; patterned ground; frost weathering; permafrost; solifluction
AB - The periglacial and geomorphological effects of frost and snow on

landform development are discussed. The most important forms of ground ice are needles, lenses, and ice-wedges which are restricted to the permanently frozen ground of the Arctic and Antarctic. Permafrost is characteristic of the Antarctic, Arctic, and sub-Arctic. Geomorphological processes related to the presence of snow cover are nivation, or snow-patch erosion, and erosion, and deposition by avalanches. Frost weathering and solifluction are the most important periglacial processes the former erodes and the latter transports and deposits. One of the most striking effects of frost action is patterned ground which results from the combination of frost-heave, solifluction and contraction cracking and occurs most extensively over permafrost. The nature of frost processes in cold, mountainous, and tropical regions is discussed. Computer simulation models are now being used to predict the likely results of frost action in any given conditions of site and climate.

-413-

AN - 27002158:
TI - Cemented soil with increased strain capacity
OTI - Tsementogrunť s povyšennoi deformativnost'iu
AU - Sakhinovskii, A.S.
SO - Moscow. Gosudarstvennyi vsesoiuznyi dorozhnyi nauchno-issledovatel'skii institut. Trudy, Ukreplenie gruntov vliazhushchimi v dorozhnom stroitel'stve (Strengthening ground with cements in road construction), 1970-Vol.38, p.101-112, In Russian. 8 refs.
DT - PA (PAPER)
LA - rus
IT - Frost heave; soil stabilization; soil cement; bituminous cements; soil strength; frost resistance; cold weather tests

-414-

AN - 27002145
TI - Ice formation in frozen soil
OTI - G isbildning i jordarter
AU - Freden, S.
SO - Norges teknisk-naturvitenskapelige forskningsrads og Statens vegvesens Utvalg for frøst i jord. Publikasjoner, Frost i jord. Symposium, 23-24 November 1970, Norway. Vol.1, Feb. 1971-No.2, p.45-49, In Norwegian with English summary and figure captions. 17 refs.
DT - PA (PAPER)
LA - nor, eng
IT - ice formation; frost heave; heat transfer; soil moisture; frozen ground thermodynamics

-415-

- AN - 27002012
TI - Computation of height of capillary rise of water in different genetic types of bound soils
AU - Chubarova, N.P.
SO - Soil mechanics and foundation engineering, Jan.-Feb. (Publ. Aug.) 1972-9(1), p.25-27. Translated from Osnovaniia, fundamenty i mekhanika gruntov.
DT - J (JOURNAL ARTICLE)
LA - eng, rus
IT - loams; loess; clay; soil moisture migration; capillarity; frost heave

-416-

- AN - 27001925
TI - Dehumidifying clayey soils with the GKZh-10 solution
OTI - Gidrofobizatsiia suglinkov rastvorom GKZh-10
AU - Grachev, I.A.; Sergeenkova, K.K.
SO - Vsesoiuznoe soveshchanie po zakrepleniiu i uplotneniiu gruntov. Materialy, 1969-6th, p.145-149, In Russian.
DT - PA (PAPER)
LA - rus
IT - clay soils; frost heave; dehumidification; earthwork

-417-

- AN - 27001855
TI - Determining mean thickness of water-film in thawed and frozen fines
DTI - Otsenka srednei tolshchiny plenok vody v talykh i merzlykh tonkodispersnykh gornykh porodakh
AU - Ananian, A.A.
SO - Sviazannaiia voda v dispersnykh sistemakh, 1972-Vol.2, p.106-113, In Russian. 20 refs.
DT - PA (PAPER)
LA - rus
IT - frozen fines; soil moisture migration; frost penetration; phase transformations; frost heave; unfrozen water content

-418-

- AN - 27001822
TI - Regularities governing the distribution of frost-heave movements in the lower part of the Angara River valley and their effect on topography
OTI - Prostranstvennye zakonómernosti i rel'efoobrazuiushchaia rol' gidrotermicheskikh dvizhenii gruntov v nizhnem Priangar'e
AU - Voloshnikov, V.A.
SO - Akademiia nauk SSSR. Sibirskoe otdelenie. Institut geografii Sibiri i Dal'nego Vostoka. Doklady, 1970-Vol.28, p.66-73, In

Russian. 5 refs.
 DT - J (JOURNAL ARTICLE)
 LA - rus
 IT - ussr - angara river; cryogenic processes; soil moisture migration; frost heave; cryogenic relief
 AB - The term "hydrothermal movements of ground" is suggested for uniformly widespread frost heaving.

-419-

AN - 27001761
 TI - Critical moisture content of ground for moisture migration to the freezing front
 OTI - Kriticheskaya vlazhnost' gruntov migratsii vlagi k frontu promerzaniya
 AU - Ershov, E.D.; Cheverev, V.G.
 SO - Merzlotnye issledovaniya, 1972-Vol. 12, p.197-199, In Russian. 9 refs.
 DT - J (JOURNAL ARTICLE)
 LA - rus
 IT - frozen fines; soil freezing; frost penetration; soil moisture migration; frost heave

-420-

AN - 27001754
 TI - Cryogenic physico-geological processes and formations in the lower Yenisey River valley
 OTI - Merzlotnye fiziko-geologicheskie protsessy i obrazovaniya v nizov'e doliny Eniseya
 AU - Gordeeva, G.I.; Garagulia, L.S.; Poltev, N.F.
 SO - Merzlotnye issledovaniya, 1972-Vol. 12, p.153-160, In Russian. 5 refs.
 DT - J (JOURNAL ARTICLE)
 LA - rus
 IT - ussr - yenisey river; cryogenic processes; solifluction; frost weathering; frost heave; thermokarst

-421-

AN - 27001741
 TI - Using electronic computers in studying the relation between surface temperature, cryogenic structure and frost heave dynamics in moist fines
 OTI - Issledovanie zavisimosti kriogennoy stroeniya i dinamiki pucheniya pri promerzaniy vlazhnykh tonkodispersnykh gruntov ot kharaktera temperaturnykh uslovii na poverkhnosti s pomoshch'yu EVM
 AU - Medvedev, A.V.; Melaned, V.G.
 SO - Merzlotnye issledovaniya, 1972-Vol. 12, p.19-28, In Russian. 3 refs.
 DT - J (JOURNAL ARTICLE)

DFFE

LA - rus
IT - analysis (mathematics); frozen fines; soil moisture migration;
soil temperature; frost penetration; frost heave; computer
applications

-422-

AN - 27001740
TI - Calculating the dynamics of temperature and moisture fields and
the intensity of frost heave in moist fines, during the freezing
of an active layer
OTI - Raschet dinamiki temperatur'nogo i vlazhnostnogo poia i velichiny
pucheniia vo vlazhnykh tonkodispersnykh gruntakh pri promerzani
sezonnotalogo sloia
AU - Melamed, V.G.; Medvedev, A.V.
SO - Merzlotnye issledovaniia, 1972-Vol.12, p.9-18, In Russian. 6
refs.
DT - J (JOURNAL ARTICLE)
LA - rus
IT - analysis (mathematics); frozen fines; active layer; cryogenic
structures; frost heave; soil moisture migration; permafrost
thermal properties

-423-

AN - 27001717
TI - Thermodynamic analysis of frost heaving of freezing ground
OTI - K termodinamicheskomu analizu kriogennogo pucheniia
promerzaiushchei gruntovoi massy
AU - Shvetsov, N.F.
SO - Akademiia nauk SSSR. Doklady, 1972-206(2), p.337-340, In
Russian. 10 refs.
DT - J (JOURNAL ARTICLE)
LA - rus
IT - analysis (mathematics); frozen fines; frost heave; soil moisture
migration; frost penetration

-424-

AN - 27001649
TI - Determining the height of capillary rise in soil of different
density and in artificial impervious layers inside the body of
earth dams
OTI - Opreделение vysoty kapillarnogo podniatija v gruntakh razlichnoi
plotnosti i konstruktsiakh iskusstvennykh kapillaropreryvatelei
v tele nasyti
AU - Shakhunians, G.M.; Mishnaevskaia, E.I.; Voitov, S.A.
SO - Moscow. Institut inzhenerov zheleznodorozhnogo transporta.
Trudy, 1972-Vol.357, p.3-100, In Russian. 17 refs.
DT - J (JOURNAL ARTICLE)
LA - rus
IT - models; tests; laboratory techniques; analysis (mathematics);

DFFE

soil moisture migration; soil freezing; earth dams; frost heave;
capillarity; frozen fines

-425-

AN - 27001129
TI - Solution of a problem on ground freezing, allowing for moisture transfer and frost heave
OTI - Zadacha o promerzani i gruntov s uchetom vlagoobmena i pucheniia
AU - Redozubov, D.V.
SO - Eksperimental'nye issledovaniia protsessov teploobmena v merzlykh gornykh porodakh (Experimental studies of heat transfer processes in frozen rocks), p.30-35, In Russian. 3 refs., Moscow, Nauka, 1972
DT - MON (MONOGRAPH)
LA - rus
IT - analysis (mathematics); soil freezing; frost penetration; soil moisture migration; frost heave

-426-

AN - 27001106
TI - Estimating soil frost heaving
OTI - Dtsenka puchinistosti gruntov pri zamerzani i
AU - Vasil'ev, I.U.M.
SO - Moscow, Gosudarstvennyi vsesoiuznyi dorozhnyi nauchno-issledovatel'skii institut. Trudy, 1970-Vol.39, p.147-155, In Russian. 4 refs.
DT - J (JOURNAL ARTICLE)
LA - rus
IT - frost heave; mineralogy; soil moisture

-427-

AN - 27001098
TI - Formation of frost heaving forces normal to the foundation base, and their computation
OTI - Formirovanie normal'nykh k ploskosti podoshvy fundamentov sil mroznogo vypuchivaniia i ikh raschet
AU - Fuskov, V.I.
SO - Novosibirsk. Institut inzhenerov zheleznodorozhnogo transporta. Trudy, 1970-No.106, p.157-170, In Russian. 11 refs.
DT - J (JOURNAL ARTICLE)
LA - rus
IT - analysis (mathematics); foundations; frost heave

747

DFFE

-428-

AN - 27001077
TI - Frost behavior of compacted soils
AU - Wang, M.-C.; Roderick, G.L.
SO - Highway research record, 1971-No.360, p.9-25, 17 refs.
DT - J (JOURNAL ARTICLE)
LA - eng
IT - ice lenses; water content; frost heave; soil compacting; soil temperature

-429-

AN - 27000955
TI - Study of frost heave in soils
OTI - Etude du gonflement des sols par le gel
AU - Khastou, B.
SO - 73p., Doctoral thesis. In French. No microfiche available.,
Paris, Université de Paris, 1970
DT - MON (MONOGRAPH)
LA - fre
IT - frost penetration; frost heave; soil freezing; experimental data

-430-

AN - 27000951
TI - Soil moisture redistribution by ice lensing in freezing soils
AU - Penner, E.
SO - National Research Council, Canada. Division of Building Research. Technical paper, May 1972-No.371, p.44-62, Paper presented at 17th Annual meeting, Canadian Soil Science Society, Lethbridge, Alberta, July 4-8, 1971. In English with French summary. 17 refs.
DT - PA (PAPER)
LA - eng, fre
IT - frost heave; soil temperature; soil moisture migration; soil freezing; ice lenses

-431-

AN - 27000950
TI - Growth and development of perturbations on the soil surface due to the repetition of freezing and thawing
AU - Higashi, A.; Corte, A.E.
SO - Hokkaido University, Sapporo, Japan. Kogakubu. Memoirs of the Faculty of Engineering, Hokkaido University, May 1972-Vol.13, Supplement, p.49-63, 4 refs.
DT - PA (PAPER)
LA - eng
IT - soil mechanics; freeze thaw cycles; patterned ground; frost heave; seasonal freeze thaw

DFFE

-432-

AN - 27000866
TI - Influence of freezing rate on frost heaving
AU - Penner, E.
SO - Highway research record, 1972-No.393, p.56-64, 9 refs.
DT - J (JOURNAL ARTICLE)
LA - eng
IT - ice lenses; soil freezing; frost heave; frost penetration; heat transfer
ST - Ice segregation

-433-

AN - 27000865
TI - Frost heaving versus depth to water table
AU - McGaw, R.
SO - Highway research record, REPT. NO. MP 594, 1972-No.393, p.45-55, 5 refs.
DT - J (JOURNAL ARTICLE)
LA - eng
IT - soil freezing; frost heave; frost penetration; water table
AB - A laboratory investigation of the influence of water table depth on the freezing characteristics of four soil types is described. The soils ranged from gravelly sand to sandy clay. Specimens were 42 in. long, with external water tables maintained at depths of 6, 18, 30, and 42 in. Specimens were frozen to a depth of 6 in. at rates of penetration between 0.10 and 0.50 in./day. The following relationships were obtained and are shown in the paper: rate of heave versus rate of penetration, rate of heave versus water table depth, and heave ratio versus water table depth. Portions of the data are extended graphically to give estimates of the influence of water table depths in excess of 3.5 ft. Rate of heave and heave ratio (ratio of heave rate to penetration rate) were observed to be functions both of water table depth and rate of penetration. With water table depth held constant, rate of heave increased with faster penetration rates. With freezing rate constant, rate of heave decreased with deeper water tables. With a single exception, heave ratio was reduced by increases in either penetration rate or water table depth. A reduction in heave ratio is shown to indicate a reduction in the water content of the frozen soil. A simple method is described by which heave ratio data may be used to obtain an estimate of the initial stability of a soil upon thawing.

749

DFFE

-434-

AN - 27000864
TI - Chemical additives to reduce frost heave and water accumulation
in soils
AU - Brandt, G.H.
SO - Highway research record, 1972-No.393, p.30-44, Includes
discussion. 35 refs.
DT - J (JOURNAL ARTICLE)
LA - eng
IT - Ice lenses; drying; frost resistance; capillary ice; chemical ice
prevention; soil moisture; moisture content; frost heave;
waterproofing

-435-

AN - 27000863
TI - Use of the ice-water surface tension concept in engineering
practice
AU - Williams, P.J.
SO - Highway research record, 1972-No.393, p.19-29, 20 refs.
DT - J (JOURNAL ARTICLE)
LA - eng
IT - soil freezing; frost resistance; ice water interface; ice
pressure; frost heave; thermal properties; interfacial tension

-436-

AN - 27000861
TI - Freezing and heaving of saturated and unsaturated soils
AU - Miller, R.D.
SO - Highway research record, 1972-No.393, p.1-11, 13 refs.
DT - J (JOURNAL ARTICLE)
LA - eng
IT - ice pressure; ice lenses; ice air interface; soil freezing; frost
heave; moisture content; ice creep

-437-

AN - 27000846
TI - Recent findings on the problem of frost in building foundations
OTI - Neue Erkenntnisse über das Frostproblem im Baugrund
AU - Klengel, K.J.
SO - Dresden. Hochschule für Verkehrswesen "Friedrich List."
Wissenschaftliche Zeitschrift, 1970-No.2, p.372-377, In German.
2 refs.
DT - J (JOURNAL ARTICLE)
LA - ger
IT - frost heave; foundations; freeze thaw tests; frozen gravel

-438-

AN - 27000799
TI - Field study of moisture movement and ground heave during freeze-up
AU - Yong, R.N.; Janiga, P.V.
SO - McGill University, Montreal. Soil Mechanics Laboratory. Soil mechanics series, Nov. 1971-No.30, 46p. plus figs., 2 refs.
DT - R (REPORT)
LA - eng
IT - frost penetration; temperature gradients; salinity; surface migration; soil moisture migration; water transport; frost heave; soil freezing

-439-

AN - 27000789
TI - Clay soil deformation during freezing and thawing
OTI - Deformatsiia glinistykh gruntov pri promerzani i ottaivanii
AU - Malyshev, M.A.
SO - Tomsk. Inzhenerno-stroitel'nyi institut. Sbornik nauchnykh trudov, 1969-Vol.14, p.58-62, In Russian.
DT - J (JOURNAL ARTICLE)
LA - rus
IT - foundations; clay soils; seasonal freeze thaw; frost heave; settlement (structural); laboratory techniques; freeze thaw cycles

-440-

AN - 27000491
TI - Damages of a cold storage due to frost heaving
AU - Kinoshita, S.; Suzuki, Y.; Horiguchi, K.; Tanuma, K.
SO - Low temperature science (Teion kagaku). Series A Physical sciences, 1971-Vol.29, p.257-266, In Japanese with English summary. 6 refs.
DT - J (JOURNAL ARTICLE)
LA - jap, eng
IT - water level; cold storage; thermal insulation; frost heave

-441-

AN - 27000490
TI - Change of water level during frost heaving III
AU - Kinoshita, S.; Suzuki, Y.; Horiguchi, K.; Tanuma, K.
SO - Low temperature science (Teion kagaku). Series A Physical sciences, 1971-Vol.29, p.245-256, In Japanese with English summary. 9 refs.
DT - J (JOURNAL ARTICLE)
LA - jap, eng
IT - meteorological data; frost heave; soil temperature; soil freezing; frost penetration; freeze thaw tests; water content; water level

DFFE

-442-

AN - 27000489
TI - Effect of thermal insulating on frost penetration II
AU - Tanuma, K.
SO - Low temperature science (Teion kagaku). Series A Physical sciences, 1971-Vol.29, p.239-244, In Japanese with English summary. 3 refs.
DT - J (JOURNAL ARTICLE)
LA - jap, eng
IT - frost penetration; frost protection; frost heave; thermal insulation; soil temperature

-443-

AN - 27000488
TI - Measurements of heat flow during frost heaving
AU - Tanuma, K.
SO - Low temperature science (Teion kagaku). Series A Physical sciences, 1971-Vol.29, p.231-237, In Japanese with English summary. 9 refs.
DT - J (JOURNAL ARTICLE)
LA - jap, eng
IT - heat flux; heat measurement; soil temperature; thermal conductivity; conduction; freezeup; soil freezing; frost heave

-444-

AN - 27000399
TI - Construction and permafrost
AU - Puzanov, I.I.; Karpov, V.M.
SO - U.S. Army Foreign Science and Technology Center. Translation, June 1972-FSTC-HT-23-1367-71, 80p., Translation of Stroitel'stvo i vechnaia merzlota, Leningrad, 1970
DT - MON (MONOGRAPH)
LA - eng, rus
IT - snow (construction material); ice (construction material); construction; permafrost beneath buildings; permafrost preservation; frost heave; ground ice; ground water; frozen ground mechanics

-445-

AN - 27000214
TI - Turf hummocks in the lower course of the Indigirka River
AU - Tolstov, A.N.
SO - U.S. Army Cold Regions Research and Engineering Laboratory, REPT. NO. TL 350, May 1972, 8p., For Russian text see 23-1311. 7 refs.
DT - J (JOURNAL ARTICLE)
LA - eng, rus
IT - hummocks; ground ice; arctic vegetation; frost heave

-446-

AN - 27000209
TI - Stability of foundations on clayey ground in regions with deep seasonal freezing
AU - Dalmatov, B.I.; Karpov, V.M.
SO - U.S. Army Cold Regions Research and Engineering Laboratory, REPT. NO. TL 344, April 1972, 11p., For Russian text see 23-4450. 7 refs.
DT - J (JOURNAL ARTICLE)
LA - eng, rus
IT - soil moisture content; foundations; settlement (structural); frozen ground settling; clay soils; seasonal freeze thaw; frost penetration; frost heave

-447-

AN - 27000078
TI - Frost heaving of clays in different states of stress
AU - Mel'nikov, B.N.; Shvets, V.B.
SO - Soil mechanics and foundation engineering, Sept.-Oct. 1971 (Publ. May 1972)-8(5), p.323-327, Translated from Osnovaniia, fundamenty i mekhanika gruntov. 4 refs.
DT - J (JOURNAL ARTICLE)
LA - eng, rus
IT - buildings; countermeasures; foundations; frost heave; clay soils; moisture migration

-448-

AN - 27000023
TI - Theory of frost heave of the ground
OTI - K teorii moroznogo pucheniia gruntov
AU - Orlov, V.O.
SO - Moscow. Vsesoiuznyi nauchno-issledovatel'skii institut zheleznodorozhnogo transporta. Trudy, 1970-Vol.408, p.20-33, In Russian. 22 refs.
DT - J (JOURNAL ARTICLE)
LA - rus
IT - theories; frozen ground temperature; soil moisture migration; frost penetration; seasonal freeze thaw; ground ice; frost heave

-449-

AN - 27000005
TI - Increasing the bearing capacity of foundations built in frozen ground
OTI - Povyshenie nesushchei sposobnosti fundamentov na merzlykh gruntakh
AU - Porkhaev, G.; Targulian, I.U.
SO - Na stroikakh Rossii, March 1972-No.3, p.47-49, In Russian.
DT - J (JOURNAL ARTICLE)
LA - rus

DFFE

IT - buildings; seasonal freeze thaw; foundations; frost heave; settlement (structural)

-450-

AN - 26003922
 TI - ENGINEERING AND GEOLOGIC INVESTIGATIONS FOR THE CONSTRUCTION OF LINEAR STRUCTURE CROSSING MAJOR RIVERS IN PERMAFROST REGIONS
 OTI - (Ob inzhenerno-geologicheskikh issledovaniyakh pri stroitel'stve lineinykh sooruzhenii na perekhodakh cherez krupnye reki v oblasti vechnoi merzloty)
 AU - Poltev, N.F.; Garagulia, L.S.
 SO - Merzlotnye issledovaniia, 1971-Vol.11, p.218-222, In Russian.
 DT - J (JOURNAL ARTICLE)
 LA - rus
 IT - bridges; pipelines; earthwork; ground ice; permafrost thermal properties; active layer; frost heave; settlement (structural)

-451-

AN - 26003915
 TI - ENGINEERING AND GEOLOGICAL STUDIES OF ICE-BEARING DISPERSE DEPOSITS FOR SMALL-SCALE SURVEYS
 DTI - (Iz opyta inzhenerno-geologicheskogo izuchenii i distykh dispersnykh otlozhenii pri melkomasshtabnykh s"emkakh)
 AU - Trush, N.I.
 SO - Merzlotnye issledovaniia, 1971-Vol.11, p.179-182, In Russian. 3 refs.
 DT - J (JOURNAL ARTICLE)
 LA - rus
 IT - frozen fines; moisture content; ground ice; ice veins; permafrost structure; active layer; frost heave; settlement (structural); permafrost samplers; drill core analysis

-452-

AN - 26003906
 TI - ENGINEERING AND GEOLOGICAL CONDITIONS OF THE YANA-INDIGIRKA INTERFLUVE
 OTI - (Inzhenerno-geologicheskie uslovia Iano-Indigirskogo mezhdurech'ia)
 AU - Nistratova, T.A.; Trush, N.I.; Korobov, I.U.F.
 SO - Merzlotnye issledovaniia, 1971-Vol.11, p.116-123, In Russian. 1 ref.
 DT - J (JOURNAL ARTICLE)
 LA - rus
 IT - ussr -yakutia; permafrost distribution; permafrost structure; active layer; frost heave; ground ice; permafrost hydrology; taliks; naleds

DFFE

-453-

AN - 26003896
 TI - DETERMINING SOIL MOISTURE CONTENT AT THE FROST-HEAVE THRESHOLD BY SOLVING A NON-LINEAR PROBLEM OF MOISTURE MIGRATION AND FROST PENETRATION, ALLOWING FOR THE DEPENDENCE OF HEAT- AND MASS TRANSFER ON TEMPERATURE AND TOTAL MOISTURE CONTENT
 OTI - (Opredelenie velichiny vlazhnosti poroga pucheniia s pomoshch'iu avtomodel'nogo resheniia nelineinnoi zadachi o promerzaniia s migratsiei vlazi (Pri uchete zavisimosti teplo- i massoobmennykh kharakteristik ot temperatury i summarnoi vlazhnosti))
 AU - Melamed, V.G.
 SO - Merzlotnye issledovaniia, 1971-Vol.11, p.24-30, In Russian. 4 refs.
 DT - J (JOURNAL ARTICLE)
 LA - rus
 IT - soil moisture migration; frost penetration; mathematical models

-454-

AN - 26003805
 TI - EXPERIMENTAL STUDY OF FROST HEAVE FORCES IN THE ZONE OF TRANSITION FROM PLASTIC INTO A HARD-FROZEN STATE
 OTI - (Eksperimental'nye issledovaniia sil pucheniia gruntov v perekhodnoi zone iz plastichnogo v tverdomerzloe sostoianie)
 AU - Tolkachev, N.A.
 SO - Osnovaniia, fundamente i podzemnye sooruzheniia, 1971-Vol.61, p.123-129, In Russian. 5 refs.
 DT - J (JOURNAL ARTICLE)
 LA - rus
 IT - sands; clays; loams; foundations; soil moisture migration; frost penetration; frost heave

-455-

AN - 26003604
 TI - THERMOKARST IN SOUTHERN YAKUTIA
 OTI - (Termokarst na iuge Iakutii)
 AU - Alekseev, V.R.; Filosofov, G.N.
 SO - Geograficheskoe obshchestvo SSSR. Zabaikal'skii filial. Izvestiia, 1970-6(2), p.35-49, In Russian. 9 refs.
 DT - J (JOURNAL ARTICLE)
 LA - rus
 IT - USSR -yakutia; thermokarst; cryogenic processes; naleds; frost heave; pingos; slope processes; solifluction

DFFE

-456-

AN - 26003573
TI - MECHANICAL PROCESSES IN SOILS DURING THE FREEZING OF THE LIQUID PHASE
AU - Fedosov, A.E.
SO - U.S. Army Cold Regions Research and Engineering Laboratory, REPT. NO. TL 320, March 1972, 59p., Translated by U.S. Joint Publications Research Service. For original Russian text see SIP 3851. 37 refs.
DT - J (JOURNAL ARTICLE)
LA - eng, rus
IT - soil moisture migration; frost penetration; frozen fines; frozen ground strength; frost heave; frozen ground settling
AB - Soils with water-filled voids begin to freeze with the formation of crystallization centers usually within the largest voids. The expansion of ice compresses the unfrozen areas and forces out water. The pressures produced may be determined by standard calculations used in soil mechanics. Moscow clays produce pressures of about 1.6 kg./sq.cm. when freezing. A formula is introduced for the calculation of the settling of a foundation erected upon frozen clay soils. The amount of settling appears to be the function of the specific gravity of the dry ground, the coefficient of porosity, the moisture content prior to freezing, and the thickness of the thawing layer under the building.

-457-

AN - 26003569
TI - DEFORMATION OF NATURAL SOIL WATER DISPERSION SYSTEMS UPON THAWING
AU - Bakulin, F.G.; Zhukov, V.F.
SO - U.S. Army Cold Regions Research and Engineering Laboratory, REPT. NO. TL 312, Jan. 1972, 10p., Translated by U.S. Joint Publications Research Service. For original Russian text see SIP 12686. 10 refs.
DT - J (JOURNAL ARTICLE)
LA - eng, rus
IT - frozen fines; soil moisture migration; ground water; frost penetration; ground ice; frost heave; thawing; frozen ground settling
AB - Ground deformation with freezing and thawing as a function of soil composition, moisture content, initial soil density and speed of freezing is mathematically analyzed and investigations related to the problem are briefly discussed. Water dispersion and ice formation have important effects on the deformation and changes in the mechanical properties of soils. The freezing of soil-water dispersions causes not only heaving and increased volume but also compaction. These dispersions retain their porous structure after thawing of the ice, and compaction is possible by destroying this structure.

DFFE

-458-

AN - 26003393
 TI - HEAT AND MASS TRANSFER PROCESSES IN FROZEN ROCKS
 OTI - (Protsessy teplo- i massoobmena v merzlykh gornykh porodakh)
 OS - Akademiya nauk SSSR. Sibirskoe otdelenie. Institut
 merzlotovedeniya
 SO - 146p., In Russian. For abstracts of individual papers see SIP
 25688-25704., Moscow, Nauka, 1965
 DT - MON (MONOGRAPH)
 LA - rus
 IT - permafrost thermal properties; mathematical models; frost
 penetration; frost heave; soil moisture migration; permafrost
 heat transfer; permafrost heat balance; snow cover effect

-459-

AN - 26003301
 TI - BASIC PROBLEMS IN STUDYING PERMAFROST IN THE TYUMEN' REGION IN
 RELATION TO ITS ECONOMIC DEVELOPMENT
 OTI - (Osnovnye zadachi izucheniya vechnomerzlykh porod Tiumerskoi
 oblasti v svyazi s ee khcizialstvennym osvoeniem)
 AU - Baulin, V.V.; Grave, N.A.; Zakharov, I.U.F.
 SO - Tyumen'. Gosudarstvennyi nauchno-issledovatel'skii i proektnyi
 Institut. Trudy, 1969-Vol.18, p.63-69, In Russian.
 DT - J (JOURNAL ARTICLE)
 LA - rus
 IT - ussr - tyumen'; economic development; permafrost structure; ground
 ice; permafrost thermal cycles; active layer; foundations; frost
 heave; settlement (structural); seasonal freeze thaw

-460-

AN - 26003234
 TI - BOULDER POLYGONS AND STRIPES IN THE CAIRNGORM MOUNTAINS, SCOTLAND
 AU - Bruce King, R.
 SO - Journal of glaciology, 1971-10(60), p.375-386, Summaries in
 French and German. 22 refs.
 DT - J (JOURNAL ARTICLE)
 LA - eng, fre, ger
 IT - soil creep; weathering; frost heave; solifluction; age
 determination; lichens; patterned ground

-461-

AN - 2600322C
 TI - "PARALLEL" LAYING OF OVERGROUND PIPELINES
 OTI - ("Parallelnaya" prokladka nadzemnykh truboprovodov)
 AU - Petrov, I.P.; Uss, L.N.
 SO - Stroitel'stvo truboprovodov, Sept. 1971-No.9, p.11-13, In Russian.
 DT - J (JOURNAL ARTICLE)
 LA - rus

DFFE

IT - pipe laying; frost heave; settlement (structural); swamps

-462-

AN - 26003169
TI - SLUDGE DEWATERING BY FREEZING
AU - Logsdon, G.S.; Edgerley, E., Jr.
SO - American Water Works Association. Journal, Nov. 1971-63(11, Pt.1), p.734-740, 25 refs.
DT - J (JOURNAL ARTICLE)
LA - eng
IT - moisture transfer; frost heave; waste disposal; waste treatment; sludges; freeze drying

-463-

AN - 26003115
TI - CONTRIBUTION TO THE STUDY OF FROZEN GROUND PHENOMENA. PRELIMINARY INVESTIGATIONS INTO A FORM OF MINIATURE STONE STRIPES IN EAST OTAGO
AU - Brockie, W.J.
SO - New Zealand Geographical Society. Conference series, New Zealand Geography Conference, 5th, Auckland, Aug. 1967, Proceedings, 1968-No.5, p.191-201, 19 refs.
DT - PA (PAPER)
LA - eng
IT - experimental data; statistical analysis; ice needles; soil moisture; freezing; patterned ground; frost heave; freeze thaw cycles; frozen ground dynamics; solifluction

-464-

AN - 26003077
TI - MEASURES FOR PREVENTING DEFORMATION OF BUILDINGS AND STRUCTURES CAUSED BY FROST-HEAVING FOUNDATIONS
DTI - (Meropriiatia protiv deformatsii zdanii i sooruzhenii ot deistviia sil moroznogo vypuchivaniia fundamentov)
AU - Kiselev, M.F.
SO - 103p., In Russian with English table of contents enclosed. 104 refs., Moscow, Stroiizdat, 1971
DT - MON (MONOGRAPH)
LA - rus
IT - countermeasures; buildings; soil freezing; frost penetration; foundations; frost heave

OFFE

-465-

AN - 26002899
TI - BITUMINOUS STABILIZATION LABORATORY STUDY
AU - Korfhage, G.R.
SO - Minnesota. Department of Highways. Office of Materials. Report, 1969-Investigation-608-FR, 43p.
DT - R (REPORT)
LA - eng
IT - soil stabilization; bituminous cements; compressive strength; freeze thaw tests; frost heave

-466-

AN - 26002897
TI - SOIL STABILIZATION STUDY
AU - Manz, O.E.
SO - 57p., Grand Forks, North Dakota University, 1969
DT - MON (MONOGRAPH)
LA - eng
IT - frost heave; soil stabilization; admixtures; compressive strength; freeze thaw cycles

-467-

AN - 26002890
TI - BASES AND FOUNDATIONS
OTI - (Osnovaniya i fundamente)
AU - Tsytoich, N.A.; Berezantsev, V.G.; Dalmatov, B.I.; Abelev, M.IU.
SO - 382p. (Pertinent pages 282-355 and 377-379), In Russian with English table of contents., Moscow, Vysshaya shkola, 1970
DT - MON (MONOGRAPH)
LA - rus
IT - permafrost structure; seasonal freeze thaw; settlement (structural); peat; bearing strength; frost heave; foundations; footings

-468-

AN - 25002876
TI - APPLIED GEOCRYOLOGY
OTI - (Geocriologia aplicada)
AU - Corte, A.E.
SO - Ciencia e investigacion, July 1967-23(7), p.311-325, In Spanish. 33 refs.
DT - J (JOURNAL ARTICLE)
LA - spa
IT - geocryology; cryogenic processes; frozen ground mechanics; frost action; freeze thaw cycles; frost heave; permafrost distribution; frost penetration
ST - PERMAFROST CONSTRUCTION

759

OFFE

-469-

AN - 26002842
 TI - RECOMMENDED PRACTICE FOR USING HIGH MOLECULAR COMPOUNDS FOR PREVENTING FROST HEAVE OF FOUNDATIONS
 OTI - (Rekomendatsii po primeneniiu vysokomolekuliarnykh soedinenii v bor'be s moroznym vypuchivaniem fundamentov)
 OS - Moscow. Nauchno-issledovatel'skii institut osnovanii i podzemnykh sooruzhenii
 SO - 24p., In Russian with English table of contents enclosed., Moscow, Gosstroil, 1969
 DT - MON (MONOGRAPH)
 LA - rus
 IT - design; foundations; footings; frost heave

-470-

AN - 26002768
 TI - ADDITIVES FOR MODIFYING THE FROST SUSCEPTIBILITY OF SOILS. PART 2
 AU - Lambe, T.W.; Kaplar, C.W.; Lambie, T.J.
 SO - U.S. Army Cold Regions Research and Engineering Laboratory, REPT. NO. TR 123/2, Oct. 1971, 41p., 10 refs.
 DT - R (REPORT)
 LA - eng
 IT - waterproofing; soil tests; frost heave; frost action; soil chemistry; frost protection; soil aggregates
 AB - Tests showed that a dispersant, tetrasodium pyrophosphate (TSPP), and an aggregant, ferric chloride, possess good frost-heave-modifying capabilities. Limited field tests indicated that TSPP can reduce heave significantly under natural conditions. Laboratory tests were conducted to determine the effect of prolonged water attack on the frost-heave-modifying capabilities of 0.3 percent treatments of TSPP and ferric chloride when used with two silty sandy gravels. The tests showed that in terms of percentage reduction of heave, the effectiveness of TSPP was not mitigated by water attack while the effectiveness of ferric chloride was slightly lessened. Both additives reduced the frost susceptibility of the soils from classification of "medium to high" to "very low to low." Theory and experimental data are presented which help to explain the response of the soils to treatment and freezing.

-471-

AN - 26002755
 TI - GEOCRYOLOGY AND ENGINEERING
 AU - Corte, A.E.
 SO - Reviews in engineering geology, Vol. II, edited by D.J. Varnes and G. Kiersch., REPT. NO. MP 95, p.119-185, Bibliography p.174-185, Boulder, Colorado, Geological Society of America, 1969
 DT - MON (MONOGRAPH)
 LA - eng
 IT - patterned ground; climatic changes; frozen ground mechanics;

DFFE

frost heave; freeze thaw cycles; ground ice; permafrost
distribution; permafrost depth
ST - PERMAFROST CONSTRUCTION

-472-

AN - 26002753
TI - FUNCTION OF WATER IN DAMAGE TO GLAZED TILES BY FROST
AU - Brough, R.; Harrison, R.; Dinsdale, A.
SO - British Ceramic Society. Transactions, May 1970-69(3), p.93-97,
Summaries in French and German. 9 refs.
DT - J (JOURNAL ARTICLE)
LA - eng
IT - frost heave; ice formation; pressure factors
ST - FILES

-473-

AN - 26002671
TI - SUBGRADE INSULATION FOR FROST HEAVE CONTROL; SUMMARY OF SECOND
AND THIRD WINTER'S PERFORMANCE
OS - Alaska. Department of Highways. Materials division
SO - 27p., July 1971
DT - R (REPORT)
LA - eng
IT - subgrade preparation; insulation; cellular materials; frost
heave; frost penetration; temperature measurement

-474-

AN - 26002636
TI - STUDY OF FACTORS INFLUENCING THE REDUCTION OF HIGHWAY SUBGRADE
SUPPORT DURING THE SPRING THAW PERIOD
AU - Cumberlandge, G.
SO - 31p., No microfiche available. M.Sc. thesis., Morgantown,
University of West Virginia, 1967
DT - MON (MONOGRAPH)
LA - eng
IT - frost heave; roadbeds; subgrade maintenance; moisture content;
seasonal variations; seasonal freeze thaw

-475-

AN - 26002573
TI - FOUNDING DEPTH IN CLAYS IN REGIONS OF DEEP SEASONAL FREEZING
(DISCUSSION)
AU - Karpov, V.M.
SO - Soil mechanics and foundation engineering, May-June 1971-3(3),
p.207-210. Translated from Osnovaniia, fundamenti i mekhanika
gruntov. 9 refs.
DT - J (JOURNAL ARTICLE)

DFFE

LA - eng, rus
IT - seasonal freeze thaw; frozen fines; frost heave; foundations

-476-

AN - 26002479
TI - MEASURES DESIGNED TO PROTECT THE FOUNDATIONS OF HEAT AND ELECTRIC POWER PLANTS FROM FROST HEAVE, AND THEIR EFFECTIVENESS
OTI - (Ob effektivnosti meropriyatii po zashchite osnovanii sooruzhenii TES ot vozdeistviia sil moroznogo pucheniia gruntov)
AU - Orlov, E.I.
SO - Energeticheskoe stroitel'stvo, 1971-No.5, p.12-15, In Russian. 9 refs.
DT - J (JOURNAL ARTICLE)
LA - rus
IT - electric power plants; foundations; footings; frost heave

-477-

AN - 26002434
TI - DOWNSLOPE SOIL MOVEMENT AT A SUB-ARCTIC LOCATION WITH REGARD TO VARIATIONS WITH DEPTH
AU - Williams, P.J.
SO - Canadian geotechnical journal, Nov. 1966-3(4), p.191-203, French summary. 10 refs.
DT - J (JOURNAL ARTICLE)
LA - eng, fre
IT - frost heave; soil mechanics; solifluction; soil creep; slope processes

-478-

AN - 26002401
TI - TRITIUM DETERMINATIONS IN THE STUDY OF PALSAS FORMATION
AU - Forsgren, B.
SO - Geografiska annaler, 1966-48A(2), p.102-110, 23 refs.
DT - J (JOURNAL ARTICLE)
LA - eng
IT - frozen ground chemistry; ground ice; soil structure; frost heave; unfrozen water content
ST - PALSAS

-479-

AN - 26002399
TI - RADIOCARBON DATES FROM A STONE-BANKED TERRACE IN THE COLORADO ROCKY MOUNTAINS, U.S.A.
AU - Benedict, J.B.
SO - Geografiska annaler, 1966-48A(1), p.24-31, 12 refs.
DT - J (JOURNAL ARTICLE)
LA - eng

762
76

OFFE

IT - vegetation patterns; frost heave; solifluction; patterned ground;
soil mechanics; radioactive age determination; slope processes
ST - STONE TERRACES

-480-

AN - 26002331
TI - THERMAL INSULATION FOR PROTECTING COMMUNICATIONS CABLES FROM
FROST HEAVE DAMAGE
AU - Kulikov, I.U.G.
SO - U.S. Army Cold Regions Research and Engineering Laboratory, REPT.
NO. TL 270, 1971, 6p., For original Russian article see 23-4431.
4 refs.
DT - R (REPORT)
LA - eng, rus
IT - transmission lines; thermal insulation; frost heave
AB - The effect of the thermal insulation or fill varies depending on
the climatic and frozen ground conditions as a result of which
the optimal dimensions of the insulation will vary somewhat for
each region.

-481-

AN - 26002330
TI - EFFECT OF FROST HEAVE ON COMMUNICATION CABLES
AU - Peretrukhin, N.A.; Kulikov, I.U.G.; Novoderezhkin, V.A.
SO - U.S. Army Cold Regions Research and Engineering Laboratory, REPT.
NO. TL 269, 1971, 31p., For original Russian article see 23-4429.
10 refs.
DT - R (REPORT)
LA - eng, rus
IT - transmission lines; frost heave
AB - Frost heave and its effect on cables were studied in experimental
sections under natural conditions. The effect of cyclic
displacements of the cable on the mechanical and electrical
strength was studied under laboratory conditions.

-482-

AN - 26002329
TI - FROST HEAVE DAMAGE TO ELECTRICAL CABLES
AU - Smirnov, N.P.
SO - U.S. Army Cold Regions Research and Engineering Laboratory, REPT.
NO. TL 268, 1971, 5p., Translation from Elektricheskie stantsii,
12(7):31-32, April 1941.
DT - R (REPORT)
LA - eng, rus
IT - damage; freezing; transmission lines; frost heave; frost
protection
AB - The effects of the composition, moisture and temperature of the
ground on the severity of frost heaving are analyzed, and
measures to prevent cable damage by frost heaving are listed.

including drainage, covering the cables with sand, the use of chemicals to depress the f.p. of the ground and the allowance of slack when laying cable in ground subject to heaving.

-483-

AN - 26002282
TI - FROST INVESTIGATIONS, 1951. COLD ROOM STUDIES. SECOND INTERIM REPORT OF INVESTIGATIONS
SO - U.S. Army Cold Regions Research and Engineering Laboratory (ACFEL), REPT. NO. ACFEL TR 36/2, June 1951-Vol.2, 225p.
DT - R (REPORT)
LA - eng
IT - cold chambers; test equipment; soil freezing; soil mechanics; frost heave; frost action
AB - The report includes Appendix A: 'Equipment and Test Procedures', which contains a description of the cold room and equipment and test procedures, and Appendix B: 'Investigational Data', which contains tables of test results, plots of temperature and heave versus time, and water content distribution in each sample before and after testing, for each test series.

-484-

AN - 26002281
TI - FROST INVESTIGATIONS, 1951. COLD ROOM STUDIES. SECOND INTERIM REPORT OF INVESTIGATIONS
SO - U.S. Army Cold Regions Research and Engineering Laboratory (ACFEL), REPT. NO. ACFEL TR 36/1, June 1951-Vol.1, 109p., 14 refs.
DT - R (REPORT)
LA - eng
IT - cold chambers; tests; aircraft landing areas; frozen ground mechanics; frost action; frost heave; frost penetration
AB - The report presents the results of cold room studies of frost action in soils. The studies are being conducted chiefly to determine the effects of each of the individual factors which influence ice segregation in soils, including gradation per cent finer than 0.02 mm., per cent and size of aggregate greater than 2.0 mm.; degree of compaction, surcharge pressures, initial degree of saturation in a closed system, alternate cycles of freeze-thaw, admixtures, capillarity, condensation, proximity of water supply, rate of penetration of 32 F. temperature, mineral composition of fine soil fraction, and permeability.

DFFE

-485-

AN - 26001906
 TI - TEST BED FOR SOIL-BASED FOUNDATIONS
 AU - Troitskii, G.M.; Iushin, A.I.; Iakovlev, I.N.
 SO - Soviet inventions illustrated. Section 2 Electrical, July 1971, p.40D2
 DT - P (PATENT)
 LA - eng, rus
 IT - foundations; footings; deformation; frost heave; simulation; models

-486-

AN - 26001897
 TI - TRANSFER OF HEAVING FORCES BY ADFREEZING TO COLUMNS AND FOUNDATION WALLS IN FROST SUSCEPTIBLE SOILS
 AU - Penner, E.; Gold, L.W.
 SO - Canadian geotechnical journal, Nov. 1971-8(4), p.514-526, With French summary. 12 refs.
 DT - J (JOURNAL ARTICLE)
 LA - eng, fra
 IT - soil freezing; shear stress; frost resistance; soil temperature; clay soils; frost heave; adfreezing strength; foundations

-487-

AN - 26001880
 TI - LABORATORY TECHNIQUE FOR DETERMINING GROUND HEAVING DURING FROST PENETRATION
 OTI - (Laboratornoe opredelenie pucheniia gruntov pri promorazhivani)
 AU - Alekseeva, E.K.
 SO - Soveshchanie po inzhenerno-geologicheskim svoistvam gornykh porod i metodam ikh izucheniia, Moscow, 1957 (Conference on engineering and geological properties of rocks and the methods of their investigation), p.304-306, In Russian., Moscow, AN SSSR, 1962
 DT - PA (PAPER)
 LA - rus
 IT - laboratory techniques; test equipment; soils; frost heave; frost penetration

-488-

AN - 26001878
 TI - ORIGIN, DISTRIBUTION AND SETTLING PROPERTIES OF LOESS IN THE ANGARA REGION
 OTI - (Rasprostraneniye, genezis i prosadochnye svoistva lessovidnykh porod Priangara)
 AU - Molodykh, I.I.
 SO - Soveshchanie po inzhenerno-geologicheskim svoistvam gornykh porod i metodam ikh izucheniia, Moscow, 1957 (Conference on engineering and geological properties of rocks and the methods of their

765

DFFE

investigation), p.183-187, In Russian., Moscow, AN SSSR, 1962
 DT - PA (PAPER)
 LA - rus
 IT - ussr -angara river; loess; frozen fines; soil formation; frozen
 ground settling; frost heave; ground thawing

-489-

AN - 26001748
 TI - SUBMARINE PINGOS IN THE BEAUFORT SEA
 AU - Shearer, J.M.; MacNab, R.F.; Pelletier, B.R.; Smith, T.B.
 SO - Science, Nov. 19, 1971-174(4011), p.816-818, 8 refs.
 DT - J (JOURNAL ARTICLE)
 LA - eng
 IT - seismic surveys; permafrost beneath lakes; thermal regime; frost
 heave; pressure; beaufort sea; subsurface structures; bottom
 topography; pingos

-490-

AN - 26001655
 TI - RECOMMENDED PRACTICE FOR USING HIGH MOLECULAR COMPOUNDS IN
 PREVENTING FOUNDATION FROST HEAVE
 DTI - (Rekomendatsii po primeneniiu vysokomolekuliarnykh soedinenii v
 bor'be s moroznym vypuchivaniem fundamentov)
 OS - Akademiia stroitel'stva i arkhitektury SSSR. Institut osnovanii
 i podzemnykh sooruzhenii
 SO - 24p., In Russian with English table of contents enclosed.,
 Moscow, Stroiizdat, 1969
 DT - MON (MONOGRAPH)
 LA - rus
 IT - buildings; foundations; permafrost beneath buildings; frost heave

-491-

AN - 26001522
 TI - DEFECTS IN BRIDGE PIERS CAUSED BY SEVERE CLIMATIC CONDITIONS
 OTI - (Defekty opor mostov v surovyykh klimaticheskikh usloviyakh)
 AU - Tatarinov, K.V.
 SO - Russia. Ministerstvo vysshego i srednego spetsial'nogo
 obrazovaniia. Izvestiia vysshikh uchebnykh zavedenii.
 Stroitel'stvo i arkhitektura, 1971-No.5, p.126-129, In Russian.
 2 refs.
 DT - J (JOURNAL ARTICLE)
 LA - rus
 IT - bridges; frost heave; construction materials; frost resistance;
 seasonal freeze thaw; settlement (structural); frost shattering

766

OFFE

-492-

AN - 26001463
TI - LAYER-BY-LAYER FROST HEAVING OF ROADBEDS
OTI - (K voprosu o posloinom puchenii gruntov zemliannogo polctna)
AU - Lukina, V.A.; Gur'ev, T.A.; Porradin, B.A.; Eliseev, A.F.
SO - Russia. Ministerstvo vysshego i srednego spetsial'nogo obrazovanii. Izvestiia vysshikh uchebnykh zavedenii. Stroitel'stvo i arkhitektura, 1971-No.3, p.140-143, In Russian. 4 refs.
DT - J (JOURNAL ARTICLE)
LA - rus
IT - cold weather tests; clay soils; soil moisture migration; frost penetration; frost heave; roadbeds; embankments

-493-

AN - 26001416
TI - EFFECT OF CLIMATIC CONDITIONS ON EARTHWORK IN THE NORTH
OTI - (Vliianie klimaticheskikh uslovii na proizvodstvo zemlianykh rabot na Severe)
AU - Plotskii, A.S.
SO - Avtomobil'nye dorogi, Aug. 1971-No.8, p.12-13, In Russian.
DT - J (JOURNAL ARTICLE)
LA - rus
IT - roadbeds; frost heave; frozen ground settling; earthwork

-494-

AN - 26001223
TI - COMPUTER APPLICATION TO DETERMINING SHEAR FORCES PRODUCED BY FROST HEAVE OF FOUNDATIONS
OTI - (Primenenie EVTSM pri opredelenii kasatel'nykh sil moroznogo vypuchivaniia fundamentov)
AU - Potapov, B.A.; Galimov, G.M.
SO - Stroitel'stvo v raionakh Vostochnoi Sibiri i Krai nego Severa, 1969-Vol.12, p.122-130, In Russian. 6 refs.
DT - J (JOURNAL ARTICLE)
LA - rus
IT - stress analysis; computer applications; active layer; soil moisture migration; frost penetration; frost heave; foundations; shear stress

-495-

AN - 26001221
TI - UNDERESTIMATION OF FROST HEAVE FORCES AT A CONSTRUCTION SITE IN EAST SIBERIA
OTI - (O nedootsenke moroznogo pucheniia gruntov na odnom iz ob"ektov stroitel'stva v Vostochnoi Sibiri)
AU - Tsiunchik, B.I.; Pal'kin, I.U.S.
SO - Stroitel'stvo v raionakh Vostochnoi Sibiri i Krai nego Severa,

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1969-Vol. 12, p. 94-101, In Russian. 2 refs.
DT - J (JOURNAL ARTICLE)
LA - rus
IT - analysis (mathematics); countermeasures; frozen fines; soil
moisture migration; frost heave; foundations; clay soils; frost
penetration

-496-

AN - 26001154
TI - IN-SITU FROST HEAVING
AU - Janiga, P.V.
SD - 138p., M. Eng. thesis. 54 refs., Montreal, McGill University,
1970
DT - O (OTHER)
LA - eng
IT - frost heave; soil moisture migration; soil mechanics; salt water;
frozen ground chemistry; saline soils; salting; water content

-497-

AN - 26001153
TI - SOME FACTORS AFFECTING HEAVING PRESSURES OF FROZEN SOILS
AU - Hammamji, Y.
SD - 94p., M. Eng. thesis. 65 refs., Montreal, McGill University, 1969
DT - O (OTHER)
LA - eng
IT - frost heave; ice pressure; frozen ground mechanics; soil
moisture; ice water interface; frost resistance; water pressure;
saline soils

-498-

AN - 26001027
TI - HEAVE AND HEAVING PRESSURES IN FROZEN SOILS: DISCUSSION
AU - Penner, E.
SD - Canadian geotechnical journal, Aug. 1971-8(3), p.499-501, For
Yong article under discussion see 26-0176. 12 refs.
CT - J (JOURNAL ARTICLE)
LA - eng
IT - soil pressure; ice pressure; ice lenses; frost heave; frozen
ground mechanics

DFFE

-499-

AN - 26000927
 TI - INFLUENCE OF TEMPERATURE ON THE LIQUID LIMITS AND MAXIMUM MOLECULAR MOISTURE CAPACITIES OF CLAY SOILS
 AU - Nevecheria, V.L.; Muratova, V.I.
 SO - Soil mechanics and foundation engineering, Jan.-Feb. 1971-8(1), p.27-28, Translated from Osnovaniia, fundamenti i mekhanika gruntov. 3 refs.
 DT - J (JOURNAL ARTICLE)
 LA - eng, rus
 IT - settlement (structural); foundations; clay soils; soil penetration; soil moisture migration; frost heave

-500-

AN - 26000851
 TI - COLD WEATHER CONSTRUCTION OF HIGH DAMS OF CLAYEY EARTH IN SIBERIA
 OTI - (Iz opyta zimnego vozvedeniia vysokikh nasypel iz glinistykh gruntov v usloviakh Sibiri)
 AU - Erlov, E.P.
 SO - Transportnoe stroitel'stvo, April 1971-No.4, p.3-4, In Russian.
 DT - J (JOURNAL ARTICLE)
 LA - rus
 IT - settlement (structural); cold weather construction; earth dams; frozen fines; clay soils; frost heave

-501-

AN - 26000804
 TI - HEAVING FORCE OF FROZEN GROUND. I. MAINLY ON THE RESULTS OF FIELD RESEARCHES
 AU - Kinoshita, S.; Ono, T.
 SO - National Research Council, Canada. Technical translation, 1366-No.1246, 30p., Translated from Low Temperature Science (Teion Kagaku) Ser.A. 21:117-139, 1963. For Japanese text and abstract see SIP 21138. 12 refs.
 DT - C (OTHER)
 LA - eng, jap
 IT - loads (forces); experimental data; frost heave; frozen ground mechanics; frost penetration

-502-

AN - 26000734
 TI - FIELD TESTING OF PLASTIC AND PLASTIC-CLAD PIPES
 AU - Selander, C.E.; Simonds, R.A.
 SO - American Water Works Association. Journal, July 1971-63(7), p.421-423
 DT - J (JOURNAL ARTICLE)
 LA - eng
 IT - frost heave; pipes (tubes); pipe laying; plastics; frost action

DFFE

-503-

AN - 26000696
TI - PRINCIPLES OF GEOCRIOLOGY, PART II (ENGINEERING GEOCRIOLOGY) CH.
VI BASES AND FOUNDATIONS
AU - Saltykov, N.I.
SO - National Research Council, Canada. Technical translation, March
1967-No. 1266, 102p., For Russian text and abstract see SIP 17839.
20 refs.
DT - O (OTHER)
LA - eng, rus
IT - thaw depth; active layer; analysis (mathematics); engineering
geology; foundations; cold weather construction; permafrost
preservation; frozen ground settling; geocryology; frost heave;
heat transfer

-504-

AN - 26000421
TI - DESIGNING PIER FOOTINGS WITH ANCHOR SLABS FOR SHEARING FORCES
PRODUCED BY FROST HEAVE
OTI - (Raschet ankernykh stolbchatykh fundamentov na deistvie
kasatel'nykh sil puchenia)
AU - Lobanov, I.Z.; Sorokin, S.V.
SO - Osnovaniia, fundamenty i podzemnye sooruzheniia. Vol.2, p.91-105.
In Russian. 10 refs., Moscow, Vysshiaia shkola, 1967
CT - PA (PAPER)
LA - rus
IT - stress analysis; shear strength; design; permafrost structure;
ground ice; active layer; foundations; footings

-505-

AN - 26000415
TI - USING SYNTHETIC RESINS FOR IMPROVING CONSTRUCTION PROPERTIES OF
SETTLING LOESS.
OTI - (Ispol'zovanie sinteticheskikh smol dlia uluchsheniia
stroitel'nykh svoistv lessovykh prosadochnykh gruntov)
AU - Kuleev, M.T.
SO - Osnovaniia, fundamenty i podzemnye sooruzheniia. Vol.2, p.36-39.
In Russian. 3 refs., Moscow, Vysshiaia shkola, 1967
DT - PA (PAPER)
LA - rus
IT - frost resistance; foundations; loess; frost penetration; frost
heave; resins; soil stabilization; settlement (structural)

OFFE

-506-

AN - 26000369
 TI - EXPERIMENTS TO SIMPLIFY FROST SUSCEPTIBILITY TESTING OF SOILS
 AU - Kaplan, C.W.
 SO - U.S. Army Cold Regions Research and Engineering Laboratory, REPT. NO. TR 223, Jan. 1971, 21p., 18 refs.
 DT - R (REPORT)
 LA - eng
 IT - frost resistance; soil freezing; frost heave; soil tests; heat transfer; laboratory techniques
 AB - Experiments conducted at USA CRREL in recent years indicate that the two weeks or so required for the frost susceptibility testing of soils with previous procedures can be shortened considerably. Results of these experiments show that useful frost heaving data can be obtained in a matter of 2 or 3 days by a more rapid freezing technique. Results of experiments in which soil specimens were exposed to a constantly maintained temperature are presented. Data show that heave rate in laboratory experiments is a variable, not a constant, of a soil and is strongly dependent upon the heat extraction rate. The important role of frost susceptibility testing and soil evaluation for highway design is discussed. The suitability of equipment for use in conducting frost-heaving tests is also discussed.

-507-

AN - 26000346
 TI - PREPARING BEARING GROUND AND FILLING UP FOUNDATION PITS OF INDUSTRIAL AND CIVIC BUILDINGS, BUILT ON SETTLING GROUND, IN FREEZING WEATHER
 OTI - (Podgotovka osnovanii i vozvedenie obratnykh zasypok kotlovanov promyshlennykh i grazhdanskikh zdaniy na prosadochnykh gruntakh v zimnee vremya)
 AU - Krutov, V.I.
 SO - Osnovaniya, fundamenty i podzemnye sooruzheniya. Vol.1., p.148-155, In Russian. 8 refs., Moscow, Vysshaya shkola, 1967
 DT - PA (PAPER)
 LA - rus
 IT - settlement (structural); construction costs; buildings; cold weather construction; foundations; earthwork; frozen fines; loess; loams; frost heave

-508-

AN - 26000344
 TI - EXPERIENCE IN BUILDING UNDERGROUND UTILITY LINES IN SETTLING GROUND
 OTI - (Opyt stroitel'stva podzemnykh kommunikatsiy v prosadochnykh gruntakh)
 AU - Eremenko, V.V.
 SO - Osnovaniya, fundamenty i podzemnye sooruzheniya. Vol.1., p.133-136, In Russian., Moscow, Vysshaya shkola, 1967

DT - PA (PAPER)
LA - rus
IT - settlement (structural); pipelines; ducts; water pipelines;
sewage; loess; loams; soil moisture; frost heave

-509-

AN - 26000341
TI - PECULIARITIES OF LOESS DEPOSITS IN EAST SIBERIA
OTI - (Nekotorye osobennosti lessovykh porod Vostochnoi Sibiri)
AU - Iatsenko, D.V.
SO - Osnovaniia, fundamenty i podzemnye sooruzheniia. Vol.1.,
p.68-79, In Russian. 5 refs., Moscow, Vysshiaia shkola, 1967
DT - PA (PAPER)
LA - rus
IT - frozen fines; loess; frost action; soil moisture migration; frost
heave; frost shattering; frozen ground settling; buildings;
foundations

-510-

AN - 26000313
TI - DEFORMATIONS OF A LONG-SPAN INDUSTRIAL BUILDING IN CONNECTION
WITH FROST SWELLING OF ITS SUBFOUNDATION SOIL
AU - Tsiunchik, B.I.; Naumov, N.IA.
SO - Soil mechanics and foundation engineering, Nov.-Dec. 1970-No.6,
p.429-431, Translated from Osnovaniia, fundamenty i mekhanika
gruntov.
DT - J (JOURNAL ARTICLE)
LA - eng, rus
IT - seasonal freeze thaw; active layer; buildings; foundations; soil
moisture; frost penetration; frost heave

-511-

AN - 26000249
TI - CRYOGENIC PHENOMENA IN TIEN SHAN
OTI - (Merzlotnye iavleniia Tian'-Shania)
AU - Gorbunov, A.P.
SO - Alma-Ata. Kazakhskii nauchno-issledovatel'skii
gidrometeorologicheskii institut. Trudy, 1970-Vol.39, 265p., In
Russian with English table of contents enclosed. 189 refs.
DT - J (JOURNAL ARTICLE)
LA - rus
IT - height finding; ussr -tien shan; climate; mountains; permafrost
structure; permafrost distribution; ground ice; permafrost
hydrology; permafrost transformation; frost heave; solifluction;
naleds; thermokarst; rock glaciers; cryogenic processes

DFFE

-512-

AN - 26000176
TI - HEAVE AND HEAVING PRESSURES IN FROZEN SOILS
AU - Yong, R.N.; Osler, J.C.
SO - Canadian geotechnical journal, May 1971-8(2), p.272-282, In English with French summary. 20 refs.
DT - J (JOURNAL ARTICLE)
LA - eng
IT - ice lenses; water content; frost heave; frozen ground mechanics; ice pressure; soil moisture migration

-513-

AN - 26000148
TI - PERMAFROST EFFECT ON THE STABILITY OF POWER LINE SUPPORTS
OTI - (Vliianie vechnomerzlogo grunta na ustoychivost' opor VL)
AU - Shirokov, I.L.
SO - Elektricheskie stantsii, Feb. 1971-No.2, p.88-89, In Russian.
DT - J (JOURNAL ARTICLE)
LA - rus
IT - power line supports; frost heave; permafrost hydrology; seasonal freeze thaw; swamps

-514-

AN - 26000121
TI - ARCTIC ENGINEERING
AU - Peyton, H.R.
SO - Journal of petroleum technology, Sept. 1970-2, p.1076-1082, 9 refs.
DT - J (JOURNAL ARTICLE)
LA - eng
IT - ice wedges; frost heave; permafrost preservation; cold weather construction; permafrost structure; permafrost distribution

-515-

AN - 26000028
TI - DETERMINATION OF RELATIVE NORMAL FORCES OF GROUND FROST HEAVING
AU - Tolkachev, N.A.
SO - U.S. Army Cold Regions Research and Engineering Laboratory, REPT. NO. TL 158, 1971, 10p., Translation from Moscow. Nauchno-issledovatel'skii Institut osnovanii i podzemnykh sooruzhenii. Sbornik trudov, No.54:165-170, 1964. 2 refs.
DT - R (REPORT)
LA - eng, rus
IT - frost action; frost heave; frozen ground mechanics; foundations
AB - The report discusses the tangential and normal forces on foundation structures as the result of freezing and thawing of soils.

773

DFFE

-516-

AN - 25004347
TI - FROST HEAVE IN KITAMI (1969-1970)
AU - Kinoshita, S.; Suzuki, Y.; Horiguchi, K.; Tanuma, K.; Ono, T.
SO - Low temperature science (Teion kagaku). Series A Physical
Sciences. Data report, 1970-No.28, p.81-84, In Japanese. 7 refs.
DT - J (JOURNAL ARTICLE)
LA - jap
IT - frost heave

-517-

AN - 25004342
TI - CRYSTAL STRUCTURE AND FROST SUSCEPTIBILITY OF THE POWDERS
AU - Horiguchi, K.
SO - Low temperature science (Teion kagaku). Series A Physical
Sciences, 1970-28, p.345-358, In Japanese with English summary.
25 refs.
DT - J (JOURNAL ARTICLE)
LA - jap, eng
IT - frost resistance; particle size distribution; frost heave;
crystal structure; ion exchanging
ST - POWDER (PARTICLES)

-518-

AN - 25004340
TI - CHANGE OF WATER LEVEL DURING FROST HEAVING II
AU - Kinoshita, S.; Suzuki, Y.; Horiguchi, K.; Tanuma, K.
SO - Low temperature science (Teion kagaku). Series A Physical
Sciences, 1970-28, p.325-336, In Japanese with English summary.
For Pt. I see 25-0308. 8 refs.
DT - J (JOURNAL ARTICLE)
LA - jap, eng
IT - frost heave; soil moisture migration; frost penetration; clay
soils; frozen ground temperature; water content

-519-

AN - 25004201
TI - STUDY OF TIME DEPENDENCE DURING SERIAL NEEDLE ICE EVENTS
AU - Outcalt, S.I.
SO - Archiv fur Meteorologie, Geophysik und Bioklimatologie. Ser. A,
1970-19(3), p.329-337, In English with German summary. 12 refs.
DT - J (JOURNAL ARTICLE)
LA - eng, ger
IT - ice crystal growth; freeze thaw cycles; soil freezing; surface
temperature; frost heave; computer applications

DFFE

-520-

AN - 25004170
TI - DETERIORATION OF STRUCTURES IN COLD REGIONS
AU - Toblason, W.
SO - Symposium on Cold Regions Engineering, Proceedings, REFT. NO. MP 440, p.425-448, 7 refs., College, University of Alaska, 1971
DT - PA (PAPER)
LA - eng
IT - deformation; deterioration; arctic climate; frost resistance; icing; houses; frozen ground temperature; foundations; construction materials; settlement (structural); permafrost preservation; frost heave; walls; roofs

-521-

AN - 25004155
TI - LABORATORY TESTING AND CHARACTERIZATION OF PERMAFROST FOR FOUNDATION USES
AU - Shuster, J.A.
SO - Symposium on Cold Regions Engineering, Proceedings, p.74-118, 17 refs., College, University of Alaska, 1971
DT - PA (PAPER)
LA - eng
IT - creep properties; shear stress; frost heave; permafrost beneath buildings; foundations; test equipment; permafrost physics; frozen ground mechanics; frozen ground compression; frozen ground strength

-522-

AN - 25004124
TI - PHENOMENON AND MECHANISM OF FROST HEAVING
AU - Kaplan, C.W.
SO - Highway research record, REPT. NO. MP 212, 1970-No.304, p.1-13, 22 refs.
DT - J (JOURNAL ARTICLE)
LA - eng
IT - frost penetration; freezing; soil moisture; frost heave
AB - This paper presents a mechanistic explanation of frost action in soils, based on the hypothesis that liquid films existing between particles and an ice lens are the focal centers of energy for heaving (work) process. Heave rate and work of heaving and their dependence on free energy generation during freezing are discussed in general terms. Typical experimental data are presented illustrating the reduction in heave rate with increased external (and internal) resistance. The role of soil structure in frost susceptibility is discussed. Changes in frost heaving rates can be effected by addition or removal of either, or both, the coarse aggregate or soil fines. Suggestions are offered for approaches to soil modification to reduce heaving.

DFFE

-523-

AN - 25004026
 TI - SOME PECULIARITIES OF OCCUPIED BUILDINGS IN THE NORTHERN PORTIONS OF THE PERMAFROST ZONE
 AU - Tumel', V.F.
 SO - U.S. Army Cold Regions Research and Engineering Laboratory (ACFEL), REPT. NO. ACFEL TL 19, 1950, 42p., Translation from Akademiia nauk SSSR. Inst. merzlotovedeniia. Trudy, Vol. 1:5-26, 1946. 27 refs.
 DT - R (REPORT)
 LA - eng, rus
 IT - foundations; permafrost beneath buildings; frost heave; deformation
 AB - The report contains statistical data obtained from soil analyses. Damage assessment of building foundations constructed on permafrost bearing soils is delineated.

-524-

AN - 25003864
 TI - DEPTH OF FOUNDATIONS
 AU - Kiselev, M.F.
 SO - Soil mechanics and foundation engineering, July-Aug. 1970-No.4, p.284-288, Translation from Osnovaniia, fundamenty i mekhanika gruntov.
 DT - J (JOURNAL ARTICLE)
 LA - eng, rus
 IT - foundations; soil moisture; frost penetration; frost heave; seasonal freeze thaw

-525-

AN - 25003863
 TI - COMPUTATION OF SIZE AND INTENSITY OF SWELLING OF FREEZING SOILS
 AU - Orlov, V.O.
 SO - Soil mechanics and foundation engineering, July-Aug. 1970-No.4, p.263-266, Translation from Osnovaniia, fundamenty i mekhanika gruntov. 8 refs.
 DT - J (JOURNAL ARTICLE)
 LA - eng, rus
 IT - crystallization; frost heave; soil moisture

-526-

AN - 25003861
 TI - RATIONAL TYPES OF FOUNDATIONS FOR CONSTRUCTION IN THE TYUMEN REGION
 AU - Tetlor, A.N.; Alekseev, A.I.; Aver'ianova, L.N.; Pavlov, V.V.; Lobov, O.N.
 SO - Soil mechanics and foundation engineering, July-Aug. 1970-No.4, p.242-247, Translation from Osnovaniia, fundamenty i mekhanika

DFFE

gruntov. 1 ref.
 DT - J (JOURNAL ARTICLE)
 LA - eng, rus
 IT - buildings; foundations; swamps; seasonal freeze thaw; frost heave

-527-

AN - 25003794
 TI - DEVELOPMENT OF CRYOGENIC PROCESSES ASSOCIATED WITH ENGINEERING AND GEOLOGICAL ACTIVITIES WHEN BUILDING GAS MAINS IN PERMAFROST REGIONS
 OTI - (Razvitiye inzhenerno-geologicheskikh protsessov pri stroitel'stve gazoprovodov v oblasti rasprostraneniya mnogoletnemerzlykh porod)
 AU - Garagulla, L.S.; Gordeeva, G.I.; Poltev, N.F.; Smirnov, V.V.
 SO - Merzlotrye issledovaniya, 1970-Vol. 10, p. 19-26. In Russian. 4 refs.
 DT - J (JOURNAL ARTICLE)
 LA - rus
 IT - melting; natural gas; permafrost depth; engineering geology; frozen ground temperature; gas pipelines
 AB - Pipeline effect on the intensification of frost heave, solifluction, thermal erosion and other processes.

-528-

AN - 25003648
 TI - ARCTIC PIPELINING-TOUGH, COSTLY, BUT FEASIBLE
 AU - Pearn, W.H.
 SO - Oil and gas journal, Nov. 16, 1970-68(46), p. 153-159
 DT - J (JOURNAL ARTICLE)
 LA - eng
 IT - pipelines; cold weather construction; meteorological factors; frost heave
 ST - PERMAFROST CONSTRUCTION; FREEZE THAW CYCLES

-529-

AN - 25003460
 TI - PALSAS NEAR GREAT WHALE (NEW QUEBEC)
 OTI - (Les palsas dans le bassin de la Grande-Rivière de la Baleine)
 AU - Hamelin, L.-E.; Cailleux, A.
 SO - Revue de géographie de Montréal, 1969-23(3), p. 329-337, 17 French with English and Russian summaries. 18 refs.
 DT - J (JOURNAL ARTICLE)
 LA - fr, eng, ger
 IT - ground ice; peat; hummocks; frost heave; frozen ground mechanics
 ST - PALSAS

OFFE

-530-

AN - 25003327
 TI - CALCULATING NORMAL FROST-HEAVE FORCES ACTING ON THE VERTICAL SIDES OF STRUCTURES SUNK INTO FREEZING GROUND
 OTI - (Raschet normal'nykh sil moroznogo puchenila na vertikal'nye gran' zaglublennykh v promerzaiushchii grunt konstruktsei)
 AU - Puskov, V.I.
 SO - Novosibirsk. Institut inzhenerov zheleznodorozhnogo transporta. Trudy, 1967-Vol.63, p.151-157, In Russian. 7 refs.
 DT - J (JOURNAL ARTICLE)
 LA - rus
 IT - frozen ground; buildings; foundations; frost heave; frost penetration

-531-

AN - 25003326
 TI - CALCULATING NORMAL FROST-HEAVE FORCES ALONG THE BOTTOM OF A RIGID LAYER WITH LIMITED YIELD
 OTI - (Raschet normal'nykh sil moroznogo puchenila gruntov po podoshve zhestkoi polosi s organichennoi podatlivost'iu)
 AU - Puskov, V.I.
 SO - Novosibirsk. Institut inzhenerov zheleznodorozhnogo transporta. Trudy, 1967-Vol.63, p.141-150, In Russian. 3 refs.
 DT - J (JOURNAL ARTICLE)
 LA - rus
 IT - frozen ground; frost heave; buildings; foundations

-532-

AN - 25003311
 TI - FROST CRACKING IN THE COLORADO FRONT RANGE
 AU - Benedict, J.B.
 SO - Geografiska annaler, 1970-52A(2), p.87-93, 11 refs.
 DT - J (JOURNAL ARTICLE)
 LA - eng
 IT - thermal effects; soil creep; desiccation; frost heave; cracking (fracturing); tensile stress

-533-

AN - 25003291
 TI - ORIGIN OF FLUTED MORaine AT THE FRONTS OF CONTEMPORARY GLACIERS
 AU - Baranowski, S.
 SO - Geografiska annaler, 1970-52A(1), p.68-75, 22 refs.
 DT - J (JOURNAL ARTICLE)
 LA - eng
 IT - temperature variations; ice cover thickness; heat transfer; glacial till; glaciology; frost heave; periglacial processes; glacier movement; ice pressure

DFFE

-534-

AN - 25003158
 TI - ENGINEERING GEOCRYOLOGICAL RESEARCH
 AU - Ushkalov, V.P.; Pchelintsev, A.M.; Efimov, A.I.; Dement'ev, A.I.
 SO - National Academy of Sciences. National Research Council.
 Publication, International Conference on Permafrost, Lafayette,
 Indiana, 1963. Proceedings, 1966-No.1287, p.400-404. For Russian
 text see SIP 21497. 5 refs.
 DT - PA (PAPER)
 LA - eng, rus
 IT - soil strength; frost heave; active layer; permafrost physics;
 seasonal freeze thaw; site surveys; soil moisture
 ST - PERMAFROST CONSTRUCTION

-535-

AN - 25003151
 TI - PHASE TRANSFORMATIONS OF WATER IN SOILS AND THE NATURE OF
 MIGRATION AND HEAVING
 AU - Tiutiumov, I.A.
 SO - National Academy of Sciences. National Research Council.
 Publication, International Conference on Permafrost, Lafayette,
 Indiana, 1963. Proceedings, 1966-No.1287, p.234-238. For Russian
 text see SIP 21492. Includes discussion. 20 refs.
 DT - PA (PAPER)
 LA - eng, rus
 IT - soil moisture migration; frost heave; phase transformations;
 unfrozen water content

-536-

AN - 25003138
 TI - PERMAFROST INTERNATIONAL CONFERENCE [International Conference on
 Permafrost, Lafayette, Ind., 1963]
 SO - National Academy of Sciences. National Research Council.
 Publication, 1966-No.1287, 563p., For selected papers, with
 abstracts, from this conference see SIP 24825 through SIP 24901.
 For Russian text papers presented at the conference but not
 included in this volume see SIP 21504 through SIP 21510. For
 papers by CRREL authors (except R.M. Davis) see 25-2105(Aitken),
 25-2112(Brown), 25-2115(Crory), 25-2119(Frost, et al),
 25-2120(Hansen), 25-2124(Kaplar), 25-2129(Lange), 25-2133(Linell,
 et al), 25-2134(Lobacz, et al), 25-2139(Lange, et al),
 25-2145(Rice and Simoni), 25-2148(Sanger), 25-2149(Sanger, et
 al), 25-2150(Swinzow), 25-2151 and 25-2152(Takagi). For papers
 not previously covered see 25-3139 through 25-3162. No
 microfiche available.
 DT - MCN (MONOGRAPH)
 LA - eng
 IT - frost heave; frost penetration; permafrost structure; ground ice;
 patterned ground; phase transformations; permafrost thermal
 structure; frozen ground mechanics; site surveys; water supply;

sewage disposal
ST - FREEZE THAW CYCLES; PERMAFROST ENGINEERING

-537-

AN - 25003094
TI - HYDROTHERMAL MOVEMENTS OF THE EARTH SURFACE
OTI - (Gidrotermicheskie dvizhenia zemnoi poverkhnosti)
AU - Rusanov, B.S.
SO - 226p., In Russian with English table of contents enclosed. 209
refs., Moscow, 1961
DT - MON (MONOGRAPH)
LA - rus
IT - frozen ground mechanics; frost penetration; soil moisture
migration; frost heave; surveying instruments; cryogenic processes
AB - Soviet geocryologists recommend this book for its exceptional
scientific and practical value due to an unusual approach to the
interpretation of cryogenic processes. Sources for error
accumulation when surveying with leveling instruments are pointed
out and practical recommendations offered for a
precision-leveling technique in cold regions.

-538-

AN - 25003077
TI - BEARING GROUND AND FOUNDATIONS
OTI - (Osnovaniia i fundamenti)
AU - Laletin, N.V.
SO - 351p. (Pertinent pages 312-329), In Russian with abridged
English table of contents enclosed. 24 refs., Moscow, Vysshiaia
shkola, 1970
DT - MON (MONOGRAPH)
LA - rus
IT - frozen ground; permafrost heat transfer; active layer;
foundations; frost heave
AB - Second edition, revised and supplemented by new data and
techniques.

-539-

AN - 25003070
TI - OPTIMAL FOUNDATIONS FOR TRANSMISSION LINE SUPPORTS IN THE FAR
NORTH
OTI - (Optimal'nye fundamenti opor linii elektroperedachi na Krainem
Severe)
AU - Gal'perin, V.V.
SO - Energeticheskoe stroitel'stvo, 1970-No.5, p.58-62, In Russian. 6
refs.
DT - J (JOURNAL ARTICLE)
LA - rus
IT - frozen ground; design; transmission lines; foundations; frost
heave

DFFE

-540-

AN - 25003068
 TI - CONSTRUCTION OF ELECTRICAL POWER STATIONS ON SAGGING GROUND
 OTI - (Opyt stroitel'stva teplovyykh elektrostantsii na prosadochnyykh gruntakh)
 AU - Zotov, M.V.
 SO - Energeticheskoe stroitel'stvo, 1970-No.5, p.17-18, In Russian.
 DT - J (JOURNAL ARTICLE)
 LA - rus
 IT - frozen ground; electric power plants; foundations; frost heave

-541-

AN - 25003018
 TI - ICE SKATING RINKS
 OS - Symposium on Ice Skating Rinks, 1968; American Society of Heating, Refrigerating and Air-Conditioning Engineers
 SO - 28p., Held at semiannual meeting of the ASHRAE, Feb 1968, Columbus, Ohio. No microfiche available., New York, ASHRAE, 1969
 DT - R (REPORT)
 LA - eng
 IT - ice rinks; frost heave; refrigerating
 AB - Contains 5 papers: Ice rink hardware, by A. Smiley Condensation and fog control in rink building by M. A. Ramsey Direct refrigerant cooled ice skating rinks, by M. W. Garland Frost heaving under rinks, by N. B. Hutcheon and Ice rink management by J. T. Femal.

-542-

AN - 25002951
 TI - SOIL MECHANICS, FOOTINGS AND FOUNDATIONS
 OTI - (Mekhanika gruntov, osnovaniia i fundamenti)
 AU - Medkov, E.I.; Berezantsev, V.G.; Gol'dshtein, M.N.; Tsar'kov, A.A.
 SO - 287p. (Pertinent pages 206-211, 218-224), Moscow, Transport, 1970
 DT - MON (MONOGRAPH)
 LA - rus
 IT - permafrost structure; frost heave; foundations; soil stabilization; permafrost heat transfer

-543-

AN - 25002914
 TI - DESIGN OF 500 kv POWER LINES TIUMEN'-SURGUT
 OTI - (Proektnye reshenia po LEP 500 kv Tiumen'-Surgut)
 AU - Popov, E.A.; Ovchinnikov, V.F.
 SO - Energeticheskoe stroitel'stvo, 1970-No.8, p.33-40, In Russian.
 DT - J (JOURNAL ARTICLE)
 LA - rus
 IT - frost heave; power lines; power line icing

-544-

AN - 25002912
TI - OPTIMAL DESIGN OF FOUNDATIONS FOR TEMPORARY BUILDINGS AND
STRUCTURES OF THE SURGUT ELECTRIC POWER PLANT
OTI - (Optimal'nye konstruktivnye reshenia fundamentov pod vremennye
zdanija i sooruzhenija Surgutskoi GRES)
AU - Zevakov, E.M.; Elenbogen, G.N.
SO - Energeticheskoe stroitel'stvo, 1970-No.8, p.24-30, In Russian.
DT - J (JOURNAL ARTICLE)
LA - rus
IT - frozen ground; frost heave; buildings; foundations

-545-

AN - 25002911
TI - CONSTRUCTION OF TEMPORARY BUILDINGS AND STRUCTURES FOR THE SURGUT
HYDROELECTRIC POWER PLANT
OTI - (Stroitel'stvo vremennykh zdani i sooruzhenii Surgutskoi GRES)
AU - Elenbogen, G.N.
SO - Energeticheskoe stroitel'stvo, 1970-No.8, p.20-24, In Russian.
DT - J (JOURNAL ARTICLE)
LA - rus
IT - frozen ground; electric power plants; frost heave; buildings

-546-

AN - 25002878
TI - PERIGLACIAL REGION OF TIEN SHAN
OTI - (La region periglaciaire du Tian-Chan)
AU - Gorbunov, A.P.
SO - Biuletyn peryglacjalny, 1969-No.19, p.151-174, In French. 22
refs.
DT - J (JOURNAL ARTICLE)
LA - fre
IT - mountains; permafrost distribution; periglacial processes;
patterned ground; cryogenic processes; frost heave; pingos

-547-

AN - 25002876
TI - ORIGIN AND AGE OF THE PRAIRIE MOUNDS OF SOUTHERN ALBERTA, CANADA
AU - Bik, M.J.J.
SO - Biuletyn peryglacjalny, 1969-No.19, p.85-130, 88 refs.
DT - J (JOURNAL ARTICLE)
LA - eng
IT - periglacial processes; patterned ground; cryogenic processes;
frost heave; pingos

DFFE

-548-

AN - 25002756
TI - RELATION OF FROST HEAVING OF ELUVIAL CLAY SOILS IN THE URALS ON
THE MOISTURE CONTENT, GRAIN SIZE, AND MINERAL COMPOSITION
AU - Mel'nikov, B.N.
SO - Soil mechanics and foundation engineering, Jan.-Feb. 1966-No.1,
p.23-24, Translated from Osnovaniia, fundamenty i mekhanika
gruntov. 3 refs.
DT - J (JOURNAL ARTICLE)
LA - eng, rus
IT - clay soils; soil moisture; frost heave

-549-

AN - 25002721
TI - ORIGIN OF HUMMOCK-AND-HOLLOW RELIEF IN THE ANGARA REGION
OTI - (K voprosu o genezise bugristo-zapadinnogo rel'efa v Priangar'e)
AU - Vitkina, N.Kh.
SO - Merzlotnye issledovaniia., 1961-Vol.1, p.112-115, In Russian. 3
refs.
DT - J (JOURNAL ARTICLE)
LA - rus
IT - permafrost distribution; permafrost thickness; cryogenic
processes; cryogenic relief; frost heave

-550-

AN - 25002672
TI - DOWNSLOPE SOIL MOVEMENT IN A COLORADO ALPINE REGION: RATES,
PROCESSES, AND CLIMATIC SIGNIFICANCE
AU - Benedict, J.B.
SO - Arctic and alpine research, Summer 1970-2(3), p.165-226, 76 refs.
DT - J (JOURNAL ARTICLE)
LA - eng
IT - soil creep; solifluction; frozen ground mechanics; frost heave;
frost penetration; surface migration; soil structure; soil
temperature

-551-

AN - 25002645
TI - SOIL MOVEMENTS UNDER THE INFLUENCE OF FREEZING
AU - Lahn, A.
SO - Ecology of the subarctic regions, Vol.1 of Ecology and
conservation, p.119-123, In English with French summary.
Includes discussion. 10 refs., Paris, Unesco, 1970
DT - PA (PAPER)
LA - eng, fre
IT - ground ice; ice wedges; frost heave; soil moisture migration;
surface migration
ST - FREEZE THAW CYCLES

-552-

AN - 25002643
TI - SOME GEOMORPHOLOGICAL PROCESSES IN CLOUD CLIMATES
AU - Rapp, A.
SO - Ecology of the subarctic regions, Vol.1 of Ecology and conservation, p.105-114, In English with French summary. Includes discussion. 41 refs., Paris, Unesco, 1970
DT - PA (PAPER)
LA - eng, fre
IT - patterned ground; active layer; frost heave; solifluction; permafrost structure
ST - PALSAS; FREEZE THAW CYCLES

-553-

AN - 25002542
TI - STUDY OF ICE FORMATION IN SOILS
AU - Jackson, K.A.; Chalmers, B.; McKay, G.
SO - U.S. Army Cold Regions Research and Engineering Laboratory (ACFEL), REPT. NO. ACFEL TR 65, May 1956, 29p., 11 refs.
DT - R (REPORT)
LA - eng
IT - soil freezing; frost heave; ice lenses
AB - Ice formation in soil is examined in the light of the nucleation theory, which assumes that the water immediately in contact with the soil particles remains supercooled as a result of interaction with the particles and has free energy to help it freeze, produce heaving, and pull the water up from the water table. Nucleation temperatures in water are examined in terms of surface energy, of water molecules, angle of contact, and cluster size, and the process of soil freezing is described. The freezing temperature of a soil, cooling curves, and the theory of frost heave are discussed in the appendices.

-554-

AN - 25002538
TI - MODIFICATION OF FROST-HEAVING OF SOILS WITH ADDITIVES. 1953 THRU 1955 INVESTIGATIONS
AU - Lambe, T.W.
SO - U.S. Army Cold Regions Research and Engineering Laboratory (ACFEL), REPT. NO. ACFEL TR 61, Jan. 1956, 62p., 13 refs.
DT - R (REPORT)
LA - eng
IT - soil freezing; admixtures; frost heave; frost protection
AB - A 3-year search for additives to reduce the frost susceptibility of soil is described. Fifteen soils and about forty additives have been tested. A discussion of the theoretical considerations for the choice of additives is presented. The additives are divided into four groups: (1) void pluggers and cements, (2) aggregants, (3) dispersants, and (4) 'waterproofers' - according to their action in soil.

DFFE

-555-

AN - 25002533
TI - ADMIXTURE TEST AREA, LORING AIR FORCE BASE, LIMESTONE, MAINE
SO - U.S. Army Cold Regions Research and Engineering Laboratory (ACFEL), REPT. NO. ACFEL TR 56, June 1955, 11p.
DT - R (REPORT)
LA - eng
IT - soil freezing; admixtures; subgrades; frost penetration; frost heave; frost resistance
ST - FREEZE THAW CYCLES
AB - The purpose of this small-scale field admixture test area is to add perspective to the laboratory program of treating frost-susceptible soils, reduce their frost susceptibility and render them satisfactory for use in construction.

-556-

AN - 25002530
TI - FROST INVESTIGATIONS. COLD ROOM STUDIES. MINERAL AND CHEMICAL STUDIES
AU - Lambe, T.W.
SO - U.S. Army Cold Regions Research and Engineering Laboratory (ACFEL), REPT. NO. ACFEL TR 53, April 1959, 73p., 10 refs.
DT - R (REPORT)
LA - eng
IT - soil freezing; frost action; soil chemistry; admixtures; frost heave
AB - The report presents the results of continuing studies to determine the effect of the mineral composition of soil fines on frost action and of laboratory investigations with various chemical additives to modify frost action in frost-susceptible soils. Frost tests were performed with 32 additives 12 of these are listed which will reduce the rate of heave by 50 percent or more when one percent or less (by soil weight) of additive is used. Ten specific conclusions are given. App. A presents laboratory data for the mineral and chemical studies presented in main part of report.

-557-

AN - 25002518
TI - FROST INVESTIGATIONS, 1952-1953. COLD ROOM STUDIES, THIRD INTERIM REPORT OF INVESTIGATIONS. MINERAL AND CHEMICAL STUDIES
AU - Lambe, T.W.
SO - U.S. Army Cold Regions Research and Engineering Laboratory (ACFEL), REPT. NO. ACFEL TR 43/2, June 1953, 25p., 8 refs.
DT - R (REPORT)
LA - eng
IT - soil freezing; soil chemistry; frost heave; admixtures; frost action
AB - The effect of soil fines composition on the frost susceptibility of the soil and finding admixtures which can in trace amounts

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reduce the frost susceptibility of soil are described. Freezing tests were made on a clean sand to which various monomineral fines were added. Results show that the composition of soil fines has a tremendous influence on the frost behavior of the soil. The nature of the exchangeable ion has a pronounced effect on the frost susceptibility of montmorillonoid fines. Trace minerals reduce frost susceptibility by altering soil structure, waterproofing, and altering permeability. Dispersants, which alter soil structure, have considerable promise as frost inhibitors, as well as several waterproofers.

-558-

AN - 25002517
 TI - FROST INVESTIGATIONS, 1952-1953. COLD ROOM STUDIES. THIRD INTERIM REPORT OF INVESTIGATIONS
 SO - U.S. Army Cold Regions Research and Engineering Laboratory (ACFEL), REPT. NO. ACFEL TR 43/1, Oct. 1958, 46p., 12 refs.
 DT - R (REPORT)
 LA - eng
 IT - tests; soil freezing; frost penetration; frost heave; frost action
 AB - The effects of several factors which influence the formation and growth of ice in soils were tested, and the results and recommendations are presented. The specimens of 38 soils of various gradations and geography were frozen under laboratory-controlled criteria. Susceptibility to frost heave is best determined by gradation characteristics. The soil type and moisture content does not influence the temperature of initial crystallization but does influence the temperature to which the soil rises immediately after crystallization and the duration of this temperature. The proportion of soil moisture frozen increases as the temperature decreases in clay but is completely frozen at 32 F. in silt and sand. The size and orientation of ice crystals in silt is more random than in clay.

-559-

AN - 25002468
 TI - FROST INVESTIGATION 1945-1946. REPORT ON TRUAX FIELD, MADISON, WISCONSIN
 SO - U.S. Army Cold Regions Research and Engineering Laboratory (ACFEL), REPT. NO. ACFEL TR 9 APP 4, June 1946, 107p.
 DT - R (REPORT)
 LA - eng
 IT - aircraft landing areas; frost penetration; subgrades; frost heave; soil mechanics
 AB - The scope of the investigation at Truax Field included periodic test pits to determine the changes in soil conditions, observation of air and subsurface temperatures, ground water observations, measurement of frost heave and subsidence, and field plate bearing tests.

-560-

AN - 25002432
TI - EXPERIMENTAL AND THEORETICAL STUDIES OF THE MECHANISM OF FROST HEAVING
AU - Chalmers, B.; Jackson, K.A.
SO - U.S. Army Cold Regions Research and Engineering Laboratory, REPT. NO. RR 199, Oct. 1970, 23p., 4 refs.
DT - R (REPORT)
LA - eng
IT - theories; analysis (mathematics); frost heave; ice lenses; soil water
AB - The paper discusses the Jackson and Chalmers theory of frost heave and describes attempts to verify it experimentally. The theory takes into account the local thermal conditions in the soil and the permeability of the soil. The theory predicts (or explains) stationary ice lens formation, where there is no advance of the frost line, and also predicts a rate of heave that is independent of the rate of advance of the freezing front. The theory assumes that a soil can be represented by a single characteristic void size although in real cases soils are not as uniform and homogeneous as assumed. Several experiments to verify the theory are described. They were generally unsuccessful, neither disproving nor substantiating the theory.

-561-

AN - 25002410
TI - EXPERIMENTAL DETERMINATION OF FROST HEAVE FORCES IN THE GROUND
AU - Vialov, S.S.; Egorov, N.I.
SO - REPT. NO. TL 170, 23p., Translation of Eksperimental'noe opredelenie sil pucheniia gruntov. Akademiia nauk SSSR. Institut merzlotovedeniia. Trudy 1958, No.14:40-55. 6 refs., Hanover, N.H., CRREL, 1970
DT - R (REPORT)
LA - eng, rus
IT - permafrost; frost heave; foundations; tests
AB - Any rational system for constructing building foundations in regions where permafrost and deep seasonal freezing are prevalent is impossible without due regard for the heaving forces which are built up during freezing of the ground. However, the data on the actual magnitude of these forces are incomplete. One factor which hinders experiments for determining heaving forces under field conditions appears to be undeveloped methods and the lack of enough simple procedural methods for such determinations. The purpose of the work was to test a new system for determining heaving forces under field conditions and development of some recommendations for using such a system.

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-562-

- AN - 25002240
 TI - BURIED SOILS ASSOCIATED WITH PERMAFROST
 AU - Brown, J.
 SD - Symposium on Pedology and Quaternary Research, May 13-14, 1969, Edmonton, Canada, REPT. NO. MP 84, p.115-127, 33 refs., Edmonton, University of Alberta, 1970
 DT - PA (PAPER)
 LA - eng
 IT - radiocarbon dating; frost heave; degradation; united states -alaska -barrow; permafrost structure; soils; ground ice
 AB - Buried remnants of former soil surfaces are commonly associated with ice-rich permafrost and the lower portion of the overlying thawed soil. A combination of ice wedge stratigraphy, radiocarbon dating, and chemical analyses of the soil, permafrost and aquatic environments are employed to interpret the northern coastal plain of Alaska. Organic matter is buried by lake erosion and deposition, wind deposition, cryopedologic processes on slopes and by frost heaving. Chemically depleted zones in the permafrost are associated with former lakes and previous periods of permafrost degradation. Remnants of at least one post-Wisconsin buried soil are found between the 0.5 and 3.0 m depth (8,200 and 10,600 years B.P.). Buried peat of several other ages also occurs in the Barrow area. The most recent (1,800-2,500 years B.P.) is associated with current ice-wedge activity. Similar techniques have been applied to the Fairbanks permafrost. The soils and permafrost of Recent age contain less extractable ions than the underlying Wisconsin-aged silts. Changes in upland soils during the two periods or differences in erosion and deposition are possible explanations.

-563-

- AN - 25002151
 TI - FUNDAMENTALS OF THE THEORY OF FROST-HEAVING
 AU - Takagi, S.
 SO - National Research Council. Publication, International Conference on Permafrost, Nov. 11-15, 1963, Lafayette, Ind. Proceedings, REPT. NO. MP 421, 1966 -No.1287, p.203-216, Includes discussions and supplement. 75 refs.
 DT - PA (PAPER)
 LA - eng
 IT - analysis (mathematics); frost heave; soil freezing

-564-

AN - 25002017
TI - LABORATORY EVALUATION OF FROST HEAVE CHARACTERISTICS OF A
SLAG-FLY ASH-LIME BASE COURSE MIXTURE
AU - Kaplan, C.W.
SO - National Research Council. Highway Research Board. Bulletin,
REPT. NO. MP 208, 1962-No. 331, p.1-20, 5 refs. Microform No.
SIP 20792.
DT - J (JOURNAL ARTICLE)
LA - eng
IT - tests; cements; frost heave
ST - POZZOLANS
AB - Laboratory tests were made on 16 specimens of a slag-fly ash-lime
base course mixture classified as frost susceptible to determine
the frost behavior characteristics of artificial pozzolanic
mixtures. Field-curing conditions were taken into consideration
in order to evaluate frost susceptibility which is affected by
the degree of cementation achieved at the time of freezing.
Since the degree of cementation is usually dependent on the
method and duration of curing, different methods of cure
treatment were tried and the effect of aging on frost
susceptibility was observed on 6-in. diam., 6-in. high specimens.
Test results showed that oven-cured specimens heaved
insignificantly, and "noncured" specimens heaved about 15% and
were classified as being of low frost susceptibility. Most
moist-cured and soaked specimens were classified as negligibly
frost-susceptible. The maximum measured heave of any of the
cured specimens during any one freezing cycle was approximately
0.2 in. and about 3.3%.

-565-

AN - 25001992
TI - EXPERIMENTAL DETERMINATION OF THE RESISTANCE OF ANCHOR-PLATE
FOOTINGS TO SHEAR STRESSES PRODUCED BY FROST HEAVE
OTI - (Eksperimental'noe opredelenie soprotivleniya ankernykh
fundamentov kasatel'nykh silam pucheniya grunta)
AU - Petrov, B.G.
SO - Transportnoe stroitel'stvo, July 1970-No.7, p.50, In Russian.
DT - J (JOURNAL ARTICLE)
LA - rus
IT - frozen ground; foundations; frost heave

-566-

AN - 25001986
TI - REPAIRING A BRIDGE DAMAGED BY FROST HEAVE
OTI - (Pereustroistvo mosta, deformirovannogo moroznym pucheniem)
AU - Gugutsidze, G.N.
SO - Transportnoe stroitel'stvo, Sept. 1970-No.9, p.12-13, In Russian.
DT - J (JOURNAL ARTICLE)
LA - rus

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IT - deformation; bridges; frost heave

-567-

AN - 25001968

TI - LAYER-BY-LAYER STUDY OF FROST HEAVE IN COHESIVE GROUND WHEN FREEZING UNDER NATURAL CONDITIONS

OTI - (Issledovanie posloinogo puchenila svlaznogo grunta pri pomerzaniil v prirodnykh usloviakh)

AU - Petrov, B.G.

SO - Akademiia stroitel'stva i arkhitektury SSSR.

Nauchno-issledovatel'skii institut osnovanii i podzemnykh sooruzhenii. Sbornik, 1970-No.59, p.167-177. In Russian. 15 refs.

DT - J (JOURNAL ARTICLE)

LA - rus

IT - frozen ground; measuring instruments; foundations; frost heave

-568-

AN - 25001777

TI - INFLUENCE OF FREEZING AND THAWING ON SOIL MOISTURE

AU - Pelton, W.L.; Campbell, C.A.; Nicholaichuk, W.

SO - Hydrology Symposium, 6th. Proceedings, p.241-267. Includes discussion. 33 refs., Ottawa, Queen's Printer, 1968

DT - PA (PAPER)

LA - eng

IT - frost penetration; frost heave; soil moisture; frozen ground hydrology; permeability

ST - FREEZE THAW CYCLES

-569-

AN - 25001599

TI - EFFECT OF MICRORELIEF ON THE PROCESSES OF SOIL HEAVE DURING FREEZING

OTI - (Vliianie mikrorel'efa na protsessy puchenila pochvy pri zamorozkakh)

AU - Moskaev, A.P.

SO - Russia. Ministerstvo vysshego i srednego spetsial'nogo obrazovaniia. Izvestiia vysshikh uchebnykh zavedenii. Lesnoi zhurnal, 1970 -No.3, p.141-144, In Russian. 13 refs.

DT - J (JOURNAL ARTICLE)

LA - rus

IT - frozen ground; frost penetration; frost heave; topographic factors; microrelief; soil freezing

790

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-570-

AN - 25001497
 TI - DEFORMATION OF A BUILDING ON FROST HEAVING GROUND, SUBJECT TO DEEP SEASONAL FREEZING
 OTI - (Deformatsiya zdaniya na puchinystrykh gruntakh v usloviyakh glubokogo sezonnogo promerzaniya)
 SO - Promyshlennoe stroitel'stvo, Dec. 1963 -No.12, p.42-43
 DT - J (JOURNAL ARTICLE)
 LA - rus
 IT - frozen ground; seasonal freeze thaw; buildings; deformation; frost heave

-571-

AN - 25001391
 TI - DESIGNING SURFACE WATER LINES LAID ON PERMAFROST IN NORIL'SK CITY
 OTI - (Opyt proektirovaniya naryuzhnykh truboprovodov na vechnomerzlykh gruntakh g. Noril'ska)
 AU - Ashenkampf, L.E.
 SO - Soveshchanie-seminar po obmenu opytom stroitel'stva na vechnomerzlykh gruntakh, Yakutsk, 1961, p.197-213, In Russian., Krasnoyarsk, -Gosstroil, -1962
 DT - PA (PAPER)
 LA - rus
 IT - permafrost thickness; ground ice; active layer; frost heave; water pipelines

-572-

AN - 25001380
 TI - DESIGN AND CONSTRUCTION OF RESIDENTIAL AND INDUSTRIAL BUILDINGS IN THE YAKUTSK REGION
 OTI - (Opyt stroitel'stva i proektirovaniya zhilykh otaplivayemykh promyshlennykh zdaniy v Yakutskom ekonomicheskoy raione)
 AU - Bondarev, I.N.
 SO - Soveshchanie-seminar po obmenu opytom stroitel'stva na vechnomerzlykh gruntakh, Yakutsk, 1961, p.50-66, In Russian., Krasnoyarsk, -Gosstroil, -1962
 DT - PA (PAPER)
 LA - rus
 IT - permafrost thickness; seasonal freeze thaw; buildings; foundations; frost heave; cold weather construction
 ST - CONSTRUCTION COSTS

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-573-

AN - 25001345
 TI - PIPE STRESS DUE TO FROST HEAVE
 AU - Browning, E.W.
 SO - Gas, Aug. 1970-46(8), p.74-77, 3 refs.
 DT - J (JOURNAL ARTICLE)
 LA - eng
 IT - pipeline heating; frost heave; frozen ground mechanics; pipeline insulation

-574-

AN - 25001303
 TI - PROCESSES AND PHENOMENA IN ENGINEERING GEOLOGY AND THE REGULARITIES GOVERNING THEIR FORMATION
 DTI - (Inzhenerno-geologicheskie protsessy i iavleniya, zakonomernosti ikh formirovaniya)
 AU - Kotlov, F.V.
 SO - Mezhdovedstvennoe soveshchanie po inzhenernoi geologii, Moscow, June 3-8, 1968, Problemy inzhenernoi geologii (Problems in engineering geology), p.184-188, In Russian. 5 refs., Moscow, -Izd-vo Moskov. Univ., -1970
 DT - PA (PAPER)
 LA - rus
 IT - slope processes; landslides; mudflows; frost heave

-575-

AN - 25001256
 TI - ENVIRONMENT OF THE CAPE THOMPSON REGION, ALASKA
 AU - Wilimovsky, N.J., ED; Wolfe, J.N., ED
 OS - U.S. Committee on Environmental Studies for Project Chariot
 SO - 1250p., For pertinent parts of this study see 23-3050 through 23-3055., (Oak Ridge, Tennessee), -U.S. Atomic Energy Commission, Division of Technical Information, -1966
 DT - MON (MONOGRAPH)
 LA - eng
 IT - engineering geology; patterned ground; drill core analysis; slope processes; frost heave; soil classification; sea ice; oceanography; radioactivity
 ST - BIOENVIRONMENT

-576-

AN - 25001069
 TI - GROUND FROST: A LISTING AND EVALUATION OF MORE RECENT LITERATURE DEALING WITH THE EFFECT OF FROST ON THE SOIL
 AU - Jessberger, H.L.
 SO - U.S. Army Foreign Science and Technology Center. Technical translation, REPT. NO. TL 66, Jan. 13, 1970 -FSTC-HT-23-311-70, 494 p., Translation of Bodenfrost. Zusammenstellung und

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Auswertung des neueren Schrifttums über die Wirkung des Frostes auf den Boden, Research Report V. 44, Munich. February 1969, p. 1-429.

DT - R (REPORT)
 LA - eng, ger
 IT - frost heave; frost penetration; porosity; heat transfer;
 hygroscopic water; frost action; bibliographies; soil freezing
 ST - GROUND THAWING

-577-

AN - 25001067
 TI - REPORT
 OS - Eastern Snow Conference. Committee on Research
 SO - Eastern Snow Conference. Proceedings, 1969 -26th, p.115-125
 DT - PA (PAPER)
 LA - eng
 IT - river ice; snowmelt; soil moisture; frost heave; ice pressure;
 spaceborne photography; bibliographies
 AB - Report is comprised of a brief annotated bibliography relating to ice and snow.

-578-

AN - 25000820
 TI - EFFECT OF BUILDINGS ON THERMAL REGIME OF BEARING GROUND
 OTI - (O vliianii zdanii na temperaturnyi rezhim gruntov)
 AU - Sokolov, A.A.
 SO - Russia. Ministerstvo vysshego i srednego spetsial'nogo obrazovaniia. Izvestiia vysshikh uchebnykh zavedenii. Stroitel'stvo i arkhitektura, 1965 -No.6, p.147-150, In Russian
 DT - J (JOURNAL ARTICLE)
 LA - rus
 IT - buildings; foundations; frozen ground thermodynamics; heat transfer; frost heave

-579-

AN - 25000710
 TI - SOIL FREEZING UNDER COLD STORAGE
 OTI - (O promerzanii grunta pod kholodil'nikami)
 AU - Ogurtsov, V.I.
 SO - Kholodil'naia tekhnika, May 1966 -No.5, p.17-20, In Russian.
 DT - J (JOURNAL ARTICLE)
 LA - rus
 IT - cold storage; refrigerating; frozen ground settling; frost heave

793

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-580-

AN - 25000701
 TI - BUILDING COLD STORAGES ON FROST-HEAVING GROUND
 OTI - (O stroitel'stve kholodil'nikov na puchinistykh gruntakh)
 AU - Lenskii, I.U.S.
 SO - Kholodil'naya tekhnika, April 1967 -No.4, p.29-30, In Russian.
 DT - J (JOURNAL ARTICLE)
 LA - rus
 IT - frozen ground; cold storage; frost heave; foundations

-581-

AN - 25000366
 TI - STABLE FORMS OF CROSS-SECTIONS OF EARTH CHANNELS IN THE SOUTHERN FAR EAST
 OTI - (Ob ustoiichivyykh formakh poperechnykh sechenii zemlianykh kanalov na luge Dal'nego Vostoka)
 AU - Piskun, L.V.
 SO - Vladivostok. Dal'nevostochnyi nauchno-issledovatel'skii institut po stroitel'stvu. Sbornik nauchnykh rabot, 1966 -Vol.8, p.116-121, In Russian. 4 refs.
 DT - J (JOURNAL ARTICLE)
 LA - rus
 IT - deformation; channels (waterways); frost heave; naleds

-582-

AN - 25000364
 TI - DEFORMATION OF BUILDINGS CONSTRUCTED ON FROST HEAVING GROUND OF THE SAKHALIN REGION (WINTER 1962/63)
 OTI - (Rezultaty nabludeniia za deformatsiiami zdaniia na puchinistykh gruntakh Sakhalinskoi oblasti (zima 1962/63 g.))
 AU - Timoshenko, V.A.
 SO - Vladivostok. Dal'nevostochnyi nauchno-issledovatel'skii institut po stroitel'stvu. Sbornik nauchnykh rabot, 1966 -Vol.8, p.97-102, In Russian. 14 refs.
 DT - J (JOURNAL ARTICLE)
 LA - rus
 IT - buildings; foundations; frost heave; seasonal freeze thaw; deformation

-583-

AN - 25000336
 TI - EFFECT OF NORMAL FORCES OF FROST HEAVING ON DEFORMATION OF A CONSTRUCTION IN PROGRESS
 AU - Orlov, E.I.
 SO - Soil mechanics and foundation engineering, Nov.-Dec. 1969 (Published 1970) -No.6, p.424-427, Translation from Osnovaniia, fundamente i mekhanika gruntov. 4 refs.
 DT - J (JOURNAL ARTICLE)

DFFE

LA - eng, rus
IT - foundations; seasonal freeze thaw; frost heave; frozen ground
thermodynamics

-584-

AN - 25000309
TI - FROST HEAVES IN KITAMI AND MONBETSU (1968-1969)
AU - Kinoshita, S.; Suzuki, Y.; Horiguchi, K.; Tanuma, K.; Acta, M.;
Ono, T.
SO - Low temperature science (Teton kagaku). Series A Physical
sciences, 1969 -Vol.27, p.379-393, In Japanese with English
summary. 11 refs.
DT - J (JOURNAL ARTICLE)
LA - jap, eng
IT - frost heave; frost penetration; frozen ground; pipes (tubes);
moisture content

-585-

AN - 25000308
TI - CHANGE OF WATER LEVEL DURING FROST HEAVING
AU - Kinoshita, S.; Suzuki, Y.; Horiguchi, K.; Tanuma, K.
SO - Low temperature science (Teton kagaku). Series A Physical
sciences, 1969 -Vol.27, p.367-377, In Japanese with English
summary. 6 refs.
DT - J (JOURNAL ARTICLE)
LA - jap, eng
IT - frozen ground; frost heave; frost penetration; soil moisture;
water content

-586-

AN - 25000307
TI - RELATION BETWEEN THE SOIL MOISTURE TRANSFER AND POROSITY DURING
FROST HEAVING
AU - Tanuma, K.
SO - Low temperature science (Teton kagaku). Series A Physical
sciences, 1969 -Vol.27, p.359-366, In Japanese with English
summary. 6 refs.
DT - J (JOURNAL ARTICLE)
LA - jap, eng
IT - frost heave; soil moisture migration; soil structure; porosity

795

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-587-

AN - 24003323
TI - FROST-HEAVING PRESSURES
AU - Hoekstra, P.; Chamberlain, E.; Frate, A.
SO - U.S. Army Cold Regions Research and Engineering Laboratory, REPT.
NO. RR 176, Oct. 1965, 12p., 28 refs.
DT - R (REPORT)
LA - eng
IT - frozen ground; frost heave; pressure factors; soil moisture
ST - PORE PRESSURE
AB - Upon freezing a saturated soil in an open system from the top down a considerable pressure develops. The pressure is the result of the surface energy of a curved ice-water interface. The curvature of the interface is necessary for ice to proliferate through the soil pores. The curvature is related to the pore size distribution of the soil. The test chamber is designed to minimize the friction of the soil with the wall. An accurate control of heat removal is obtained by thermoelectric cooling. A load cell placed on top of the sample is used to measure the pressure developed and at the same time prevents heaving of the sample. By measuring the pressure on a layered sample it can be shown that the pressure develops at the freezing front. The results on several soils indicate that the maximum pressure that develops has a characteristic value for each soil. For each soil used the water content versus tension curve is given and the maximum pressure is related to this curve.

-588-

AN - 24003289
TI - PRINCIPLES OF FROST HEAVING
AU - Takagi, S.
SO - U.S. Army Cold Regions Research and Engineering Laboratory, REPT.
NO. RR 140, Sept. 1965, 24p., Refs. on p.7-10.
DT - R (REPORT)
LA - eng
IT - soil freezing; frost heave
AB - Two formulations of soil freezing are presented, using a simple frost heaving model. Equations are given for freezing by segregation. A model is suggested to understand the properties of the segregating water layer in freezing by segregation, the adsorbed water around soil particles, the liquid-like layer on the ice surface, and various boundary liquids. The appendices present a literature review, an analysis of energy balance at the freezing front in freezing by segregation, additional equations for freezing by segregation, and technical notations.

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-589-

AN - 24003249
 TI - QUANTITATIVE DATA FROM A PATTERNED GROUND SITE OVER PERMAFROST
 AU - Schmertmann, J.H.; Taylor, R.S.
 SO - U.S. Army Cold Regions Research and Engineering Laboratory, REPT.
 NO. RR 96, Feb. 1965, 76p., 22 refs.
 DT - R (REPORT)
 LA - eng
 IT - frost penetration; permafrost physics; greenland -camp tuto;
 patterned ground; active layer; frost heave; soil moisture
 AB - Techniques were established by which quantitative data can be
 obtained from patterned ground features. The field work was
 carried out during the summers of 1954 and 1955 near Camp Tuto,
 Greenland. The chemical nature of the soils does not contribute
 to feature formation. It is the mechanical processes acting on
 these materials that are important. A sharp rise in the soil
 water content in the form of ice was consistently noted when
 passing through the base of the active layer into the present
 permafrost. A net heave occurred at both feature center and
 border locations. The magnitude of the heave is about 0.05 ft for
 the centers and 0.03 ft for the borders. Feature age was
 estimated to be about 150 yr. Vertical sorting occurs over the
 entire depth of the active layer but radial sorting is confined
 to the upper 2 ft. Ground-water flow occurs mostly through the
 feature borders, and incoming radiation has an important effect
 on the progression of the frost line. The progression of thaw is
 very rapid and, by the end of summer, the thaw penetration is
 greatest under the feature centers.

-590-

AN - 24003207
 TI - ROLE OF THE ELECTRIC DOUBLE LAYER IN THE MECHANISM OF FROST
 HEAVING
 AU - Cass, L.A.; Miller, R.D.
 SO - U.S. Army Cold Regions Research and Engineering Laboratory
 (SIPRE), REPT. NO. RR 49, Aug. 1959, 15p. plus appends., 21 refs.
 DT - R (REPORT)
 LA - eng
 IT - frost heave; clay soils; ice water interface; ice lenses;
 freezing potential (electrical)
 ST - OSMOSIS
 AB - It is suggested that the osmotic activity of the electrical
 double layer on mineral particles can account for the heaving
 phenomenon in soils and equations are given relating the osmotic
 pressure (and freezing temperature) of water at the base of a
 growing ice lens to overburden pressure, depth of water table,
 depth to the conducting stratum, hydraulic conductivity of soil,
 and rate of heave. Water flows to the ice face ordinarily by
 hydraulic conduction, but by diffusion in the unfrozen film
 between the upper-most particles and the underside of the ice
 lens. Coarse materials show little heave because of diffusion
 limitations on recharge of the unfrozen film. The theory of

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Jackson and Chalmers that supercooling is required for heaving is denied, and a "solution model" is proposed in which heaving can occur in the absence of soil. Various methods of modifying or controlling frost heaving are reviewed in the light of the theory, and experiments are proposed for evaluating the theory.

-591-

AN - 24003152
 TI - EFFECT OF MINERALOGICAL COMPOSITION OF FINES ON FROST SUSCEPTIBILITY OF SOILS
 AU - Lambe, T.W.; Kaplar, C.W.; Lambie, T.J.
 SO - U.S. Army Cold Regions Research and Engineering Laboratory, REPT. NO. TR 207, Sept. 1969, 31p., 14 refs.
 DT - R (REPORT)
 LA - eng
 IT - clays; frozen fines; frost heave; soil freezing
 AB - Freezing tests performed on about 400 artificially blended specimens with various amounts and different kinds of mineral fines

-592-

AN - 24003077
 TI - LABORATORY EVALUATION OF FROST HEAVE CHARACTERISTICS OF A SLAG - FLY ASH - LIME BASE-COURSE MIXTURE
 AU - Kaplar, C.W.
 SO - U.S. Army Cold Regions Research and Engineering Laboratory, REPT. NO. TR 96, Jan. 1963, 28p., 5 refs.
 DT - R (REPORT)
 LA - eng
 IT - countermeasures; tests; subgrade soils; frost action; frost heave
 AB - Sixteen specimens of a slag-fly ash-lime base-course mixture were tested for frost susceptibility in the laboratory. The mixture consisted of 66 per cent slag, 30 per cent fly ash and 4 per cent lime, by weight. Base courses of this type are being used in certain parts of the country in competition with conventional base-course materials. Test results showed that oven-cured specimens heaved insignificantly even after 10 cycles of slow freezing in an open-system test, and were classified to be of low frost susceptibility. In accordance with adopted criteria, based on average rate of heave in mm/day, most moist-cured and soaked specimens were classified as very low frost-susceptible. Specimens cured only in moist sand performed significantly better on the whole than those first submerged in water and then moist-cured. On "moist-cured only" specimens, heaving decreased with increase in curing time. The maximum measured heave of any of the cured specimens, soaked or otherwise, during any one freezing cycle was approximately 0.2 in. and about 3.3 per cent.

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-593-

AN - 24003007
 TI - REVIEW OF CERTAIN PROPERTIES AND PROBLEMS OF FROZEN GROUND, INCLUDING PERMAFROST
 AU - Lovell, C.W., Jr.; Herrin, M.
 OS - Purdue University, Lafayette, Ind. Engineering Experiment Station
 SO - U.S. Army Cold Regions Research and Engineering Laboratory (SIPRE), REPT. NO. TR 9, March 1953, 124p., Numerous refs.
 DT - R (REPORT)
 LA - eng
 IT - permafrost; frozen ground; artificial freezing; frost heave; thermal conductivity
 AB - The intrinsic factors and a limited coverage of the environmental factors influencing freezing and thawing actions are presented. The topics reviewed include: the theory of frost action in saturated and non-saturated soils and the disturbances produced by the freezing and thawing cycle the effects of frost action as manifested by frost heave on freezing in seasonally and perenially frozen ground reduction in load-carrying capacity on thawing, and soil movements along slopes. Material on ground properties and conditions affecting or affected by frost action include reports on the composition and thermal properties of soils, structure of unfrozen and frozen ground, density and degree of compaction, degree of saturation and the theory of f.p. depression. Surface icing and its control conclude the review. A summary of research recommendations is included.

-594-

AN - 24002861
 TI - OCCURRENCE OF PERMAFROST IN NORWAY
 OTI - (Evlg tele i Norge)
 AU - Vorren, K.-D.
 SO - Dttar, March 1967 -51(1), 26p., In Norwegian.
 DT - J (JOURNAL ARTICLE)
 LA - nor
 IT - norway; permafrost distribution; hummocks; frost heave; vegetation

-595-

AN - 24002703
 TI - CLIMATICALLY SIGNIFICANT FOSSIL PERIGLACIAL PHENOMENA IN NORTHCENTRAL UNITED STATES
 AU - Black, R.F.
 SO - Biuletyn peryglacjalny, 1969 -Vol.20, p.225-238, In French. 35 refs.
 DT - J (JOURNAL ARTICLE)
 LA - re
 IT - periglacial processes; ice veins; patterned ground; frost shattering; frost heave; solifluction; pingos; thermokarst

799

DFFE

-596-

AN - 24002633
TI - THAWING OF PERENNIALLY FROZEN GROUND BENEATH FOUNDATIONS
OTI - (Protalvanie mnogoletnemerzlykh gruntov v osnovanii sooruzhenii)
AU - Porkhaev, G.V.
SO - Akademiia stroitel'stva i arkhitektury SSSR. Institut osnovanii
i podzemnykh sooruzhenii. Trudy, 1967 -Vol.57, p.96-111, In
Russian. 13 refs.
DT - J (JOURNAL ARTICLE)
LA - rus
IT - frost heave; thawing; foundations

-597-

AN - 24002401
TI - FOOTINGS, FOUNDATIONS AND UNDERGROUND STRUCTURES. No.58
OTI - (Osnovaniia, Fundamenty i podzemnye sooruzheniia. Sbornik No.58)
OS - Russia. Gosudarstrennyi komitet po delam stroitel'stva
SO - 191p., In Russian with English table of contents enclosed. For
individual articles see Nos. 24-2402 through 24-2405.,
Moscow, -Stroizdat, -1966
DT - MON (MONOGRAPH)
LA - rus
IT - construction; foundations; frozen ground; seasonal freeze thaw;
frost heave

-598-

AN - 24002330
TI - FACTORS AFFECTING THE FROST SUSCEPTIBILITY CHARACTERISTICS OF
PULVERIZED FUEL ASH
AU - Sutherland, H.B.; Gaskin, P.N.
SO - Canadian geotechnical journal, Feb. 1970 -7(1), p.69-78, In
English with French summary. 14 refs.
DT - J (JOURNAL ARTICLE)
LA - eng, fre
IT - compressive strength; tensile strength; permeability; soil
freezing; frost heave; cement additives
ST - FLY ASH

-599-

AN - 24002329
TI - FROST HEAVING FORCES IN LEDA CLAY
AU - Penner, E.
SO - Canadian geotechnical journal, Feb. 1970 -7(1), p.8-16, In
English with French summary. 10 refs.
DT - J (JOURNAL ARTICLE)
LA - eng, fre
IT - temperature effects; frost heave; clay soils; ice lenses; stress
analysis; frost penetration

008

DFFE

-600-

AN - 24002308
 TI - SPECIAL ENGINEERING GEOLOGY
 OTI - (Spetsial'naya inzhenernaya geologiya)
 AU - Kolomenskii, N.V.
 SO - 336p. (Pertinent pages 115 - 152). In Russian. 39 refs.,
 Moscow, Nedra, 1969
 DT - MON (MONOGRAPH)
 LA - rus
 IT - construction; permafrost thickness; frost heave; solifluction;
 slope processes; engineering geology
 AB - Pertinent pages concern engineering problems related to slope
 processes and to freezing and thawing of ground.

-601-

AN - 24002066
 TI - PERMAFROST AND RELATED ENGINEERING PROBLEMS IN ALASKA
 AU - Ferrians, D.J., Jr.; Kachadoorian, R.; Greene, G.W.
 SO - U.S. Geological Survey. Professional paper, 1969 -No.673, 37p.,
 28 refs.
 DT - MON (MONOGRAPH)
 LA - eng
 IT - thawing; active layer; permafrost distribution; engineering
 geology; cold weather construction; frost heave

-602-

AN - 24002042
 TI - FREEZING OF SOILS
 AU - Parkhomenko, S.G.
 SO - National Research Council, Canada. Technical translation.
 Translated from Akademiia Nauk SSSR. Institut Merzlotovedeniia.
 Materialy k ucheniiu o merzlykh zonakh zemnoi kory. Vypusk III,
 1956, Aug. 1963 -No. TI-1038, p.34-68, 51 refs.
 DT - PA (PAPER)
 LA - eng, rus
 IT - soil freezing; soil moisture; soil physics; soil chemistry; frost
 heave

-603-

AN - 24001942
 TI - FROST PROTECTION WITH INSULATING MATERIALS
 OTI - (Telesikring ved isoleringsmaterialer)
 AU - Skogseid, A.
 SO - Norway. Veglaboratoriet. Meddelelser, 1968 -No.35, 15 p., In
 Norwegian. 8 refs.
 DT - R (REPORT)
 LA - nor
 IT - roadbeds; insulation; frost protection; frost heave

108

DFFE

-604-

AN - 24001935
TI - DESIGNING FOUNDATIONS AND FOOTINGS OF POWER LINE SUPPORTS IN PERMAFROST REGIONS FOR COMBINED ACTION OF WIND-LOAD AND FROST-HEAVE FORCES
OTI - (O raschete osnovanii i fundamentov opor linii elektroporedach i raiionakh s vechnomerzlymi gruntami pri sovmestnom deistvii vetrovoi nagruzki i nagruzki ot sil moroznogo puchenija)
AU - Gal'perin, V.V.
SO - Energeticheskoe stroitel'stvo, 1969 -No. 10, p.70-73, In Russian.
DT - J (JOURNAL ARTICLE)
LA - rus
IT - permafrost thickness; power lines; foundations; power line icing

-605-

AN - 24001846
TI - RESEARCH ON SOIL PHYSICS IN THE TERTIARY OF LOWER SAXONY AND ITS APPLICATION TO SHAFT CONSTRUCTION
OTI - (Bodenphysikalische Untersuchungen im Niederrheinischen Tertiar und ihre Anwendung beim Schachtbau)
AU - Kaltenberg, J.; Wolters, R.
SO - Fortschritte in der Geologie von Rheinland und Westfalen, July 1958 -Vol. 1, p. 73-83, In German. 11 refs.
DT - J (JOURNAL ARTICLE)
LA - ger
IT - soil mechanics; frost heave; mine shafts; cryogenic formations

-606-

AN - 24001774
TI - EFFECT OF NORMAL FROST HEAVE FORCES ON GAS-LINES
OTI - (Vozdeistvie normal'nykh sil moroznogo puchenija grunta na gazoprovody)
AU - Tagunov, M.I.
SO - Stroitel'stvo truboprovodov, Sept. 1969 -No.9, p.19-20, In Russian. 6 refs.
DT - J (JOURNAL ARTICLE)
LA - rus
IT - pipelines; frost heave

-607-

AN - 24001445
TI - ARTIFICIAL SALTING OF GROUNDS TO COMBAT THE HAZARD OF FROST HEAVING
AU - Kronik, I.A.A.; Ukhov, S.B.; Tsytoich, N.A.
SO - Soil mechanics and foundation engineering, Jan.-Feb. 1969 -No.1, p.38-43, Translated from Osnovaniia, fundamenty i mekhanika gruntov. 8 refs.
DT - J (JOURNAL ARTICLE)

802

DFFE

LA - eng, rus
 IT - countermeasures; salting; artificial thawing; frost penetration;
 frost heave

-608-

AN - 24001400
 TI - COLMATAGE OF SANDS IN THE FOUNDATION FILLS IN FROST HEAVE REGIONS
 OTI - (Kak'matazh peskov v obsypkakh fundamentov dlia puchinistykh
 gruntov)
 AU - Fedorova, N. IA.
 SO - Vladivostok. Dal'nevostochnyi nauchno-issledovatel'skii institut
 po stroitel'stvu. Sbornik nauchnykh rabot, 1964 -Vol.6,
 p.117-119, In Russian. 3 refs.
 DT - J (JOURNAL ARTICLE)
 LA - rus
 IT - construction; frozen ground; foundations; frost heave; earth fills

-609-

AN - 24001393
 TI - CERTAIN ASPECTS OF ENGINEERING GEOLOGY IN PERMAFROST
 AU - Swinzow, G.K.
 SO - Engineering geology, REPT. NO. MP 415, July 1969 -3(3),
 p.177-215, 51 refs.
 OT - J (JOURNAL ARTICLE)
 LA - eng
 IT - frost heave; pingos; ice wedges; patterned ground; permafrost
 structure; frozen ground mechanics; cold weather construction;
 engineering geology
 AB - Permafrost distribution reaches one-fifth of the dry land surface
 on the earth, and its occurrence is connected with many phenomena
 not found in other parts of the world. Patterned ground, ice
 wedges, pingos and icings are described in general terms.
 Strength of frozen ground and its rheology are discussed. The
 principal topics of engineering geology in permafrost are
 reviewed.

-610-

AN - 24001364
 TI - DESIGNING FOUNDATIONS AND FOOTINGS FOR BUILDINGS OF FEW STORIES
 AND STRUCTURES IN REGIONS OF DEEP SEASONAL FREEZING AND PERMAFROST
 OTI - (Osnovnye printsipy proektirovaniia osnovanii i fundamentov
 maloetazhnykh zdaniy i sooruzhenii v raionakh s glubokim sezonnym
 promerzaniem i rasprostraneniem vechnomerzlykh gruntov)
 AU - Fedorova, N. IA.
 SO - Vladivostok. Dal'nevostochnyi nauchno-issledovatel'skii institut
 po stroitel'stvu. Sbornik nauchnykh rabot, 1962 -Vol.3, p.87-93,
 In Russian. 1 ref.
 DT - J (JOURNAL ARTICLE)
 LA - rus

DFFE

IT - permafrost; design; frost heave; foundations

-611-

AN - 24001294
 TI - PROBLEMS CONCERNING FORMATION OF CRYOGENIC RELIEF
 OTI - (Problemy genezisa krigennogo rel'efa)
 AU - Vtiurin, B.I.
 SO - Meshcheriakov, I.U.A. and Korzhuev, S.S. (eds.), Geografiia i geomorfologiya Azii (Geography and geomorphology of Asia), p.118-129, In Russian. 37 refs., Moscow, -Nauka, -1969
 DT - PA (PAPER)
 LA - rus
 IT - permafrost origin; ground ice; frost heave; patterned ground; cryogenic processes

-612-

AN - 24001263
 TI - COMPUTER USED IN SOILS STUDY
 SO - Better roads, May 1969 -39(5), p.29
 DT - J (JOURNAL ARTICLE)
 LA - eng
 IT - soil stabilization; computer applications; seasonal freeze thaw; frost heave

-613-

AN - 24001125
 TI - FROST PHENOMENA ON MARS
 AU - Anderson, D.M.; Gaffney, E.S.; Philip, F.L.
 SO - Science, REPT. NO. MP 27, Jan. 20, 1967 -Vol.155, p.319-322, 11 refs.
 DT - J (JOURNAL ARTICLE)
 LA - eng
 IT - frost heave; saline soils; extraterrestrial ice
 ST - MARS (PLANET); JUPITER (PLANET)
 AB - The hypothesis that the Martian wave of darkening might be a frost heaving phenomenon has been examined. Consideration of the water-vapor sorption characteristics of a silicate mineral surface at temperatures below freezing leads to the conclusion that, without strongly deliquescent salts to attract and retain liquid water in the Martian soil, frost heaving phenomena are not to be expected on Mars. On the other hand, frost heaving phenomena involving the freezing and thawing of ammonia may be common in the soils of Jupiter.

804

DFFE

-614-

AN - 24001020
 TI - PLASTICS IN ROADBUILDING
 AU - Ripley, J.G.
 SO - Engineering and contract record, March 1967 -80(3), p.69-71
 DT - J (JOURNAL ARTICLE)
 LA - eng
 IT - frost heave; cold weather construction; subgrade preparation;
 cellular materials; frost penetration

-615-

AN - 24000836
 TI - ADFREEZING OF LEDA CLAY TO ANCHORED FOOTING COLUMNS
 AU - Penner, E.; Irwin, W.W.
 SO - Canadian geotechnical journal, Aug. 1969 -6(3), p.327-337, In English, with French summary. 7 refs.
 DT - J (JOURNAL ARTICLE)
 LA - eng, fre
 IT - frost penetration; foundations; frost heave; footings; pressure factors; clay soils
 ST - ADFREEZING STRENGTH

-616-

AN - 24000663
 TI - FROST HEAVE EFFECT ON THE STABILITY OF DATUM MARKS DURING SEASONAL FREEZING
 OTI - (Vliianie moroznogo pucheniia na ustoiichivost' reperov v usloviakh sezonnogo promerzaniia)
 AU - Uspenskiĭ, M.S.
 SO - Mezhdumezhdunarodnoye soveshchanie po merzlotovedeniiu, 7th, Moscow, Materialy po fizike i mekhanike merzlykh gruntov (physics and mechanics of frozen ground), p.69-73, In Russian. , Moscow, -Nauka, -1959
 DT - PA (PAPER)
 LA - rus
 IT - frost heave; seasonal freeze thaw

-617-

AN - 24000662
 TI - DETERMINING MAGNITUDE AND INTENSITY OF FROST HEAVE OF SOILS
 OTI - (Opredelenie velichiny i intensivnosti pucheniia promerzaiushchikh gruntov)
 AU - Bradiuk, G.P.
 SO - Mezhdumezhdunarodnoye soveshchanie po merzlotovedeniiu, 7th, Moscow, Materialy po fizike i mekhanike merzlykh gruntov (physics and mechanics of frozen ground), p.63-68, In Russian. 11 refs., Moscow, -Nauka, -1959
 DT - PA (PAPER)

805

DFFE

LA - rus
IT - soil freezing; frost heave

-618-

AN - 24000661
TI - FROST HEAVE OF COHESIVE SOILS
OTI - (Rezultaty issledovaniia protsessa pucheniia svlaznykh gruntov pri promerzani) i)
AU - Bredtuk, G.P.
SO - Mezhdueedomstvennoe soveshchanie po merzlotovedeniiu, 7th, Moscow, Materialy po fizike i mekhanike merzlykh gruntov (physics and mechanics of frozen ground), p.56-62, In Russian. 9 refs., Moscow, Nauka, -1959
DT - PA (PAPER)
LA - rus
IT - frost heave; soil freezing

-619-

AN - 24000445
TI - STUDYING FROST HEAVE OF PARTIALLY WATER-SATURATED GROUND
OTI - (Issledovanie moroznogo pucheniia gruntov pri nepolnom ikh vodonasyshtenii)
AU - Karpov, V.M.
SO - Leningrad. Inzhenerno-stroitel'nyi institut. Nauchnye trudy, 1962 -Vol.37, p.42-55, In Russian. 8 refs.
DT - J (JOURNAL ARTICLE)
LA - rus
IT - soil moisture; frost heave

-620-

AN - 24000441
TI - LABORATORY DETERMINATION OF THE STRENGTH OF GROUND FREEZING TO THE FOUNDATION
OTI - (K metodike laboratornogo opredeleniia prochnosti smerzaniia gruntov s materialom fundamenta)
AU - Puskov, V.I.
SO - Novosibirsk. Institut inzhenerov zheleznodorozhnogo transporta. Trudy, 1962 -Vol.28, p.137-149, In Russian. 6 refs.
DT - J (JOURNAL ARTICLE)
LA - rus
IT - frost heave; foundations; models

DFFE

-621-

AN - 24000440
TI - SALTING SOIL WITH SODIUM CHLORIDE
OTI - (Nekotorye dannye po zaschleniiu gruntov khloristym natriem)
AU - Soldatenko, A.P.
SO - Novosibirsk. Institut inzhenerov zheleznodorozhnogo transporta.
Trudy, 1962 -Vol.28, p.129-136, In Russian. 6 refs.
DT - J (JOURNAL ARTICLE)
LA - rus
IT - countermeasures; frost heave; soil freezing; salting

-622-

AN - 24000429
TI - EXPERIMENTATION WITH DECREASING FROST-HEAVE STRESSES ON FOUNDATIONS
OTI - (Opyty po umen'sheniiu sil vypuchivaniia fundamentov)
AU - Puskov, V.I.
SO - Novosibirsk. Institut inzhenerov zheleznodorozhnogo transporta.
Trudy, 1961 -Vol.22, p.13-140, In Russian. 6 refs.
DT - J (JOURNAL ARTICLE)
LA - rus
IT - foundations; frost heave

-623-

AN - 24000428
TI - DESIGN OF FOUNDATIONS FOR FROST HEAVE
OTI - (K raschetu fundamentov na vypuchivanie)
AU - Puskov, V.I.
SO - Novosibirsk. Institut inzhenerov zheleznodorozhnogo transporta.
Trudy, 1961 -Vol.22, p.15-130, In Russian. 15 refs.
DT - J (JOURNAL ARTICLE)
LA - rus
IT - foundations; frost heave

-624-

AN - 24000408
TI - MODELING FROST HEAVE OF WATER-SATURATED GROUND FOR ONE-DIMENSIONAL PROBLEMS
OTI - (K voprosu o modelirovani protsessa moroznogo pucheniia vcdonasyshchennogo grunta cilia odnomernoii zadachi)
AU - Velichanskii, G.V.
SO - Leningrad. Institut inzhenerov zheleznodorozhnogo transporta.
Sbornik trudov, 1962 -Vol.198, p.86-101, In Russian. 11 refs.
DT - J (JOURNAL ARTICLE)
LA - rus
IT - frost heave; models

DFFE

-625-

AN - 24000407
 TI - USING FROST HEAVE INTENSITY GRAPHS IN SELECTING COUNTERMEASURES
 OTI - (Ispol'zovanie epir intensivnosti pucheniia pri proektirovanii protivopuchinnykh ustroistv)
 AU - D'iakov, K.N.
 SO - Leningrad. Institut inzhenerov zheleznodorozhnogo transporta. Sbornik trudov, 1962 -Vol.198, p.68-85, In Russian. 9 refs.
 DT - J (JOURNAL ARTICLE)
 LA - rus
 IT - countermeasures; frost heave

-626-

AN - 24000319
 TI - GEOMORPHOLOGICAL PROCESSES IN THE MELTING LAYER IN SPITSBERGEN
 OTI - (Einige geomorphologische Prozesse in der Auftauschicht auf Spitzbergen)
 AU - Czeppe, Z.
 SO - Jena. Universitaet. Wissenschaftliche Zeitschrift. Mathematischnaturwissenschaftliche Reihe, 1968 -17(2), p.241-244; In German. 9 refs.
 DT - J (JOURNAL ARTICLE)
 LA - ger
 IT - norway -spitsbergen; periglacial processes; active layer; frost heave

-627-

AN - 24000318
 TI - RELIEF OF PERIGLACIAL REGIONS
 OTI - (Le modele des regions periglacieres)
 AU - Tricart, J.
 SO - Traite de geomorphologie, Vol. 2, 512p., In French. Numerous refs., Paris, -Soc. d'edition d'enseignement superieur, -1967
 DT - MON (MONOGRAPH)
 LA - fre
 IT - geomorphology; frost action; periglacial processes; glacial geology; slope processes; cryogenic soils; frost heave; patterned ground

-628-

AN - 24000170
 TI - FROST HEAVE IN KITAMI (1967-1968)
 AU - Kinoshita, S.; Horiguchi, K.; Tanuma, K.; Ono, T.
 SO - Low temperature science (Teion kagaku): Series A Physical Sciences, 1968 -Vol.26, p.363-381, In Japanese, with English summary. 17 refs.
 DT - J (JOURNAL ARTICLE)
 LA - jap, eng

DFFE

IT - frozen ground; frost penetration; soil moisture migration; frost heave; ice lenses

-629-

AN - 23005767
 TI - INSTRUCTIONS FOR DESIGNING AND BUILDING LIGHTLY LOADED FOUNDATIONS ON FROST HEAVING GROUND
 OTI - (Ukazaniia po proektirovaniu i stroitel'stvu malonagruzhennykh fundamentov na puchinistykh gruntakh)
 OS - Akademiia stroitel'stva i arkhitektury SSSR. Institut osnovanii i podzemnykh sooruzhenii
 SO - 28p., In Russian with English table of contents enclosed., Moscow, Gosstroizdat, -1963
 DT - J (JOURNAL ARTICLE)
 LA - rus
 IT - frozen ground mechanics; frost heave; foundations

-630-

AN - 23005735
 TI - FOUNDATIONS, BASEMENTS AND ENGINEERING GEOLOGY
 OTI - (Osnovaniia, fundamenty i inzhenernaia geologiya)
 AU - Nerpin, S.V.; Kotov, A.I.; Rasha, D.N.
 SO - 350p. (Pertinent pages 346-352), In Russian. 23 refs., Moscow, Rezhnoi transport, -1963
 DT - MON (MONOGRAPH)
 LA - rus
 IT - construction; permafrost; frozen ground; frost heave; foundations

-631-

AN - 23005723
 TI - ENGINEERING GEOLOGY OF CHALK
 AU - Higginbottom, I.E.
 OS - Institution of Civil Engineers, London
 SO - Chalk in earthworks and foundations: proceedings of the symposium held at the Institution of Civil Engineers, April 22, 1965, p.1-13, 17 refs., London, -Institution of Civil Engineers, -1966
 DT - PA (PAPER)
 LA - eng
 IT - engineering geology; frost heave; solifluction
 ST - CHALK

DFFE

-632-

AN - 23005657
TI - CALCULATING MOISTURE ACCUMULATION IN SOIL DURING WINTER
OTI - (O raschetakh zimnego vlagonakopleniya v gruntakh)
AU - Puzakov, N.A.
SO - Akademiia nauk SSSR. Laboratoriia gidrogeologicheskikh problem. Sovremennoe predstavlenie o svyazannoi vode v porodakh (Present outlook on bound water in rocks), p.123-125, In Russian, Moscow, -Izd-vo Akad. nauk SSSR, -1963
DT - J (JOURNAL ARTICLE)
LA - rus
IT - soil moisture; frost heave

-633-

AN - 23005492
TI - PROTECTING SUBGRADES FROM FROST HEAVE BY LAYERS OF CEMENTED EARTH
OTI - (Morozozashchitnye sloi iz mestnykh gruntov, ukreplennykh tsementom)
AU - Vasil'ev, I.U.M. ; Mel'nikova, M.G.
SO - Avtomobil'nye dorogi, Dec. 1968 -No.12, p.15-16, In Russian. 2 refs.
DT - J (JOURNAL ARTICLE)
LA - rus
IT - countermeasures; subgrade preparation; frost heave

-634-

AN - 23005322
TI - INSULATED AND IMPROVED SUBGRADES FOR ELIMINATING FROST HEAVE
AU - Keiner, E.P., Jr.
SO - Civil engineering, Feb. 1969 -39(2), p.38-39
DT - U (JOURNAL ARTICLE)
LA - eng
IT - insulation; subgrade preparation; frost heave; cellular materials

-635-

AN - 23004979
TI - MECHANISM OF BARRIER BAR DISPLACEMENT
OTI - (O mekhanizme peremeshcheniya beregovykh barov)
AU - Pravotorov, I.A.
SO - Moscow. Universitet. Vestnik. Seriya 5 Geografiia, Nov.-Dec. 1968 -No.6, p.75-77, In Russian with English summary.
DT - J (JOURNAL ARTICLE)
LA - rus
IT - ground ice; frost heave; frost shattering

DFFE

-636-

AN - 23004639
 TI - UNDERWATER PATTERNED GROUND IN ARTIFICIALLY DRAINED LAKES, GARRY ISLAND, N.W.T.
 AU - Mackay, J.R.
 SO - Geographical bulletin, Jan. 1967 -9(1), p.33-34, In English, with French summary. 7 refs.
 DT - J (JOURNAL ARTICLE)
 LA - eng, fre
 IT - frozen lakes; canada -northwest territories -garry island; patterned ground; lacustrine deposits; frost penetration; frost heave
 ST - FREEZE-THAW CYCLES

-637-

AN - 23004607
 TI - ICE DISTRIBUTION IN PERMAFROST PROFILES
 AU - Williams, P.J.
 SO - Canadian journal of earth sciences, Dec. 1968 -5(6), p.1381-1386. 11 refs.
 DT - J (JOURNAL ARTICLE)
 LA - eng
 IT - boreholes; frost heave; canada -northwest territories -mackenzie river delta; soil analysis; permafrost; ice lenses; soil moisture migration
 ST - AIR INTRUSIONS

-638-

AN - 23004535
 TI - ARIDITY AND FROST
 OTI - (Aridnost' i merzlota)
 AU - Frish, V.A. ; Frish, E.V.
 SO - Priroda, April 1968 -No.4, p.82-84, In Russian.
 DT - J (JOURNAL ARTICLE)
 LA - rus
 IT - frost heave; pingos; permafrost; taliks

-639-

AN - 23004449
 TI - THE DEPTH OF FOUNDATION LAYING IN FROST HEAVING GROUND
 OTI - (o glubine zalozheniia fundamentov v puchinistykh gruntakh)
 AU - Ushkalov, V.P.
 SO - Osnovaniia, fundamenty i mekhanika gruntov, 1963 -2(5), p 31, In Russian.
 DT - J (JOURNAL ARTICLE)
 LA - rus
 IT - foundations; frost heave

DFFE

-640-

AN - 23004447
TI - RECOMMENDATIONS FOR CALCULATING DEPTH OF FOUNDATION LAYING IN
FROST HEAVING GROUND (DISCUSSION)
OTI - (Predlozheniia po utochneniiu glubiny zalozheniia findamentov v
usloviakh puchenii gruntov pri promerzanii (v poriadke
obsuzhdeniia))
AU - Kiselev, M.F.
SO - Osnovaniia, fundamenty i mekhanika gruntov, 1963 -2(5), p.15-16,
In Russian. 4 refs.
DT - J (JOURNAL ARTICLE)
LA - rus
IT - foundations; frozen ground; frost heave

-641-

AN - 23004446
TI - SALTING OF GROUND AS A MEASURE AGAINST FROST HEAVE OF FOUNDATIONS
OTI - (Zasolenie gruntov kak sredstvo predotvrashcheniia moroznogo
vypuchivaniia fundamentov)
AU - Boiko, I.V.
SO - Osnovaniia, fundamenty i mekhanika gruntov, 1962 -6(4), p.13-15,
In Russian. 4 refs.
DT - J (JOURNAL ARTICLE)
LA - rus
IT - deformation; foundations; frost heave; frozen ground; salting

-642-

AN - 23004431
TI - PROTECTING CABLES FROM FROST HEAVE DAMAGE BY THERMAL INSULATION
OTI - (Teplovaia izoliatsiia kak sredstvo zashchity kabelei sviazi ot
povrezhdeniia pri puchenii grunta)
AU - Kulikov, I.U.G.
SO - Babushkin, Russia. Vsesoiuznyi nauchno-issledovatel'skii
institut transportnogo stroitel'stva. Trudy, 1966 -Vol.57,
p.93-95, In Russian. 4 refs.
DT - J (JOURNAL ARTICLE)
LA - rus
IT - frost heave; thermal insulation

-643-

AN - 23004429
TI - EFFECT OF FROST HEAVE ON COMMUNICATION CABLES
OTI - (Vliianie moroznogo puchenii gruntov na kabel'nye linii sviazi)
AU - Peretrukhin, N.A. ; Kulikov, I.U.G. ; Novoderezhkin, V.A.
SO - Babushkin, Russia. Vsesoiuznyi nauchno-issledovatel'skii
institut transportnogo stroitel'stva. Trudy, 1966 -Vol.57,
p.28-56, In Russian. 10 refs.
DT - J (JOURNAL ARTICLE)

LA - rus
IT - Frost heave; transmission lines

-644-

AN - 23004406
TI - EFFECT OF SOIL TEXTURE ON FROST HEAVE
OTI - (Vliianie struktury grunta na puchenie)
AU - Averochkina, M.V.
SO - Moscow. Vsesoiuznyi nauchno-issledovatel'skii institut zheleznodorozhnogo transporta. Trudy, 1967 -Vol.326, p.82-84, In Russian.
DT - J (JOURNAL ARTICLE)
LA - rus
IT - Frost heave

-645-

AN - 23004097
TI - INSTRUCTIONS FOR DESIGNING AND BUILDING FOUNDATIONS FOR LIGHT LOAD, ON FROST HEAVING GROUND
OTI - (Ukazaniia po proektirovaniu i stroitel'stvu malonagruzhennykh fundamentov na puchinistykh gruntakh)
OS - Akademiia stroitel'stva i arkhitektury SSSR. Institut osnovanii i podzemnykh sooruzhenii
SO - 27p., In Russian., Moscow, -Gosudarstvennoe izdatel'stvo literatury po stroitel'stvu, arkhitekture i stroitel'nykh materialam, -1963
DT - MON (MONOGRAPH)
LA - rus
IT - foundations; frost heave

-646-

AN - 23004096
TI - PREVENTING FROST HEAVE OF BUILDING FOUNDATIONS
OTI - (Meropriiatiia protiv moroznogo vypuchivaniia fundamentov)
AU - Kostinenko, G.I.
OS - Akademiia stroitel'stva i arkhitektury SSSR. Institut osnovanii i podzemnykh sooruzhenii
SO - 30p., In Russian. 42 refs., Moscow, -Gosudarstvennoe izdatel'stvo literatury po stroitel'stvu, arkhitekture i stroitel'nykh materialam, -1962
DT - MON (MONOGRAPH)
LA - rus
IT - frost heave; foundations

DFFE

-647-

AN - 23004071
TI - FROST-HEAVE STUDIES AT KNOB LAKE, 1964-65
AU - Gray, J.T.
SO - McGill University, Montreal. Sub-arctic Research Laboratory,
Schefferville, Que. McGill sub-arctic research papers, 1966
-No.21, p.108-128, 6 refs.
DT - J (JOURNAL ARTICLE)
LA - eng
IT - frost penetration; measurement; temperature factors; canada
-quebec -knob lake; frost heave; thermistors; soil temperature
ST - FREEZE THAW CYCLES

-648-

AN - 23004064
TI - NEW EXPERIMENTS TO SIMPLIFY FROST SUSCEPTIBILITY TESTING OF SOILS
AU - Kaplan, C.W.
SO - Highway research record, REPT. NO. MP 207, 1968 -No. 215,
p.48-59, 16 refs.
DT - J (JOURNAL ARTICLE)
LA - eng
IT - tests; frozen ground; experimental data; frost heave; test
equipment; soil tests; frost resistance
AB - Experiments conducted in recent years indicate that frost
susceptibility testing of soils can be shortened considerably
from the 2 weeks or so previously required. Results of
experiments show that useful frost-heaving data can be obtained
in a matter of 2 or 3 days by a more rapid freezing technique.
Results of experiments whereby soil specimens are exposed to a
constantly maintained temperature are presented. Data show that
heave rate in laboratory experiments is a variable and not a
constant of a soil and is strongly dependent upon the heat
extraction rate. The important role of frost susceptibility
testing and soil evaluation for highway design is discussed.
Comments are provided on suitability of equipment for use in
conducting frost-heaving tests.

-649-

AN - 23003996
TI - CRYOGENIC PHYSICO-GEOLOGICAL PHENOMENA IN PERMAFROST REGIONS
AU - Kachurin, S.P.
SO - National Research Council, Canada. Technical translation, 1964
-TT-1157, 91p.. Translated from Principles of geocryology
(permafrost studies), Part I, general geocryology, Chapter XI.
Academy of Sciences of the USSR. Moscow 1959, p.365-398.
Bibliography p.29-77. For abstract of original article see SIP
17921.
DT - MON (MONOGRAPH)
LA - eng, rus
IT - soil moisture migration; ground ice; naleds; frost heave;

thermokarst; cryogenic processes

-650-

AN - 23003894
 TI - FOOTINGS AND FOUNDATIONS
 OTI - (Osnovaniia i fundamente)
 AU - Laletin, N.V.
 SO - 380p., In Russian. 44 refs., Moscow, -Vysshiaia shkola, -1964
 DT - MON (MONOGRAPH)
 LA - rus
 IT - countermeasures; foundations; construction; permafrost; frost heave; naleds
 AB - This is a university textbook which includes a chapter dealing with building foundations in permafrost, structural properties of perennially frozen ground and frost heave and naled countermeasures (Chapter 19, p.340-355).

-651-

AN - 23003796
 TI - DETERMINING MAGNITUDE OF SOIL FROST HEAVING USING PROBABILITY THEORY
 OTI - (Opredelenie velichiny mroznogo puchenia gruntov s primeneniem metodov teorii veroiatnostei)
 AU - Kulikov, I.U.G.
 SO - Moscow. Vsesoiuznyi nauchno-issledovatel'skii institut transportnogo stroitel'stva. Trudy, ab-1967 -Vol. 62, p. 184-188, In Russian. 3 refs.
 DT - MON (MONOGRAPH)
 LA - rus
 IT - permafrost; frozen ground; active layer; frost heave

-652-

AN - 23003795
 TI - ELECTROCHEMICAL TREATMENT OF FROST HEAVING GROUND
 OTI - (Elektrokhimicheskaja obrabotka puchiniastykh gruntov)
 AU - Zrinkin, G.N. ; Gracher, I.A.
 SO - Moscow. Vsesoiuznyi nauchno-issledovatel'skii institut transportnogo stroitel'stva. Trudy, 1967 -Vol.62, p. 175-183, In Russian. 10 refs.
 DT - MON (MONOGRAPH)
 LA - rus
 IT - permafrost; frozen ground; countermeasures; active layer; frost heave; chemical ice prevention

DFFE

-653-

AN - 23003794
TI - EXPERIMENTS IN USING POTASSIUM CHLORIDE AS A COUNTERMEASURE OF
FOUNDATION FROST HEAVE
OTI - (Opyt primeneniia khloristogo kalija kak sredstva bor'by s
vypuchivaniem fundamentov sooruzhenii)
AU - Dubnov, I.U.D.
SO - Moscow. Vsesoiuznyi nauchno-issledovatel'skii institut
transportnogo stroitel'stva. Trudy, 1967 -Vol.62, p.168-174, In
Russian. 9 refs.
DT - MON (MONOGRAPH)
LA - rus
IT - permafrost; frozen ground; countermeasures; active layer; frost
heave; foundations; chemical ice prevention

-654-

AN - 23003793
TI - FROST HEAVING OF DUSTY LOAM DURING FREEZING AND PHYSICO-CHEMICAL
COUNTERMEASURES
OTI - (Puchenie pylevatykh suglinkov pri promerzanii i
fizikokhimicheskie priemy bor'by s nim)
AU - Nersesova, Z.A.
SO - Moscow. Vsesoiuznyi nauchno-issledovatel'skii institut
transportnogo stroitel'stva. Trudy., 1967 -Vol.62, p.157-167, In
Russian. 32 refs.
DT - MON (MONOGRAPH)
LA - rus
IT - countermeasures; permafrost; active layer; frozen ground; frost
heave

-655-

AN - 23003790
TI - BASIC CAUSES AND REGULARITIES OF LATERAL DECLINATION OF THE
FOUNDATIONS OF POWER LINE SUPPORT POLES IN FROST HEAVING GROUND
OTI - (Osnovnye prichiny i zakonomernosti bokovykh otklonenii
fundamentov opor kontaktnoi seti v puchinistykh gruntakh)
AU - Merenkov, N.D.
SO - Moscow. Vsesoiuznyi nauchno-issledovatel'skii institut
transportnogo stroitel'stva. Trudy, 1967 -Vol.62, p.110-130, In
Russian. 15 refs.
DT - MON (MONOGRAPH)
LA - rus
IT - frozen ground; frost heave; active layer; foundations; power lines

DFFE

-656-

AN - 23003789
TI - DETERMINING THE VALUES OF NORMAL FROST HEAVE FORCES
OTI - (Opredelenie velichiny normal'nykh sil puchenija)
AU - Kulikov, I.U.G. ; Peretrukhin, N.A.
SO - Moscow. Vsesoluznyi nauchno-issledovatel'skii institut
transportnogo stroitel'stva. Trudy, 1967 -Vol.62, p.106-109, In
Russian. 6 refs.
DT - MON (MONOGRAPH)
LA - rus
IT - permafrost; frozen ground; frost heave

-657-

AN - 23003788
TI - THERMOPHYSICAL BASIS FOR CALCULATING THE FORCES OF FOUNDATION
FROST HEAVE
OTI - (Teplofizicheskie obosnovaniia rascheta sil bypuchivaniia
fundamentov)
AU - Fel'dman, G.M. ; Shchelakov, V.K.
SO - Moscow. Vsesoluznyi nauchno-issledovatel'skii institut
transportnogo stroitel'stva. Trudy, 1967 -Vol.62, p.100-105, In
Russian. 4 refs.
DT - MEN (MONOGRAPH)
LA - rus
IT - permafrost; frozen ground; frost heave; foundations

-658-

AN - 23003787
TI - INTERACTION BETWEEN FOUNDATION AND FROST HEAVING GROUND
OTI - (Vzaimodelstvie fundamentov s promerzavushchimi puchiniyami
gruntov)
AU - Peretrukhin, N.A.
SO - Moscow. Vsesoluznyi nauchno-issledovatel'skii institut
transportnogo stroitel'stva. Trudy, 1967 -Vol.62, p.74-99, In
Russian. 17 refs.
DT - MON (MONOGRAPH)
LA - rus
IT - permafrost; frozen ground; frost heave; foundations

-659-

AN - 23003786
TI - LABORATORY INVESTIGATION OF TANGENTIAL FORCES OF FROST HEAVE
OTI - (Laboratornye issledovaniia kasatel'nykh sil puchenija)
AU - Dubnov, I.U.D.
SO - Moscow. Vsesoluznyi nauchno-issledovatel'skii institut
transportnogo stroitel'stva. Trudy, 1967 -Vol.62, p.61-73, In
Russian. 14 refs.
DT - MON (MONOGRAPH)

DFFE

LA - rus
IT - permafrost; frozen ground; frost heave; measurement

-660-

AN - 23003785
TI - RATE OF FROST HEAVE OF THE GROUND AT THE LATERAL SURFACE OF FOUNDATIONS
OTI - (Skorost' pucheniia grunta u bokovo! poverkhnosti fundamenta)
AU - Dubnov, I.U.D.
SO - Moscow. Vsesoiuznyi nauchno-issledovatel'skii institut transportnogo stroitel'stva. Trudy, 1967 -Vol.62, p.55-60. In Russian. 7 refs.
DT - MON (MONOGRAPH)
LA - rus
IT - permafrost; frozen ground; frost heave; foundations

-661-

AN - 23003784
TI - FORCE OF FOUNDATION FROST HEAVE
OTI - (Sila moroznogo vypuchivaniia fundamentov)
AU - Peretrukhin, N.A.
SO - Moscow. Vsesoiuznyi nauchno-issledovatel'skii institut transportnogo stroitel'stva. Trudy, 1967 -Vol.62, p.25-54. In Russian. 17 refs.
DT - MON (MONOGRAPH)
LA - rus
IT - permafrost; frozen ground; frost heave; foundations

-662-

AN - 23003783
TI - FROST HEAVE OF LOAMY SOIL
OTI - (Issledovanie moroznogo pucheniia suglinkov)
AU - Peretrukhin, N.A.
SO - Moscow. Vsesoiuznyi nauchno-issledovatel'skii institut transportnogo stroitel'stva. Trudy, 1967 -Vol.62, p.5-24. In Russian. 12 refs.
DT - MON (MONOGRAPH)
LA - rus
IT - frost heave; measuring instruments
ST - FROST HEAVE RATE; FROST HEAVE COEFFICIENTS

818

DFFE

-663-

AN - 23003782
 TI - FROST HEAVE AND WAYS OF PROTECTING STRUCTURES AGAINST ITS EFFECT
 OTI - (Moroznoe puchenie gruntov i sposoby zashchity sooruzhenii ot ego vozdeistviia)
 AU - Peretrukhin, N.A., ED.
 SO - Moscow. Vsesoiuznyi nauchno-issledovatel'skii institut transportnogo stroitel'stva. Trudy, Vol.62, 194p., In Russian., Moscow, -Transport, -1967
 DT - MON (MONOGRAPH)
 LA - rus
 IT - countermeasures; active layer; frost heave; foundations

-664-

AN - 23003571
 TI - PARTICLE SORTING BY REPEATED FREEZING AND THAWING
 AU - Corte, A.E.
 SO - Biuletyn peryglacjalny, 1966 - No.15, p.175-240, 32 refs.
 DT - J (JOURNAL ARTICLE)
 LA - eng
 IT - experimentation; migration; fines; frost heave; test equipment; ice lenses; particles; sorting; ice water interface; soil freezing; soil patterns
 ST - FREEZE THAW CYCLES

-665-

AN - 23003566
 TI - DETERMINING THICKNESS OF FROST SUSCEPTIBLE ZONE ABOVE THE GROUND-WATER LEVEL IN COHESIVE SOIL
 OTI - (Opredelenie vysoty morozopasnoi zony nad urovnem gruntovykh vod v svyaznykh gruntakh)
 AU - Chubarova, N.P.
 SO - Moscow. Nauchno-issledovatel'skii institut osnovanii i podzemnykh sooruzhenii. Osnovaniia, fundamenty i podzemnye sooruzheniia, p.163-165, In Russian. 2 refs., Moscow, -Izdatel'stvo literatury po stroitel'stву, -1967
 DT - MON (MONOGRAPH)
 LA - rus
 IT - frost heave

-666-

AN - 23003530
 TI - PACKING FOR PRESERVING FOUNDATIONS FROM BUCKLING AND FAILURE BY FROST CRACKS
 AU - Gapeev, S.I.
 SO - Soil mechanics and foundation engineering, Nov.-Dec. 1967 (Publ. 1968) -No.6, p.422-423, Translated from Osnovaniia, fundamenty i mekhanika gruntov. 5 refs.

OFFE

DT - J (JOURNAL ARTICLE)
LA - eng, rus
IT - foundations; frost heave; frost shattering

-667-

AN - 23003516
TI - STABILITY OF FOUNDATIONS UNDER CONDITIONS OF SOIL HEAVING DURING FREEZING
AU - Shvets, V.B. ; Kochengin, B.I.
SO - Soil mechanics and foundation engineering, May-June 1966 (Publ. 1967) -No. 3, p.198-201, Translated from Osnovaniia, fundamenty i mekhanika gruntov. 10 refs.
DT - J (JOURNAL ARTICLE)
LA - eng, rus
IT - construction; frost heave; foundations

-668-

AN - 23003512
TI - EXPERIMENTAL FOUNDATIONS WITH DRAIN BLANKETS AND WELLS IN HEAVING SOILS
AU - Fedorova, N.IA.
SO - Soil mechanics and foundation engineering, March-April 1966 (Publ. 1967) -No.2, p.122-124, Translation from Osnovaniia, fundamenty i mekhanika gruntov. 2 refs.
DT - J (JOURNAL ARTICLE)
LA - eng, rus
IT - construction; frozen ground; frost heave; buildings

-669-

AN - 23003507
TI - CONSTRUCTION OF FOUNDATIONS OF BUILDINGS OF MODERATE HEIGHT ON GROUND SUBJECT TO HEAVING
AU - Timoshenko, V.A.
SO - Soil mechanics and foundation engineering, March-April 1965 (Publ. 1966) -No.2, p.92-94, Translated from Osnovaniia, fundamenty i mekhanika gruntov. 4 refs.
DT - J (JOURNAL ARTICLE)
LA - eng, rus
IT - construction; frozen ground; frost heave; buildings

820

DFFE

-670-

AN - 23003445
 TI - STABILITY AND THE WAYS OF STABILIZING THE BANKS OF DRAINAGE
 CANALS IN FROST-SUSCEPTIBLE GROUND
 OTI - (Ustoichivost' i sposoby krepleniya otkosov osushitel'nykh
 kanalov v morozopasnykh gruntakh)
 AU - Nesterenko, I.M.
 SO - B Gidrotekhnika i melioratsiya, March 1967 -No. 3, p.92-96, In
 Russian. 4 refs.
 DT - J (JOURNAL ARTICLE)
 LA - rus
 IT - frost heave; drainage; slope stability; solifluction

-671-

AN - 23003393
 TI - PORE PRESSURES AT A PENETRATING FROST LINE AND THEIR PREDICTION
 AU - Williams, P.J.
 SO - Geotechnique, Sept. 1966 -16(3), p.187-208, 17 refs. Summary in
 French
 DT - J (JOURNAL ARTICLE)
 LA - eng, fre
 IT - frozen ground; a-frost penetration; tests; test equipment;
 experimentation; frost heave; forecasting; ground water; pressure
 factors; ice water interface

-672-

AN - 23003392
 TI - HEAVING PRESSURE IN SOILS DURING UNIDIRECTIONAL FREEZING
 AU - Fenner, E.
 SO - Canadian geotechnical journal, Nov 1967 -4(4), p.398-408 .. 7
 refs. Summary in French
 DT - J (JOURNAL ARTICLE)
 LA - eng, fre
 IT - pressure; soil freezing; ice lenses; interfaces; frost heave;
 frost penetration

-673-

AN - 23003223
 TI - WATER MIGRATION IN FREEZING GROUND AND PHYSICO-CHEMICAL
 COUNTERMEASURES FOR FROST HEAVE
 OTI - (Priroda migratsii vody v gruntakh pri promerzani i osnovy
 fiziko-khimicheskikh priemov bor'by s pucheniem)
 AU - Tlutiunov, I.A. ; Nersesova, Z.A.
 SO - 158p., In Russian. 193 refs., Moscow, -Izdatel'stvo akademii nauk
 SSSR, -1963
 DT - MON (MONOGRAPH)
 LA - rus
 IT - countermeasures; geocryology; frozen ground; soil water; frost

DFFE

ST - heave
- WATER MIGRATION

-674-

AN - 23003173
TI - THE MECHANICS OF ENGINEERING SOILS
AU - Capper, P.L.; Cassle, W.F.
SO - 27Op., London - Spon., -1949
DT - MON. (MONOGRAPH)
LA - eng
IT - countermeasures; frozen ground; frost heave
AB - In this monograph, pages 66 and 67 deal with frost effects on soil, frost heave, frost boil and preventive measures

-675-

AN - 23003088
TI - SOIL FREEZING AND SOIL WATER CHARACTERISTIC CURVES
AU - Koopmans, R.W.R.; Miller, R.D.
SO - Soil Science Society of America. Proceedings, Nov.-Dec. 1966
-30(6), p.680-685, 16 refs.
DT - J (JOURNAL ARTICLE)
LA - eng
IT - freezing; soil water; frost heave; experimentation

-676-

AN - 23003087
TI - CLOSED-SYSTEM FREEZING OF UNSATURATED SOIL
AU - Dirksen, C.; Miller, R.D.
SO - Soil Science Society of America. Proceedings, March-April 1966
-30(2), p.168-173, 21 refs.
DT - J (JOURNAL ARTICLE)
LA - eng
IT - frost heave; freezing; experimentation; soil water

-677-

AN - 23003053
TI - SLOPE MOVEMENT AND RELATED PHENOMENA
AU - Everett, K.R.
SO - U.S. Committee on Environmental Studies for Project Chariot, Environment of the Cape Thompson region, Alaska, p.175-220, 10 refs., Oak Ridge, -U.S. Atomic Energy Commission, -1966
DT - O (OTHER)
LA - eng
IT - soil moisture; soil temperatures; thawing; united states -alaska
-ogotoruk creek; slope processes; frost heave
ST - PROJECT CHARIOT

-678-

AN - 23003047
TI - PERMAFROST AND FOUNDATIONS
AU - Johnston, G.H.
SO - Canadian building digest, April 1965 -No. 64, 4p.
DT - D (OTHER)
LA - eng
IT - foundations; frost heave; permafrost

-679-

AN - 2300288
TI - SNOW AND ICE DAMAGE ON ELECTRIC COMMUNICATION LINES IN HOKKAIDO
OTI - (Hokkaido no denki tsushin senro to seppyogai)
AU - Kimura, T.
SO - Seppy, Sept. 1964 -26(5), p.140-149, In Japanese.
DT - J (JOURNAL ARTICLE)
LA - jap
IT - accumulation; ground thawing; japan -hokkaido; damage; power line icing; transmission lines; frost heave; roadbeds; snow loads

-680-

AN - 23002865
TI - SEASONAL SOFTENING OF GROUND AT THE BASE OF A RIGHT-OF-WAY
OTI - (Sezonnaya razuprochneniya gruntov osnovnoi ploshchadki zemliannogo polotna)
AU - Averochkina, M.V. ; Titov, V.P.
SO - Vsesoyuznyi nauchno-issledovatel'skii institut zheleznodorozhnogo transporta. Vestnik, 1968 -27(2), p.28-30, In Russian. 6 refs.
DT - J (JOURNAL ARTICLE)
LA - rus
IT - roadbeds; ground freezing; frost heave; thawing; deformation

-681-

AN - 23002770
TI - INVESTIGATING FROST HEAVE AREAS
OTI - (Yabliudeniya na puchiniistykh uchastkakh)
AU - Gritsyk, V.I. ; Karmanov, V.V.
SO - Put' i putevoe khoziaistvo, 1968 -No.4, p.40-42, In Russian
DT - J (JOURNAL ARTICLE)
LA - rus
IT - frost heave; countermeasures

DFFE

-682-

AN - 23002768
TI - CHEMISTRY HELPS COMBATTING FROST HEAVE
OTI - (Khimia pomogaet borot'sia s puchinami)
AU - Zolotarevskaya, N.M. ; Kriukov, G.N.
SO - Put' i putevoe khoziaistvo, 1967 -12, p.7-8, In Russian
DT - J (JOURNAL ARTICLE)
LA - rus
IT - countermeasures; frost heave; chemical ice prevention

-683-

AN - 23002760
TI - FROST HEAVE IN MOMBETSU (1966-1967)
AU - Kinoshita, S. ; Suzuki, Y. ; Horiguchi, K. ; Aota, M. ; Tanuma, K.
SO - Low temperature science (Teton kagaku). Series A Physical sciences, 1967 -Vol.25, p.229-232, In Japanese. 4 refs.
DT - J (JOURNAL ARTICLE)
LA - jap
IT - japan -mombetsu; frost heave; climate

-684-

AN - 23002759
TI - FROST HEAVE IN KITAMI (1966-1967)
AU - Kinoshita, S. ; Ono, T.
SO - Low temperature science (Teton kagaku). Series A Physical sciences, 1967 -Vol.25, p.225-228, In Japanese. 2 refs.
DT - J (JOURNAL ARTICLE)
LA - jap
IT - japan -kitami; frost heave; climate

-685-

AN - 23002754
TI - THE RELATION BETWEEN HEAVE AMOUNT AND WATER CONTENT DURING UNIDIRECTIONAL SOIL FREEZING
AU - Tanuma, K.
SO - Low temperature science (Teton kagaku). Series A Physical sciences, 1967 -Vol.25, p.179-184, In Japanese, with English summary. 2 refs.
DT - J (JOURNAL ARTICLE)
LA - jap, eng
IT - moisture factors; frost heave; soil freezing

DFFE

-686-

AN - 23002671
 TI - FROST AND FROZEN GROUND EFFECTS ON POWER LINES
 OTI - (Vozdel'stvie merzlotno-gruntovykh lavlenii na kabele svyazi)
 AU - Kulikov, I.U.G. ; Novoderezhkin, V.A. ; Peretrukhin, N.A. ; Frolov, P.A.
 SO - 47 p., In Russian. 15 refs., Moscow -Sviaz' -1967
 DT - MON (MONOGRAPH)
 LA - rus
 IT - power lines; power line icing; frozen ground; frost heave; thermal insulation

-687-

AN - 23002607
 TI - THE CAUSES OF DEFORMATION OF BUILDINGS IN THE CHITA REGION
 OTI - (Prichiny deformatsii nekotorykh zdaniy v raione Chity)
 AU - Bialynitskii, V.A. ; Zalezhev, I.U.E. ; Lorentsova, L.I.
 SO - Transportnoe stroitel'stvo, Feb. 1967 -No.2, p.28-30
 DT - J (JOURNAL ARTICLE)
 LA - rus
 IT - buildings; deformation; frost heave

-688-

AN - 23002598
 TI - INCREASING THE STABILITY OF FOUNDATIONS BUILT ON FROST HEAVING GROUND
 OTI - (Povyshenie ustoiichivosti fundamentov opor v puchinistykh gruntakh)
 AU - Merenkov, N.D.
 SO - Transportnoe stroitel'stvo, March 1968 -no.3, p.40-41
 DT - J (JOURNAL ARTICLE)
 LA - rus
 IT - permafrost; construction; foundations; frost heave; deformation

-689-

AN - 23002575
 TI - ALLOWING FOR THE FROST-HEAVE FORCES WHEN DESIGNING ANCHORS FOR TRANSMISSION LINE TOWERS
 OTI - (Uchet sil moroznogo pucheniia pri raschete zakrepleniia opor kontaktnoi seti)
 AU - Merenkov, N.D.
 SO - Transportnoe stroitel'stvo, June 1966 -No.6, p.40-42, 2 refs.
 DT - J (JOURNAL ARTICLE)
 LA - rus
 IT - frozen ground; construction; frost heave; power line supports; anchors

-690-

AN - 23002365
TI - STUDYING FROST HEAVING IN THE ALDAN REGION OF SOUTHERN YAKUTIYA
OTI - (Issledovaniia puchinistosti gruntov Aldanskogo raiona Iuzhnoi
IAkutii)
AU - Pankratov, S.F. ; Trush, N.I. ; Ananian, A.A.
SO - Merzlotnye issledovaniia, 1967-7, p. 264-275, In Russian.
DT - PA (PAPER)
LA - rus
IT - ussr -aldan plateau; frozen ground; frost heave

-691-

AN - 23002227
TI - ALLOWING FOR FROST HEAVE WHEN STUDYING FREEZING AND THAWING OF
CLAYEY SOILS
OTI - (Ob uchete puchenii pri issledovaniiakh protsessov promerzaniia
i ottaivanii glinistikh gruntov)
AU - Brediuk, G.P.
SO - Vsesoiuznoe mezhdudomstvennoe soveshchanie po geokriologii
(merzlotovedeniiu). Materialy VIII Soveshchanii, 1966-Vol.4, p.
226-233, In Russian. 6 refs.
DT - PA (PAPER)
LA - rus
IT - analysis (mathematics); clay soils; freezing; thawing; frost heave

-692-

AN - 23002207
TI - FROST HEAVING OF CLAYEY FINES EXPLAINED BY THERMODYNAMICS OF
IRREVERSIBLE PROCESSES
OTI - (Puchenie pylevato-glinistykh porod pri promerzanii v svete
termodynamiki neobratimyykh protsessov)
AU - Shvetsov, P.F.
SO - Vsesoiuznoe mezhdudomstvennoe soveshchanie po geokriologii
(merzlotovedeniiu). Materialy VIII Soveshchanii, 1966-Vol.4,
p.46-58, In Russian. 26 refs.
DT - PA (PAPER)
LA - rus
IT - analysis (mathematics); frozen fines; frost heave; temperature
gradients; moisture factors

-693-

AN - 23002200
TI - HEAVING PRESSURE IN SOILS DURING UNIDIRECTIONAL FREEZING
AU - Renner, E.
SO - Canadian geotechnical journal, Nov. 1967 -4(4), p.398-408, 7 refs.
DT - J (JOURNAL ARTICLE)
LA - eng
IT - ice water interface; grain size; frozen ground; frost heave; ice

DFFE

lenses

-694-

AN - 23002124
 TI - FROST HEAVING OF FINE GRAINED SOILS
 OTI - [Kriogennoe puchenie tonkodispersnykh gruntov]
 AU - Orlov, V.O.
 SO - 177p., in Russian. 260 refs., Moscow, -Izd-vo Akad. nauk SSSR, -1962
 DT - MON (MONOGRAPH)
 LA - rus
 IT - frozen ground; frozen fines; frost heave

-695-

AN - 23002034
 TI - PRESSURES DEVELOPED DURING THE UNIDIRECTIONAL FREEZING OF WATER-SATURATED POROUS MATERIALS
 AU - Penner, E.
 SO - International Conference on Low Temperature Science, Sapporo, Aug. 14-19, 1966, Proceedings, Vol. 1, Part 2, p. 1401-1412. 8 refs., Sapporo, -Institute of Low Temperature Science, Hokkaido University, -1967
 DT - PA (PAPER)
 LA - eng
 IT - pressure factors; frost heave; soil freezing; ice lenses ice water interface; cellular materials

-696-

AN - 23002032
 TI - RELATIONSHIP BETWEEN PARTIAL SOIL FREEZING AND SURFACE FORCES
 AU - Yong, R.N.
 SO - International Conference on Low Temperature Science, Sapporo, Aug. 14-19, 1966, Proceedings, Vol. 1, Part 2, p. 1375-1385. Also published as McGill University, Soil Mechanics Laboratory, Ser. No. 17, Aug. 1966. See SIP 24633. 10 refs., Sapporo, -Institute of Low Temperature Science, Hokkaido University, -1967
 DT - PA (PAPER)
 LA - eng
 IT - adsorption; capillarity; frozen ground mechanics; soil freezing; unfrozen water content; frost heave

827

127

DFFE

-697-

AN - 23002031
TI - FROST HEAVE IN SOILS: THE INFLUENCE OF PARTICLES ON SOLIDIFICATION
AU - Uhlman, D.R. ; Jackson, K.A.
SO - International Conference on Low Temperature Science, Sapporo,
Aug. 14-19, 1966, Proceedings, Vol. 1, Part 2, p. 1361-1373, 7
refs., Sapporo, -Institute of Low Temperature Science, Hokkaido
University, -1967
DT - PA (PAPER)
LA - eng
IT - frost heave; soil moisture migration; ice water interface; soil
freezing; heat transfer

-698-

AN - 23002030
TI - HEAVING FORCE OF FROZEN SOILS
AU - Kinoshita, S.
SO - International Conference on Low Temperature Science, Sapporo,
Aug. 14-19, 1966, Proceedings, Vol. 1, Part 2, p. 1345-1360, 17
refs., Sapporo, -Institute of Low Temperature Science, Hokkaido
University, -1967
DT - PA (PAPER)
LA - eng
IT - pressure factors; frost heave; frozen ground

-699-

AN - 23001926
TI - PHYSICS OF SNOW AND ICE: PROCEEDINGS, VOL. 1, PARTS 1 AND 2
[International Conference on Low Temperature Science, Sapporo,
Japan, 1966, Conference on physics of snow and ice, Sapporo,
Japan, 1966]
AU - Oura, H., ED
SO - 1414p., Parts 1 and 2 of Vol. 1, published separately, contain
108 papers presented at the conference. Composite author index
and table of contents for entire volume included in each part.
References included with individual papers., Sapporo, -Institute
of Low Temperature Science, Hokkaido University, 1967
DT - PA (PAPER)
LA - eng
IT - snow physics; sea ice; frost heave; avalanches; ice

OFFE

-700-

AN - 23001685
TI - FILLS FOR PROTECTING FOUNDATIONS FROM FROST HEAVING
OTI - (Obsypki dlia predokhraneniia morozoboinymi treshchinami)
AU - Gapeev, S.I.
SO - Osnovaniia, fundamenty i mekhanika gruntov, 1967 -No.6, p.26-27,
In Russian
DT - J (JOURNAL ARTICLE)
LA - rus
IT - foundations; frost heave; insulation

-701-

AN - 23001669
TI - STABILITY OF FOUNDATIONS UNDER FROST HEAVING CONDITIONS DURING
FREEZING
OTI - (Ob ustoiichivosti fundamentov v usloviakh pucheniia gruntov pri
promerzaniit)
AU - Shvets, V.B. ; Kochengin, B.I.
SO - Osnovaniia, fundamenty i mekhanika gruntov, 1966 -No.3, p.26-28,
In Russian. 4 refs.
DT - J (JOURNAL ARTICLE)
LA - rus
IT - frozen ground; foundations; frost heave

-702-

AN - 23001664
TI - EXPERIMENTAL FOUNDATIONS IN FROST HEAVING SOILS USING DRAINAGE
INTERLAYERS AND OUTLETS
OTI - (Opytnye fundamenty s dreniruiushchimi prosloikami i skvazhinami
v puchinistyykh gruntakh)
AU - Fedorova, N.IA.
SO - Osnovaniia, fundamenty i mekhanika gruntov, 1966 -No.2, p.26-27,
In Russian. 2 refs.
DT - J (JOURNAL ARTICLE)
LA - rus
IT - frozen ground; foundations; frost heave

-703-

AN - 23001661
TI - RELATION OF FROST HEAVE TO MOISTURE CONTENT, GRAIN SIZE, AND
MINERAL COMPOSITION OF THE URAL RESIDUAL CLAYEY SOILS
OTI - (Zavisimost' moroznogo pucheniia elluvial'nykh glinistykh gruntov
Urals ot vlazhnosti, granulometricheskogo a mineralogicheskogo
sostavov)
AU - Mel'nikov, B.N.
SO - Osnovaniia, fundamenty i mekhanika gruntov, 1966 -No.1, p.12-13,
In Russian. 3 refs.
DT - J (JOURNAL ARTICLE)

829

DFFE

LA - rus
IT - frozen ground; frost heave

-704-

AN - 23001545
TI - METHOD FOR DETERMINING NORMAL FROST HEAVING FORCES ACCOUNTING FOR THE COMPRESSIONAL PROPERTIES OF NON-FROZEN GROUND
OTI - (Metod opredeleniia normal'nykh sil pucheniia s uchetom kompressionnykh svoistv nemerzlogo grunta)
AU - Kulikov, I.U.G. ; Peretrukhin, N.A.
SO - Akademiia nauk SSSR. Sibirskoe otdelenie. Institut merzlotovedeniia. Materialy VIII vsesoiuznogo mezhduvedomstvennogo soveshchanii po geokriologii (merzlotovedeniia), 1966 -Vol.8, p.269-272, In Russian. 4 refs.
DT - PA (PAPER)
LA - rus
IT - analysis (mathematics); frost heave

-705-

AN - 23001543
TI - APPROXIMATE METHOD FOR CALCULATING FORCES OF NORMAL FROST HEAVING
OTI - (Priblizhennyi metod rascheta sil normal'nogo pucheniia)
AU - Zaretskii, I.U.K.
SO - Akademiia nauk SSSR. Sibirskoe otdelenie. Institut merzlotovedeniia. Materialy VIII vsesoiuznogo mezhduvedomstvennogo soveshchanii po geokriologii (merzlotovedeniia), 1966 -Vol.8, p.251-259, In Russian. 2 refs.
DT - PA (PAPER)
LA - rus
IT - analysis (mathematics); frost heave

-706-

AN - 23001538
TI - PHYSICO-CHEMICAL MEASURES AGAINST FROST HEAVING OF THE GROUND
OTI - (Fiziko-khimicheskii sposob bor'by s moroznym pucheniem gruntov)
AU - Ukhov, S.B.
SO - Akademiia nauk SSSR. Sibirskoe otdelenie. Institut merzlotovedeniia. Materialy VIII vsesoiuznogo mezhduvedomstvennogo soveshchanii po geokriologii (merzlotovedeniia), 1966 -Vol.8, p.200-212, In Russian. 13 refs.
DT - PA (PAPER)
LA - rus
IT - frost heave; chemical ice prevention

-707-

AN - 23001484
TI - EXPERIMENTAL STUDY OF NORMAL FROST HEAVING FORCES ACTING ON GROUND
OTI - (Eksperimental'nye issledovaniia normal'nykh sil moroznogo pucheniia gruntov)
AU - Tolkachev, N.A.
SO - Akademiia stroitel'stva i arkhitekury SSSR. Nauchno-issledovatel'skii institut osnovanii i podzemnykh sooruzhenii. Sbornik, 1963 -No. 52, p.91-116, In Russian. 22 refs.
DT - J (JOURNAL ARTICLE)
LA - rus
IT - frost heave

-708-

AN - 23001483
TI - FROST HEAVE FORCES AND DEFORMATIONS ACTING ON FOUNDATIONS AND THE WAYS OF DECREASING THEM
OTI - (Sily i deformatsii moroznogo vypuchivaniia fundamentov i mery ikh umen'sheniia)
AU - Ushkalov, V.P.
SO - Akademiia stroitel'stva i arkhitekury SSSR. Nauchno-issledovatel'skii institut osnovanii i podzemnykh sooruzhenii. Sbornik, 1963 -No. 52, p.69-90, In Russian. 11 refs.
DT - J (JOURNAL ARTICLE)
LA - rus
IT - foundations; deformation; frost heave

-709-

AN - 23001480
TI - FROST HEAVE COUNTERMEASURES FOR FOUNDATIONS BUILT ON HEAVING GROUND
OTI - (Moroznoe puchenie i meropriiatiia po umen'sheniu deformatsii fundamentov na puchinistykh gruntakh)
AU - Kiselev, M.F.
SO - Akademiia stroitel'stva i arkhitekury SSSR. Nauchno-issledovatel'skii institut osnovanii i podzemnykh sooruzhenii. Sbornik, 1963 -No. 52, p.5-41, In Russian. 33 refs.
DT - J (JOURNAL ARTICLE)
LA - rus
IT - construction; frost heave; foundations

OFFE

-710-

AN - 23001434
TI - INTERPLAY BETWEEN FROST-HEAVING GROUND AND FOUNDATIONS BUILT ON SLOPES
OTI - (Osobennosti vzaimodelstviia promerzaiushchego puchinistogo grunta s fundamentami ustanovlennymi na otkosakh i kosogorakh)
AU - Merenkov, N.D.
SO - Akademiia nauk SSSR. Sibirskoe otdelenie. Institut merzlotovedeniia. Materialy VIII vsesoiuznogo mezhdudomstvennogo soveshchaniia po geokriologii (merzlotovedeniia), 1966 -Vol.5, p.150-159, In Russian. 3 refs.
DT - PA (PAPER)
LA - rus
IT - construction; foundations; frost heave

-711-

AN - 23001270
TI - CALCULATING FROST HEAVING OF THE BEARING GROUND WHEN DESIGNING MEASURES AGAINST FOUNDATION DEFORMATION
OTI - (K raschetu puchinistosti gruntov osnovanii pri proektirovanii meropriiatiu protiv vypuchivaniia fundamentov)
AU - Orlov, V.O.
SO - Akademiia nauk SSSR. Sibirskoe otdelenie. Institut merzlotovedeniia. Sovremennye voprosy regional'noi i inzhenernoi geokriologii (merzlotovedeniia) (Current problems in regional and engineering geocryology), p.186-193, In Russian. 1 ref., Moscow, -Nauka, -1964
DT - PA (PAPER)
LA - rus
IT - construction; countermeasures; foundations; frost heave

-712-

AN - 23001269
TI - HEAVING OF FREEZING GROUND IN DISCRETE INCREMENTS
OTI - (O skachkoobraznosti pucheniia promerzaiushchikh gruntov)
AU - Pchelintsev, A.M.
SO - Akademiia nauk SSSR. Sibirskoe otdelenie. Institut merzlotovedeniia. Sovremennye voprosy regional'noi i inzhenernoi geokriologii (merzlotovedeniia) (Current problems in regional and engineering geocryology), p.181-185, In Russian. 5 refs., Moscow, -Nauka, -1964
DT - PA (PAPER)
LA - rus
IT - frost heave

832

32

DFFE

-713-

AN - 23001218
TI - DYNAMICS OF THE REACTION BETWEEN POTASSIUM CHLORIDE AND GROUND AT LOW TEMPERATURES
OTI - (Dinamika vzaimodel'stviia khloristogo kaliia s gruntom pri nizkikh temperaturakh)
AU - Tlutunova, F.I.
SO - Moscow. Nauchno-issledovatel'skii institut osnovanii i podzemnykh sooruzhenii. Sbornik. Kriogennye protsessy v pochvakh i gornykh porodakh (cryogenic processes in rocks and soils), p.9-104. In Russian. 9 refs., Moscow, -Nauka, -1965
DT - PA (PAPER)
LA - rus
IT - countermeasures; frost heave; antifreezes

-714-

AN - 23001196
TI - CERTAIN CONSEQUENCES OF UNDERESTIMATING FROZEN GROUND CONDITIONS DURING CONSTRUCTION IN CHITA CITY
OTI - (O nekotorykh posledstviakh nedootsenki merzlotno-gruntovykh uslovii pri stroitel'stve v g. Chite)
AU - Tsiunchik, B.L.
SO - Russia. Ministerstvo vysshego i srednego spetsial'nogo obrazovaniia. Izvestiia vysshikh uchebnykh zavedenii. Stroitel'stvo i arkhitektura, 1967 -No.7, p.23-26, In Russian. 4 refs.
DT - J (JOURNAL ARTICLE)
LA - rus
IT - construction; frost heave

-715-

AN - 23001185
TI - INFLUENCE OF DEPTH OF FROST PENETRATION ON THE FROST SUSCEPTIBILITY OF SOILS
AU - Osler, J.C.
SO - Canadian geotechnical journal, Aug. 1967 -4(3), p.334-346, 13 refs.
DT - J (JOURNAL ARTICLE)
LA - eng
IT - frost penetration; frost heave; ice water interface; soil freezing

833

DFFE

-716-

AN - 23001168
TI - FOUNDATION DESIGN FOR FROST HEAVING
OTI - (K raschetu fundamenta na vypuchivanie)
AU - Oparin, A.A.
SO - Russia. Ministerstvo vysshego i srednego spetsial'nogo obrazovaniia. Izvestiia vysshikh uchebnykh zavedenii. Stroitel'stvo i arkhitektura, 1966 -No.10, p.27-31. In Russian. 7 refs.
DT - J (JOURNAL ARTICLE)
LA - rus
IT - design; foundations; frost heave

-717-

AN - 23001061
TI - EFFECT OF CRYOGENIC PHYSICAL-GEOLOGICAL PHENOMENA ON TOPOGRAPHY OF THE PATOMSKOE PLATEAU
OTI - (Vliianie merzlotnykh fiziko-geologicheskikh iavlenii na formirovanie rel'efa Patomskogo nagor'ia)
AU - Romanovskii, N.N.; Poltev, N.F.; Budarin, I.U.M.
SO - Akademiia nauk SSSR. Sibirskoe otdelenie. Institut merzlotovedeniia. Materialy VIII vsesoiuznogo mezhdudomstvennogo soveshchania po geokriologii (merzlotovedeniia), 1966 -Vol.6, p.39-49, In Russian. 4 refs.
DT - PA (PAPER)
LA - rus
IT - topography; ussr -patom plateau; naleds; frost heave; frost shattering; solifluction

-718-

AN - 23001035
TI - MAPPING WEST SIBERIA ACCORDING TO FROST HEAVE INTENSITY
OTI - (K raionirovaniu Zapadnoi Sibiri po intensivnosti proiavleniia protsessov puchinoobrazovaniia v gruntakh)
AU - Nevecheria, V.L.
SO - Akademiia nauk SSSR. Sibirskoe otdelenie. Institut merzlotovedeniia. Materialy VIII vsesoiuznogo mezhdudomstvennogo soveshchania po geokriologii (merzlotovedeniia), 1966 -Vol.3, p.53-59, In Russian. 4 refs.
DT - PA (PAPER)
LA - rus
IT - construction; ussr -west siberia; mapping; frost heave; permafrost

DFFE

-719-

AN - 23001006
TI - EFFECTIVENESS OF FROST HEAVE COUNTERMEASURES
OTI - (Analiz raboty protivopuchinnykh ustroystv)
AU - Cheptsov, V.V.
SO - Russia. Komitet po zemlianomu polotnu. Sooruzhenie i
ekspluatatsiia zemlianogo polotna iz pylevatykh gruntov
(Construction and exploitation of subgrades made of fine soils),
p.134-137, In Russian. , Moscow, -Transport, -1964
DT - PA (PAPER)
LA - rus
IT - countermeasures; frost heave

-720-

AN - 23000656
TI - HYDROINSULATION OF DITCH WALLS AND ITS EFFECT ON MOISTURE CONTENT
OF THE GROUND BENEATH EXCAVATIONS
OTI - (Vliianie gidroizoliatsii kiuvetov na vlazhnost' gruntov v
vyemkakh)
AU - Gritsyk, V.I.
SO - Russia. Komitet po zemlianomu polotnu. Bor'ba s puchinami na
zheleznykh i avtomobil'nykh dorogakh (Control of frost heave on
railroad tracks and highways), p.174-178, In Russian. ,
Moscow, -Transport, -1965
DT - PA (PAPER)
LA - rus
IT - countermeasures; frozen ground; frost heave

-721-

AN - 23000654
TI - CRYOGENIC SURVEY AS A MEANS OF PREVENTING FROST HEAVINGS OF
ENGINEERING STRUCTURES
OTI - (O merzlotnoi s"emke kak osnove preduprezhdeniia deformatsii
inzhenernykh sooruzhenii ot moroznogo pucheniia gruntov)
AU - Pikulevich, L.D.
SO - Russia. Komitet po zemlianomu polotnu. Bor'ba s puchinami na
zheleznykh i avtomobil'nykh dorogakh (Control of frost heave on
railroad tracks and highways), p.163-169, In Russian. 13 refs.,
Moscow, -Transport, -1965
DT - PA (PAPER)
LA - rus
IT - countermeasures; frost heave

835

DFFE

-722-

AN - 23000653
TI - PROCEDURES FOR ENGINEERING AND GEOLOGICAL INVESTIGATIONS OF FROST HEAVE AREAS
OTI - (O metodike inzhenerno-geologicheskikh izyskaniy na uchastkakh obrazovaniya puchiny)
AU - Ermakov, I.G.
SO - Russia. Komitet po zemlianomu polotnu. Bor'ba s puchinami na zheleznnykh i avtomobil'nykh dorogakh (Control of frost heave on railroad tracks and highways), p.159-163, In Russian. 6 refs., Moscow, -Transport, -1965
DT - PA (PAPER)
LA - rus
IT - design; frozen ground; frost heave; subgrades

-723-

AN - 23000652
TI - WAYS OF OBTAINING DIAGRAMS OF FROST HEAVING INTENSITY IN FREEZING GROUNDS
OTI - (Sposoby vylavleniya eptur intensivnosti pucheniya promerzshikh gruntov)
AU - Brediuk, G.P.
SO - Russia. Komitet po zemlianomu polotnu. Bor'ba s puchinami na zheleznnykh i avtomobil'nykh dorogakh (Control of frost heave on railroad tracks and highways), p.147-159, In Russian. 11 refs., Moscow, -Transport, -1965
DT - PA (PAPER)
LA - rus
IT - frost heave

-724-

AN - 23000651
TI - MAPPING WEST SIBERIA ACCORDING TO FROST HEAVING INTENSITY FOR CONSTRUCTION PURPOSES
OTI - (Raznirovaniye Zapadnoi Sibiri po intensivnosti puchinoobrazovaniya v gruntakh primenitel'no k zadacham transportnogo stroitel'stva)
AU - Nevecheria, V.L.
SO - Russia. Komitet po zemlianomu polotnu. Bor'ba s puchinami na zheleznnykh i avtomobil'nykh dorogakh (Control of frost heave on railroad tracks and highways), p.139-146, In Russian. 5 refs., Moscow, -Transport, -1965
DT - PA (PAPER)
LA - rus
IT - frozen ground; frost heave; mapping

DFFE

-725-

AN - 23000649
TI - BASIC CAUSES AND CONDITIONS OF HEAVING OF SEASONALLY FREEZING GROUND
OTI - (Osnovnye prichiny i usloviya pucheniya sezonno-promerzaiushchikh gruntov)
AU - Pchelintsev, A.M.
SO - Russia. Komitet po zemlianomu polotnu. Bor'ba s puchinami na zheleznykh i avtomobil'nykh dorogakh (Control of frost heave on railroad tracks and highways), p.122-130, In Russian. 19 refs. Moscow, -Transport, -1965
DT - PA (PAPER)
LA - rus
IT - countermeasures; frozen ground; seasonal freeze thaw; frost heave

-726-

AN - 23000643
TI - USE OF SALT IN FROST HEAVE CONTROL
OTI - (Primenenie soli dlia bor'by s pucheniem gruntov)
AU - Lobanov, I.Z.
SO - Russia. Komitet po zemlianomu polotnu. Bor'ba s puchinami na zheleznykh i avtomobil'nykh dorogakh (Control of frost heave on railroad tracks and highways), p.66-73, In Russian. 6 refs., Moscow, -Transport, -1965
DT - PA (PAPER)
LA - rus
IT - countermeasures; frozen ground; frost heave; salting

-727-

AN - 23000642
TI - FROST HEAVE CONTROL BY CHEMICAL ADMIXTURES
OTI - (Primenenie nekotorykh khimicheskikh dobavok v tseliakh bor'by s puchinami)
AU - Averochkina, M.V.
SO - Russia. Komitet po zemlianomu polotnu. Bor'ba s puchinami na zheleznykh i avtomobil'nykh dorogakh (Control of frost heave on railroad tracks and highways), p.62-66, In Russian. Moscow, -Transport, -1965
DT - PA (PAPER)
LA - rus
IT - countermeasures; frozen ground; frost heave; chemical ice prevention
AB - Use of sulfite-alcohol residues in combination with potassium bichromate and calcium chloride, naphthenate soap, polyphosphates, oleic acid and carbamide resins in frost heave control.

837

-728-

AN - 23000641
TI - USE OF HYDROPHOBIC SILICON-ORGANIC FLUIDS IN FROST HEAVE CONTROL
OTI - (Primenenie gidrofobizirulushchikh kremnii-organicheskikh
zhidkostei dlia bor'by s puchinami)
AU - Volotskoi, D.V.
SO - Russia. Komitet po zemlianomu polotnu. Bor'ba s puchinami na
zheleznykh i avtomobil'nykh dorogakh (Control of frost heave on
railroad tracks and highways), p.57-62, In Russian. ,
Moscow, -Transport, -1965
DT - PA (PAPER)
LA - rus
IT - countermeasures; frozen ground; frost heave
ST - SILICON-ORGANIC COMPOUNDS

-729-

AN - 23000633
TI - FUNDAMENTALS OF DESIGNING PROTECTIVE MEASURES AGAINST FROST HEAVE
AND THEIR EFFECTIVENESS
OTI - (Printsial'nye osnovy proektirovaniia protivopuchinnnykh
meropriiatiit i ikh effektivnost')
AU - Shakhuntants, G.M.
SO - Russia. Komitet po zemlianomu polotnu. Bor'ba s puchinami na
zheleznykh i avtomobil'nykh dorogakh (Control of frost heave on
railroad tracks and highways), p.5-23, In Russian. 6 refs.,
Moscow, -Transport, -1965
DT - PA (PAPER)
LA - rus
IT - countermeasures; frost heave

-730-

AN - 23000455
TI - GROUND HEAVING IN THE AREA OF BRATSK HYDROELECTRICAL POWER STATION
OTI - (Puchenie gruntov v raione stroitel'stva Bratskoi GES)
AU - Pikulevich, L.D.
SO - Merzlotnye issledovaniia, 1963 -Vol.3, p.131-157, In Russian. 4
refs.
DT - J (JOURNAL ARTICLE)
LA - rus
IT - ussr -bratsk; permafrost; frost heave

DFFE

-731-

AN - 23000403
 TI - CALCULATING MAGNITUDE OF GROUND FREEZING AND FROST HEAVE,
 ALLOWING FOR WATER MIGRATION
 OTI - (Raschet promerzaniia i velichiny pucheniia grunta s uchetom
 migratsii vlagi)
 AU - Zolotar', I.A.
 SO - Akademiia nauk SSSR. Sibirskoe otdelenie. Institut
 merzlotovedeniia. Protsessy teplo- i massoobmena v merzlykh
 gornnykh porodakh (Heat- and mass-exchange processes in frozen
 rocks), p.19-25, In Russian. 10 refs., Moscow, Nauka, 1965.
 OT - MON (MONOGRAPH)
 LA - rus
 IT - analysis (mathematics): frozen ground; heat transfer; mass
 transfer; frost heave; soil moisture migration

-732-

AN - 23000385
 TI - FROST CLEAVAGE OF GROUND RELATED TO THE PRESENCE OF FIRN
 OTI - (Morozobolnnaia treshch ncvatost' gruntov, sviazannaa s nalichiem
 snezhnikov)
 AU - Demshin, I.A.
 SO - Geograficheskoe obshchestvo SSSR. Zabaikal'skii otdel.
 Izvestiia, 1965 -1(1), p.64-67, In Russian. 1 ref.
 DT - J (JOURNAL ARTICLE)
 LA - rus
 IT - frozen ground; firnification; frost heave

-733-

AN - 23000315
 TI - NEW METHOD OF DETERMINING THE DEPTH OF FOUNDATION LAYING IN
 HEAVING GROUND
 OTI - (Novaia metodika opredeleniia glubin zalozeniiia fundamentov v
 puchiniistykh gruntakh)
 AU - Pikulevich, L.O.
 SO - Merzlotnye issledovaniia, 1964 -Vol.4, p.88-103, In Russian. 18
 refs.
 DT - J (JOURNAL ARTICLE)
 LA - rus
 IT - deformation; foundations; frost heave

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AN - 23000026
TI - INVESTIGATIONS OF PATTERNED GROUND FROST HEAVING AND GENERAL
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SO - British Antarctic Survey. Bulletin, May 1967 -No. 12, p.1-22, 27
refs.
DT - J (JOURNAL ARTICLE)
LA - eng
IT - south orkney islands -signy island; patterned ground; frost heave

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840

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