**Design Documentation: Krypton Encapsulation
Preconceptual Design**

**Ralph M. Parsons Company
D. A. Knecht (INEL Contact)**

October 1994

Lockheed Idaho Technologies Company

**PREPARED FOR THE
DEPARTMENT OF ENERGY
IDAHO OPERATIONS OFFICE
UNDER CONTRACT DE-AC07-94ID13223**

DISTRIBUTION OF THIS DOCUMENT IS UNLIMITED

MASTER

DISCLAIMER

**Portions of this document may be illegible
in electronic image products. Images are
produced from the best available original
document.**

FOREWORD

This report represents work performed by The Ralph M. Parsons Company under Contract No. DE-AC07-81ID12176 (Task No. 81-3) with the U.S. Department of Energy (DOE), with technical guidance provided by Exxon Nuclear Idaho Company, Inc., (ENICO), Idaho National Engineering Laboratory, and by Battelle, Pacific Northwest Laboratories.

This report presents preconceptual designs, process evaluations, and life cycle costing data for comparison of two alternate candidate processes for encapsulation of Krypton-85 released during reprocessing of commercial irradiated nuclear fuels.

SUMMARY

The following table presents various parameters as identified in this report for comparison of the two alternate candidate processes.

<u>PARAMETER</u>	<u>ION IMPLANTATION/ SPUTTERING</u>	<u>ZEOLITE ENCAPSULATION</u>
1. Process Conditions	10 ⁻² Torr Vacuum, 300°C	14,700 psia, 700°C
2. Process Units	8	1
3. Product Form	Sealed container of metallic solid	Doubly contained pellets
4. Product Size	10.75 in. O.D. x 17 in. long	8.625 in. O.D. x 20 in. long
5. Kr ⁸⁵ in Process as Gas	Negligible	45,000 Ci
6. Product Throughput	305/yr.	600/yr.
7. Required Availability	70%	83%
8. Remote Operations/Product Batch	9	10
9. Processing Time	129 hrs.	12 hrs.
10. Hrs./Product Batch	16 hrs.	12 hrs.
11. Building Floor Area	7,138 SF	4,368 SF
12. Total Air Supply	77,000 CFM	6,700 CFM
13. Demand Power	539 KVA	258 KVA
14. Developments Needed	1.8 scale-up, remote operation, power supplies, target/substrate assemblies.	Commercial scale of equipment, scale-up from tests, N-stamp equipment
15. Licensing Concerns	60 day lag storage, but may not be needed	60 day lag storage, process vessel
16. Capital Costs		
a) Improv. to Land	\$ 53,100	\$ 51,000
b) Building	6,684,400	5,560,400
c) Equipment	3,602,500	4,518,600
Total	<u>\$10,340,000</u>	<u>\$10,130,000</u>
17. Energy Consumption		
a) Annual	3,880,800 KW-hr	1,857,600 KW-hr
b) Per Product Batch	12,724 KW-hr	3,096 KW-hr
c) Per Mole of Gas	384 KW-hr	179 KW-hr
18. Life Cycle Costs (30 years)		
a) Initial Investment	\$ 9,306,000	\$ 9,117,000
b) Energy Cost	1,935,588	926,494
c) Operating Manpower	6,639,350	6,775,860
d) Operating Materials	7,648,283	4,094,059
e) Maintenance Matls.	690,568	884,353
f) Insurance Costs	105,327	103,117
Total Life Cycle Costs	<u>\$26,430,684</u>	<u>\$21,900,883</u>
19. Feasibility	Viable with 5 Yr. Development Program	Viable with 5 yr. Development Program

TABLE OF CONTENTS

SECTION 1	INTRODUCTION
SECTION 2	GENERAL CRITERIA
SECTION 3	PROCESSES AND EQUIPMENT
3.1	Ion Implantation/Sputtering
3.1.1	Process Description and Equipment
3.1.2	Lag Storage Equipment
3.1.3	Substrate Handling and Sealing
3.1.4	Product Storage and Handling
3.2	Zeolite Encapsulation
3.2.1	Process Description and Equipment
3.2.2	Lag Storage Equipment
3.2.3	Substrate Handling and Sealing
3.2.4	Product Storage and Handling
SECTION 4	BUILDINGS AND BUILDING SERVICES
4.1	Ion Implantation/Sputtering
4.1.1	Building Description
4.1.2	Heating and Ventilating
4.1.3	Electrical
4.2	Zeolite Encapsulation
4.2.1	Building Description
4.2.2	Heating and Ventilating
4.2.3	Electrical
SECTION 5	FEASIBILITY EVALUATIONS
5.1	General
5.2	Ion Implantation/Sputtering
5.3	Zeolite Encapsulation
5.4	Conclusions
SECTION 6	LICENSIBILITY

SECTION 7 LIFE CYCLE COSTING ANALYSIS

- 7.1 Basis and Approach
- 7.2 Ion Implantation/Sputtering
- 7.3 Zeolite Encapsulation
- 7.4 Conclusions

APPENDICES

- A. Drawing List and Drawings
- B. Major Equipment List
- C. Outline Specifications
- D. Calculations
- E. Cost Estimates

SECTION 1

INTRODUCTION

U.S. EPA regulations limit the release of Krypton-85 to the environment from commercial facilities after January 1, 1983. In order to comply with these regulations, Krypton-85, which would be released during reprocessing of commercial nuclear fuel, must be collected and stored. Technology currently exists for separation of krypton from other inert gases, and for its storage as a compressed gas in steel cylinders. The requirements, which would be imposed for 100-year storage of Krypton-85, have led to development of processes for encapsulation of krypton within a stable solid matrix. The objective of this effort was to provide preconceptual engineering designs, technical evaluations, and life cycle costing data for comparison of two alternate candidate processes for encapsulation of Krypton-85. This report has been prepared by The Ralph M. Parsons Company for the U.S. Department of Energy.

The general bases for this effort are contained within the Statement of Work for Preconceptual Design, Process Feasibility, and Economic Analysis for Krypton Encapsulation Facilities, December 3, 1980.

Preconceptual designs, process evaluations, and life cycle costing data are provided for facilities utilizing the following alternate processes:

- (1) Ion Implantation/Sputtering Encapsulation
- (2) Zeolite Encapsulation

Process throughput capacities for the encapsulation facilities considered in this report are based on 110% of an estimated 17×10^6 curies/year of Krypton-85 released from a plant reprocessing 2000 MTHM/year of LWR fuels. The process gas feed stream is assumed to consist of 2% xenon, 8% argon, and 90% krypton by volume, with Krypton-85 making up 6% of the total krypton, based on the capabilities of existing technology for cryogenic noble gas separation. The facilities are required to operate 24 hours/day for 300 days/year, with a useful life of at least 30 years.

The process and equipment sizes selected for the alternate encapsulation processes are based only on a viable size basis for the required throughput. No attempt has been made to optimize, either on the basis of capital or life cycle costs. For either process there is a wide range of combinations of units, sizes, and substrate materials, all of which will satisfy the requirements. Therefore, this report should be used for comparing the two processes only. Optimization studies, as part of a conceptual or preliminary design effort, will better define the actual costs of implementing krypton encapsulation on a commercial scale.

SECTION 2

GENERAL CRITERIA

The following general criteria apply to the preconceptual design of the encapsulation facilities, and are the basis for the process evaluations and life cycle costing data.

1. The encapsulation facility will be a stand-alone facility located in the vicinity of a cryogenic noble gas separation facility as part of a commercial nuclear fuel reprocessing plant.
2. The commercial nuclear fuel reprocessing plant is assumed to be located at the Oak Ridge National Laboratory (ORNL) at Oak Ridge, Tennessee, for cost estimating purposes.
3. All utility services and power will be provided to the encapsulation facility through the reprocessing plant.
4. The design, installation, and operation of the encapsulation facility will conform to the applicable federal nuclear regulations and the applicable federal, state, and local industrial codes and standards. The encapsulation facility will be licensed by the Nuclear Regulatory Commission (NRC).
5. The encapsulation facility will be designed and operated to limit radiation exposure of personnel to "as low as reasonably achievable" (ALARA), in accordance with the requirements of the NRC.
6. The encapsulation facility will be designed, to the extent practical, for remote operation, and for contact maintenance after remote decontamination.
7. The encapsulation facility will include equipment and provisions for storage of up to 60 days operational supply of feed gas.
8. The encapsulation facility will include equipment and provisions to store the encapsulated Krypton-85 due to operation for up to one year.
9. Encapsulated product from the encapsulation facility will be compatible with the storage concepts reported in SAND 80-0122, "Krypton-85 Disposal Program Annual Report, October 1, 1978 to September 30, 1979", based on studies for a spent unprocessed fuel (SURF) storage facility.

SECTION 3

PROCESSES AND EQUIPMENT

3.1 ION IMPLANTATION/SPUTTERING

3.1.1 PROCESS DESCRIPTION AND EQUIPMENT

Ion implantation is a process by which gases can be implanted into solids by bombarding the surface of the solid with energetic ions. For positively charged krypton ions, created by collisions between energetic electrons and krypton gas atoms, the depth of implantation amounts to only a few atom layers for ion energies in the keV range.

Sputter deposition is a film growth vapor deposition process in which a substrate is uniformly coated with a solid. The coating is initiated by accelerating positively charged ions to the surface of a target, resulting in sufficient momentum transfer to overcome the binding energy of the target atoms in their lattice.

In combining these processes, a dense thermionically supported plasma is created in the annulus between the target and the substrate. Positively charged krypton ions are accelerated to the target by applying a large negative voltage to the target, so that the krypton ions act as the sputtered ions. The krypton ions are also accelerated to the substrate to implant in the sputtering deposit by applying a lesser negative voltage to the substrate. Implanted krypton ions are entrapped by the growing sputtered deposit. The resulting deposited solid, based on analysis of laboratory scale process deposits, incorporates up to 12.9% krypton by weight.

The krypton encapsulation facility design (see Appendix D-7) is based on using eight process units. Each unit operates as a batch process, with a calculated processing time of 129 hours, and entraps 34.06 moles (763 liters at standard conditions) of krypton in each deposit. The equipment would operate 24 hours per day, 300 days per year, with a required availability of approximately 70% while the facility is in operation.

The substrate is a standard 10-inch stainless steel pipe and pipe cap, which, when seal welded after processing, provides containment of the encapsulation deposit. The target is a standard 6-inch steel pipe and pipe cap which is initially coated with 1.30 centimeters of 79% nickel and 21% lanthanum by weight, and will result in a 1.0 centimeter thick sputtering deposit. The plasma is initiated by electrons emitted from a tungsten filament in the annulus between the target and the substrate. Cooling water for heat removal during processing is provided to the interior of the target and to the exterior of the substrate. Electrical insulators are provided on all connections and to isolate the target, substrate, and filament from each other. These assemblies will be fabricated, factory tested, and shipped to the encapsulation facility as an assembled unit. A total of 305 assemblies per year are utilized to encapsulate 10,380 moles (232,500 liters at standard conditions) of feed gas per year.

The primary supporting equipment to the process are the power supplies and current limiters and controls for the target, substrate, and filament, vacuum pumps, and cooling systems. A list of major equipment for Ion Implantation/Sputtering is given in Appendix B-1.

3.1.2 LAG STORAGE EQUIPMENT

The facility is required to include the capability to store up to 60 days operational supply of feed gas (46,500 liters at standard conditions). The lag storage equipment is based on storage at 500 psig gas pressure. The equipment consists of a bank of pressure vessels, each constructed of 12-inch Schedule 80S pipe by 12'0" long. A total of eight vessels is required to provide the necessary capacity. The vessels are arranged horizontally in a two wide by four high array. Calculations (see Appendix D-3) show that natural convection will remove the heat generated by radioactive decay of Krypton-85, and will maintain the temperature of the stored gas at less than 250°F. Based on ENICO-1081, "Materials Screening Tests for the Krypton-85 Storage Development Program-Final Report", April, 1981, the storage vessels will be constructed of Type 316L stainless steel to provide corrosion resistance to rubidium, the decay product of Krypton-85, and compounds of rubidium, and to allow decontamination.

3.1.3 SUBSTRATE HANDLING AND SEALING

New target/substrate assemblies are received at the facility and stored in the substrate storage area. A total of 305 target/substrate assemblies are used each year. During processing, shielding is required for the encapsulation deposit, which contains a large quantity of radioactive krypton, to allow maintenance on other units within the cell. A lead lined shielding assembly is provided which also acts as a cooling jacket around the target/substrate assembly during processing.

New target/substrate assemblies can be installed in the cell either manually or remotely. A shielding assembly is placed on a mini-trailer robo-carrier with the overhead bridge crane which spans the cell. The robo-carrier is a remotely controlled cart and platform lift assembly, with pre-programmed positioning capability. A new target/substrate assembly is placed in the shielding assembly, manually or with the use of the bridge crane. The robo-carrier then moves to the appropriate station, and lifts the assembly upward, mating with electrical and piping connections, and locking in position.

After processing, the robo-carrier returns to the processing station, the assembly is remotely unlocked, and is lowered and moved away to the welding station. The bridge crane is used to lift the target/substrate assembly, which now includes encapsulated krypton, and position it for welding. A lid is welded to the target/substrate assembly with a fully remotely operated welder, assisted or maintained by two Model "F" type master-slave manipulators. A shielding viewing window is provided to allow operator supervision of welding.

After welding, the product canister is replaced on the robo-carrier with the bridge crane, and moved to the inspection station. The lid weld is visually inspected through a shielding viewing window. The

product canister is purged and filled with helium, through a connection provided for this purpose, and the lid weld is helium leak tested. If required, the weld could also be dye penetrant inspected. The remote equipment is assisted or maintained by two Model "F" type master-slave manipulators. The product canister is now ready for storage.

These operations for substrate handling and sealing are not ideal from the standpoint of remote operations, but recognizing that they are performed on an average of only once every 16 hours, and that a more elaborate scheme would be less reliable and considerably more expensive, these operations are considered to be appropriate.

3.1.4 PRODUCT STORAGE AND HANDLING

Completed product canisters are stored for up to one year within the facility. The product canister is placed horizontally in a cradle on the robo-carrier. The robo-carrier is moved out of the process cell into the product load-in area, and is positioned and lifts the canister to a pre-selected storage location. A pneumatic piston is used to push the canister into the storage rack.

The storage rack holds product canisters in a horizontal array, to allow cooling by natural convection. Calculations (see Appendix D-5) show that natural convection will remove the heat generated by radioactive decay of Krypton-85, and will maintain the temperature of the stored product at less than 250°F. The storage rack is 26 ft.-0 in. long, and stores canisters in a six by six array, for a total of 468 available storage positions. Product canisters are stored 15 inches on center in the array, with a maximum of 13 canisters in each position.

The storage positions consist of a pair of lines of rollers, one each at 45 degrees in each lower quadrant. The rollers are spaced with two together on 6 inch centers, for a total of 208 rollers at each storage position (36 positions). The rollers are constructed of Nitronic 60 material, for decontaminability and non-galling, and are each held in a bracket by a through bolt. The roller/bracket assemblies are mounted on 4 inch angles, (total of 72, two for each position) which are mounted in a frame of angle columns, (total of 35, in five rows of seven at about 5 ft.-0 in. center-to-center). The storage rack, except for rollers, is constructed of 304L SS.

Inserted product canisters push other canisters in the same position along the length of the storage rack. Canisters are inserted sequentially by storage position. When the storage rack is filled, the oldest 36 product canisters are exposed at the far end of the storage rack. A second mini-trailer robo-carrier, which is also a spare for the process robo-carrier, is used to retrieve the oldest product canisters for shipment to long-term storage.

3.2 ZEOLITE ENCAPSULATION

3.2.1 PROCESS DESCRIPTION AND EQUIPMENT

Gases can be entrapped by sintering in solids such as zeolite or vycor which have molecular defects in their structure. Krypton gas can be diffused into the solid, and encapsulated in a structural vacancy when the molecular lattice of the solid substrate is sintered at high temperatures. The encapsulation facility design is based on the use of zeolite 5A as the substrate, due to the relatively much higher cost of vycor (see Appendix D-9).

Encapsulation of krypton in zeolite requires high pressure and moderate temperature. The base case utilized for design of the encapsulation facility consists of a working volume of 8 liters loaded with 7,750 cubic centimeters of compacted zeolite 5A pellets. The process will operate in a batch sequence, with each batch encapsulating 17.3 moles (387.5 liters at standard conditions) of gas when held at a pressure of 1000 atmospheres (14,700 psia) and 700°C for 2 hours. Each batch, including loading, pressurization, heating, processing, cooling, depressurization, purging, and unloading is estimated to take 10 hours. A total of 600 batches per year are utilized to encapsulate 10,380 moles (232,500 liters at standard conditions) of feed gas (see Appendix D-7). Assuming a single unit, the process will operate 24 hours per day, 300 days per year, with a required availability of approximately 83% while the facility is in operation.

The process equipment is an application of commercial hot isostatic pressing equipment. The pressure vessel is a cooled shell with a capacity of 30 liters (approximately 12 in. dia. x 16 in. high), with a top plug. The pressure vessel is estimated to be 6 inches thick. A moveable yoke is used to restrain the plug during operation and to provide partial protection from vessel fragments in the event of a rupture. The interior of the vessel contains electrical heating for the substrate container.

The substrate container is a thin-walled cylinder, constructed of Type 316L stainless steel, with a volume of 8.8 liters (7 in. dia. x 14 in. high). The differential pressure across the container wall is maintained at 50 psig or less by pressurizing the annulus between the pressure vessel and the substrate container with helium.

The primary supporting equipment to the process are compressors and controls for pressurization of the system, vacuum pumps, and cooling systems. A list of major equipment for Zeolite Encapsulation is given in Appendix B-2.

3.2.2 LAG STORAGE EQUIPMENT

The facility is required to include the capability to store up to 60 days operational supply of feed gas (46,500 liters at standard conditions). The lag storage equipment is based on storage at 500 psig gas pressure. The equipment consists of a bank of pressure vessels, each constructed of 12-inch Schedule 80S pipe by 12'0" long. A total of eight

vessels is required to provide the necessary capacity. The vessels are arranged horizontally in a two wide by four high array. Calculations (see Appendix D-3) show that natural convection will remove the heat generated by radioactive decay of Krypton-85, and will maintain the temperature of the stored gas at less than 250°F. Based on ENICO-1081, "Materials Screening Tests for the Krypton-85 Storage Development Program-Final Report", April, 1981, the storage vessels will be constructed of Type 316L stainless steel to provide corrosion resistance to rubidium, the decay product of Krypton-85, and compounds of rubidium, and to allow decontamination.

3.2.3 SUBSTRATE HANDLING AND SEALING

New substrate assemblies are received at the facility and stored in the substrate storage area. A total of 600 substrate assemblies are used each year. During processing, the heavy-wall pressure vessel provides adequate shielding for the encapsulated product, which contains a large quantity of radioactive krypton. However, personnel will not enter the cell due to the extremely high processing pressure, and danger in the unlikely event of equipment/piping failure.

New substrate assemblies can be installed in the cell either manually or remotely. The overhead bridge crane which services the cell places the assembly in one of two substrate activation furnaces, for drying and preheating. Activation is estimated to take 12 hours. When ready for processing, the vessel yoke is retracted, the vessel top plug is removed, and the bridge crane places the substrate assembly in the Hot Isostatic Press.

After processing, the vessel yoke and plug are again removed. The bridge crane is used to lift the substrate assembly, which now includes encapsulated krypton, and position it for welding. A lid is welded to the substrate assembly with a fully remotely operated welder, assisted or maintained by two Model "F" type master-slave manipulators. A shielding viewing window is provided to allow operator supervision of welding. The substrate assembly is placed in a carbon steel pipe overpack, and a lid is welded to the overpack to form the product canister.

After welding, the bridge crane moves the product canister to the inspection station. The lid weld is visually inspected through a shielding viewing window. The product canister is purged and filled with helium, through a connection provided for this purpose, and the lid weld is helium leak tested. If required, the weld could also be dye penetrant inspected. The remote equipment is assisted or maintained by two Model "F" type master-slave manipulators. The product canister is now ready for storage.

These operations for substrate handling and sealing are not ideal from the standpoint of remote operations, but recognizing that they are performed on an average of only once every 12 hours, and that a more elaborate scheme would be less reliable and considerably more expensive, these operations are considered to be appropriate.

3.2.4 PRODUCT STORAGE AND HANDLING

Completed product canisters are stored for up to one year within the facility. The bridge crane places the product canister horizontally in a cradle on a mini-trailer robo-carrier. The robo-carrier is a remotely controlled cart and platform lift assembly, with pre-programmed positioning capability. The robo-carrier is moved out of the process cell into the product load-in area, and is positioned and lifts the canister to a pre-selected storage location. A pneumatic piston is used to push the canister into the storage rack.

The storage rack holds product canisters in a horizontal array, to allow cooling by natural convection. Calculations (see Appendix D-8) show that natural convection will remove the heat generated by radioactive decay of Krypton-85, and will maintain the temperature of the stored product at less than 250°F. The storage rack is 26 ft.-0 in. long, and stores canisters in a seven by seven array, for a total of 637 available storage positions. Product canisters are stored 12 inches on center in the array, with a maximum of 13 canisters in each position.

The storage positions consist of a pair of lines of rollers, one each at 45 degrees in each lower quadrant. The rollers are spaced with two together on 6 inch centers, for a total of 208 rollers at each position (49 positions). The rollers are constructed of Nitronic 60 material for decontaminability and non-galling, and are each held in a bracket by a through bolt. The roller/bracket assemblies are mounted on 4 inch angles (total of 98, two for each position), which are mounted in a frame of angle columns (total of 40, in five rows of 8 at about 5 ft.-0 in. center-to-center). The storage rack, except for rollers, is constructed of 304L SS.

Inserted product canisters push other canisters in the same position along the length of the storage rack. Canisters are inserted sequentially by storage position. When the storage rack is filled, the oldest 49 product canisters are exposed at the far end of the storage rack. A second mini-trailer robo-carrier, which is also a spare for the in-cell robo-carrier, is used to retrieve the oldest product canisters for shipment to long term storage.

SECTION 4

BUILDINGS AND BUILDING SERVICES

4.1 ION IMPLANTATION/SPUTTERING

4.1.1 BUILDING DESCRIPTION

The Ion Implantation/Sputtering Facility is a rectangular building with overall dimensions of 89 ft.-0 in. by 50 ft.-6 in. The building is constructed of reinforced concrete for all areas required to survive design basis natural phenomena. Other areas of the building are constructed of reinforced masonry concrete block walls with roofing over metal decking supported by structural steel beams, and are required to survive operating basis natural phenomena. Areas required to survive design basis natural phenomena are those areas of the building necessary for containment of Krypton-85. Preconceptual drawings of the Ion Implantation/Sputtering Facility are contained in Appendix A. Outline specifications of the facility materials and equipment are contained in Appendix C-1.

The facility is on two levels, with power supplies to the process and heating and ventilating equipment located on the second level, which is 89 ft.-0 in. by 29 ft.-6 in. The total floor area of the facility is 7,138 square feet.

All exterior walls of the building are covered with insulated metal siding. The building roof is an "inverted" type, consisting of asphalt felt layers, insulation, and roofing aggregate.

4.1.1.1 Process Cell

The Process Cell is 34 ft.-0 in. long by 13 ft.-6 in. wide by 12 ft.-0 in. high constructed of 12 in. thick reinforced concrete walls and ceiling, and a 6 in. thick concrete floor supported by compacted backfill and concrete footings. The cell is designed to provide shielding from radiation exposure to personnel. Shielding viewing windows are provided for remote operations, substrate inspection, and substrate sealing. An overhead bridge crane services the Process Cell for loading, unloading, and transporting substrate containers.

4.1.1.2 Gas Storage Area

The Gas Storage Area is 16 ft.-6 in. long by 13 ft.-6 in. wide by 12 ft.-0 in. high constructed of 12 in. thick reinforced concrete walls and ceiling and a 6 in. thick concrete floor supported by compacted backfill and concrete footings. The Gas Storage Area is designed to provide shielding for the Gas Storage Equipment, which may contain 60 days operational supply of feed gas, and to provide protection from the accidental rupture of the storage vessels.

4.1.1.3 Interim Product Storage Area

The Interim Product Storage Area is 26 ft.-0 in. long by 13 ft.-0 in. wide by 12 ft.-0 in. high constructed of reinforced concrete walls and ceiling and a 6 in. thick concrete floor supported by compacted backfill and concrete footings. The Interim Product Storage Area is designed to provide shielding for encapsulated product due to operation for one year. Shielding hatches are provided for access for maintenance.

4.1.1.4 Support Areas

Other Support Areas included in the building design are as follows:

(1) Substrate and Container Storage. 19 ft.-6 in. long by 15 ft.-0 in. wide by 9 ft.-0 in. high, constructed of masonry concrete block exterior walls, metal studs and gypsum board interior walls, and suspended plaster ceiling.

(2) Health Office. 13 ft.-0 in. long by 8 ft.-6 in. wide by 9 ft.-0 in. high, constructed of masonry concrete block exterior walls, metal studs and gypsum board interior walls, and suspended acoustical ceiling.

(3) Decontamination Area. 13 ft.-0 in. long by 6 ft.-0 in. wide by 9 ft.-0 in. high, constructed of metal studs and Type "X" gypsum board walls and suspended plaster ceiling, with an enclosed shower with ceramic tile floor and walls.

(4) Operating Gallery. 20 ft.-6 in. long by 20 ft.-6 in. wide by 9 ft.-0 in. high, constructed of masonry concrete block exterior walls, metal studs and gypsum board interior walls, and suspended acoustical ceiling.

(5) Supervisor's Office. 12 ft.-0 in. long by 10 ft.-0 in. wide by 9 ft.-0 in. high, constructed of masonry concrete block exterior walls, metal studs and gypsum board interior walls, and suspended acoustical ceiling. Includes an 11 ft.-0 in. long by 4 ft.-0 in. high glass window to the Operating Gallery.

(6) Electrical and HVAC Area. 87 ft.-0 in. long by 27 ft.-6 in. wide by 12 ft.-0 in. high, (second level), constructed of reinforced concrete floor, walls, and ceiling.

(7) Electrical and Equipment Area. 28 ft.-6 in. long by 27 ft.-6 in. wide by 12 ft.-0 in. high, (first level), constructed of reinforced concrete floor, walls, and ceiling.

(8) Product Storage Load-In Area. 13 ft.-0 in. long by 8 ft.-0 in. wide by 12 ft.-0 in. high, constructed of reinforced concrete floor, walls, and ceiling.

(9) Product Load-Out Area. 15 ft.-6 in. long by 13 ft.-0 in. wide by 12 ft.-0 in. high, constructed of reinforced concrete floor, walls, and ceiling.

(10) Restroom and Locker Area. 18 ft.-6 in. long by 15 ft.-0 in. wide by 9 ft.-0 in. high, constructed of masonry concrete block exterior walls, metal studs and Type "X" gypsum board interior walls, and suspended plaster ceiling.

4.1.2 HEATING AND VENTILATING

Three Heating and Ventilating Systems are provided for the Ion Implantation/Sputtering Facility. One system services the HVAC and Electrical Equipment Areas. A second system services the non-contaminated operating areas, consisting of the offices, the Operating Gallery, and the Restroom and Locker Area. A third system services the potentially contaminated areas, consisting of the Process Cell, Gas Storage Area, Interim Storage Area, Substrate and Container Storage, Product Storage Load-In Area, and Product Load-Out Area. As shown on Drawing V-1, the Heating and Ventilating Systems for the non-contaminated operating areas and for the potentially contaminated areas utilize common supply and exhaust air systems.

The Heating and Ventilating System for the HVAC and Electrical Equipment Areas provides a maximum of 72,000 cfm (summer) and a minimum of 9,000 cfm (winter) through four 25%, 15 hp vent fans. Air is exhausted through four 18,000 cfm maximum capacity roof ventilators. Steam unit heaters are provided, with 50,000 Btu/hr. capacity, for space heating.

The Heating and Ventilating Systems for the non-contaminated operating areas and for the potentially contaminated areas are once through air flow systems, designed to maintain confinement zones based on differential air pressure to ensure air flow from less contaminated to more contaminated areas. Ventilation and temperature control will provide a suitable working environment in areas occupied by personnel. Air filtration is employed to reduce potential radioactive contaminants in the effluent to "as low as reasonably achievable" (ALARA) prior to discharge to the environment.

The supply air system, which provides approximately 5,000 cfm to the non-contaminated and potentially contaminated systems, consists of two 100% (one standby) supply fans. Each supply air plenum includes a tornado shut-off valve, a steam preheat coil, 30% efficiency roughing and 80% efficiency pre-filters, backdraft damper, air flow monitor, and flow control damper. 100% outside air is supplied to the non-contaminated system and the potentially contaminated system.

Approximately 1200 cfm is supplied to the non-contaminated operating areas through a steam heating coil and a refrigerant cooling coil. Approximately 200 cfm is directed to the vestibule, and by infiltration to the Restroom and Locker Area, and is exhausted by exfiltration and by a powered roof ventilator. 1000 cfm is directed to the offices and the Operating Gallery, and is exhausted through the exhaust air system. The offices are maintained at -0.10 in. water gauge air pressure. The Operating Gallery is maintained at -0.20 in. water gauge air pressure.

Approximately 3800 cfm is supplied to the potentially contaminated areas. Approximately 3200 cfm is supplied directly to the Process Cell through heating/cooling coils. 600 cfm is supplied to the Load-Out Area, the Gas Storage Area, and the Substrate and Container Storage Area, which are maintained at -0.10 in. water gauge air pressure, and then to the Interim Storage Area, which is maintained at -0.25 in. water gauge air pressure, to the Load-In Area, which is maintained at 0.40 in. water gauge air pressure, and to the Process Cell, which is maintained at 0.60 in. water gauge air pressure.

The exhaust air system, which exhausts approximately 5000 cfm from the non-contaminated and the potentially contaminated systems, consists of two 100% (one standby) exhaust fans. Each exhaust air plenum includes a flow control damper, a water spray cooling chamber, two stages of high efficiency particulate air (HEPA) filters, a backflow damper, an air flow monitor, a flow control damper, and a constant air radiation monitor. Exhaust air is directed through an exhaust air stack on the facility roof.

4.1.3 ELECTRICAL

4.1.3.1 Power Distribution

The Site power for non-critical loads in the Ion Implantation/Sputtering Facility will be distributed at 13.8 kV to the unit substation (US1). The two #4/0, 15 kV, 3 phase, primary feeders will be provided by Others. The unit substation steps down the voltage to the 277/480V motor control center, MCC1 and the split bus motor control center MCC2. Small loads are supplied power at 120/208V, 3 phase through stepdown transformers.

4.1.3.2 Standby Power

Standby power for critical loads will be distributed at 277/480 volts from the automatic transfer switch in the standby section of motor control center MCC2. The standby section and transfer switch of MCC2 will be seismically qualified.

The critical equipment that requires standby power to ensure availability in the event of a power failure will be connected to the standby section of the motor control center MCC2. The critical process equipment includes an emergency panelboard, ventilation exhaust fans, and certain control functions. The small critical loads will be supplied power through a stepdown transformer. The system voltages will be 277/480V, 3 phase and 120/280V, 3 phase. A power outage occurring ahead of the standby section of MCC2 will momentarily shut down all equipment connected to it.

The automatic transfer from normal power to standby power, and the subsequent manual return to normal power, causes an interruption of services to all loads connected to this system. The fans will be arranged to restart automatically. Lighting and alarm circuit breakers will remain closed through an interruption of service and require no operator action to reset.

4.1.3.3 Lighting

The lighting levels will be designed for 50 foot candles at work stations, 30 fc in work areas and 10 fc in aisles or corridors in accordance with ERDA 6301. Fluorescent lighting luminaires with energy-saving ballasts and lamps will be utilized in the office and rooms with low ceilings. High pressure sodium fixtures (HPS) with prismatic glass reflectors will be utilized in other locations for energy conservation. Special lighting designed for remote servicing and constructed to permit decontamination will be provided in the cell. The building exterior doorways will be illuminated with wall-mounted HPS fixtures.

Emergency lighting will be provided by fully automatic battery units, wall mounted near doors and stairways. Certain building lighting fixtures will be connected to the emergency lighting panelboard.

4.1.3.4 Lightning Protection

Lightning protection with a UL Master Label will be provided.

4.1.3.5 Grounding

A No. 4/0 AWG soft drawn bare copper ground loop, with 3/4 inch by 10 foot copper-clad steel ground rods, will be provided. The grounding counterpoise around the building will be connected to the Site duct bank ground.

4.1.3.6 Telephone

The telephone system will be installed in conduit within the building and a 3 inch conduit only will be extended and capped 5 ft outside this building. Telephone cabinets will be provided, as required. The telephone system wiring will be by Others.

4.1.3.7 Public Address and Intercom

No intercom or public address is required in the building. A cell monitoring system will be provided.

4.1.3.8 Fire Alarm and Evacuation Alarm

The building fire alarm and evacuation alarm will be compatible with and connected to the Site system.

4.2 ZEOLITE ENCAPSULATION

4.2.1 BUILDING DESCRIPTION

The Zeolite Encapsulation Facility is a rectangular building with overall dimensions of 84 ft.-0 in. by 52 ft.-0 in. The building is constructed of reinforced concrete for all areas required to survive design basis natural phenomena. Other areas of the building are constructed of reinforced masonry concrete block walls with roofing over metal decking supported by structural steel beams, and are required to survive operating basis natural phenomena. Areas required to survive design basis natural phenomena are those areas of the building necessary for containment of Krypton-85. Preconceptual drawings of the Zeolite Encapsulation Facility are contained in Appendix A. Outline specifications of the facility materials and equipment are contained in Appendix C-2.

The facility is on one level, with a total floor area of 4,368 square feet.

All exterior walls of the building are covered with insulated metal siding. The building roof is an "inverted" type, consisting of asphalt felt layers, insulation, and roofing aggregate.

4.2.1.1 Process Cell

The Process Cell is 24 ft.-0 in. long by 14 ft.-0 in. wide by 12 ft.-0 in. high constructed of 18 in. thick reinforced concrete walls and ceiling, with a two-level basement area for location of the Hot Isostatic Press and the Sump Catch Tank, and for use as a pipe chase. The floor of the lower level of the basement area is 9 ft.-0 in. below the cell operating level floor. The pipe chase is 2 ft.-6 in. wide, with the floor 4 ft.-0 in. below the operating level floor. The basement floor is an 18 in. thick reinforced concrete mat foundation. The operating floor is 12 in. thick reinforced concrete. The Process Cell is designed to provide shielding and to withstand 1PSI overpressure as a result of accidental rupture of the Hot Isostatic Press, and includes metal clad blast-proof doors and blast-proof shielding windows. The estimated maximum overpressure as a result of release of the high pressure gas in the Hot Isostatic Press is 0.80 PSI. Viewing windows are provided for remote operations, substrate inspection, and substrate sealing. An overhead bridge crane services the Process Cell for loading, unloading, and transporting substrate containers.

4.2.1.2 Gas Storage Area

The Gas Storage Area is 16 ft.-6 in. long by 15 ft.-0 in. wide by 12 ft.-0 in. high constructed of 12 in. thick reinforced concrete walls and ceiling and a 6 in. thick concrete floor supported by compacted backfill and concrete footings. The Gas Storage Area is designed to provide shielding for the Lag Storage Equipment, which may contain 60 days operational supply of feed gas, and to provide protection from the accidental rupture of the storage vessels.

4.2.1.3 Interim Product Storage Area

The Interim Product Storage Area is 26 ft.-0 in. long by 13 ft.-0 in. wide by 12 ft.-0 in. high constructed of 12 in. thick reinforced concrete walls and ceiling and a 6 in. thick concrete floor supported by compacted backfill and concrete footings. The Interim Product Storage Area is designed to provide shielding for encapsulated product due to operation for one year. Shielding hatches are provided for access for maintenance.

4.2.1.4 Support Areas

Other Support Areas included in the building design are as follows:

(1) Substrate and Container Storage. 19 ft.-6 in. long by 14 ft.-6 in. wide by 9 ft.-0 in. high, constructed of masonry concrete block exterior walls, metal studs and gypsum board interior walls, and suspended ceiling.

(2) Health Office. 13 ft.-0 in. long by 8 ft.-0 in. wide by 9 ft.-0 in. high, constructed of masonry concrete block exterior walls, metal studs and gypsum board interior walls, and suspended acoustical ceiling.

(3) Decontamination Area. 13 ft.-0 in. long by 6 ft.-0 in. wide by 9 ft.-0 in. high, constructed of metal studs and Type "X" gypsum board walls and suspended plaster ceiling, with an enclosed shower with ceramic tile floor and walls.

(4) Operating Gallery. 20 ft.-6 in. long by 15 ft.-0 in. wide by 9 ft.-0 in. high, constructed of masonry concrete block exterior walls, metal studs and gypsum board interior walls, and suspended acoustical ceiling.

(5) Supervisor's Office. 12 ft.-0 in. long by 10 ft.-0 in. wide by 9 ft.-0 in. high, constructed of masonry concrete block exterior walls, metal studs and gypsum board interior walls, and suspended acoustical ceiling. Includes an 11 ft.-0 in. long by 4 ft.-0 in. high glass window to the Operating Gallery.

(6) HVAC and Electrical Area. 34 ft.-0 in. long by 29 ft.-0 in. wide by 12 ft.-0 in. high, constructed of reinforced concrete floor, walls, and ceiling.

(7) Product Storage Load-In Area. 13 ft.-0 in. long by 8 ft.-0 in. wide by 12 ft.-0 in. high, constructed of reinforced concrete floor, walls, and ceiling.

(8) Gas Cooling Area. 15 ft.-0 in. long by 8 ft.-0 in. wide by 12 ft.-0 in. high, constructed of reinforced concrete floor, walls, and ceiling.

(9) Product Load-Out Area. 13 ft.-0 in. long by 11 ft.-6 in. wide by 12 ft.-0 in. high, constructed of reinforced concrete floor, walls, and ceiling.

(10) Restroom and Locker Area. 19 ft.-0 in. long by 15 ft.-0 in. wide by 9 ft.-0 in. high, constructed of masonry concrete block exterior walls, metal studs and Type "X" gypsum board interior walls, and suspended plaster ceiling.

4.2.2 HEATING AND VENTILATING

Three Heating and Ventilating Systems are provided for the Zeolite Encapsulation Facility. One system services the HVAC and Electrical Equipment Areas. A second system services the non-contaminated operating areas, consisting of the offices, Operating Gallery, and the Restroom and Locker Area. A third system services the potentially contaminated areas, consisting of the Process Cell, Gas Storage Area, Interim Storage Area, Substrate and Container Storage, Product Storage Load-In Area, and Product Load-Out Area. As shown on Drawing V-2, the Heating and Ventilating Systems for the non-contaminated operating areas and for the potentially contaminated areas utilize common supply and exhaust air systems.

The Heating and Ventilating System for the HVAC and Electrical Equipment Area provides a maximum of 4000 cfm through a 1 hp vent fan. Air is exhausted through a 4000 cfm maximum capacity roof ventilator. Steam unit heaters, with 50,000 BTU/hr. capacity, are provided for space heating.

The Heating and Ventilating Systems for the non-contaminated operating areas and for the potentially contaminated areas are once through air flow systems, designed to maintain confinement zones based on differential air pressure to ensure air flow from less contaminated to more contaminated areas. Ventilation and temperature control will provide a suitable working environment in areas occupied by personnel. Air filtration is employed to reduce potential radioactive contaminants in the effluent to "as low as reasonably achievable" (ALARA) prior to discharge to the environment.

The supply air system, which provides approximately 2700 cfm to the non-contaminated and potentially contaminated systems, consists of two 100% (one standby) supply fans. Each supply air plenum consists of a tornado shut-off valve, a steam preheat coil, 30% efficiency roughing and 80% efficiency pre-filters, backdraft damper, air flow monitor, and flow control damper. 100% outside air is supplied to the non-contaminated system and the potentially contaminated system.

Approximately 900 cfm is supplied to the non-contaminated operating areas through a steam heating coil and a refrigerant cooling coil. Approximately 120 cfm is directed to the vestibule, and by infiltration to the Restroom and Locker Area, and is exhausted by exfiltration and by a powered roof ventilator. 800 cfm is directed to the

offices and the Operating Gallery, and is exhausted through the exhaust air system. The offices are maintained at -0.10 in. water gauge air pressure. The Operating Gallery is maintained at -0.20 in. water gauge air pressure.

Approximately 1800 cfm is supplied to the potentially contaminated areas. Approximately 1200 cfm is supplied directly to the Process Cell through heating/cooling coils. Approximately 600 cfm is supplied to the Load-Out Area, the Gas Storage Area, and the Substrate and Container Storage Area, which are maintained at -0.10 in. water gauge air pressure, and then to the Interim Storage Area, which is maintained at -2.0 in. water gauge air pressure, to the Load-In Area, which is maintained at -2.20 in. water gauge air pressure, and to the Process Cell, which is maintained at -2.40 in. water gauge air pressure.

The exhaust air system, which exhausts approximately 2800 cfm from the non-contaminated and potentially contaminated systems, consists of two 100% (one standby) exhaust fans. Each exhaust air plenum includes a flow control damper, a water spray cooling chamber, two stages of high efficiency particulate air (HEPA) filters, a backflow damper, an air flow monitor, a flow control damper, and a constant air radiation monitor. Exhaust air is directed through an exhaust air stack on the facility roof.

4.2.3 ELECTRICAL DESIGN DESCRIPTION

4.2.3.1 Power Distribution

The Site power for non-critical loads in the Zeolite Encapsulation Facility will be distributed at 13.8 kV to the unit substation (US1). The two #4/0, 15 kV, 3 phase, primary feeders will be provided by Others. The unit substation steps down the voltage to the 277/480V split bus motor control center, MCC1. Small loads are supplied power at 120/208V, 3 phase through stepdown transformers.

4.2.3.2 Standby Power

Standby power for critical loads will be distributed at 277/480 volts from the automatic transfer switch in the standby section of motor control center MCC1. The standby section and transfer switch of MCC1 will be seismically qualified.

The critical equipment that requires standby power to ensure availability in the event of a power failure will be connected to the standby section of the motor control center. The critical process equipment includes an emergency panelboard, ventilation exhaust fans, and certain control functions. The small critical loads will be supplied power through a stepdown transformer. The system voltages will be 277/480V, 3 phase and 120/280V, 3 phase. A power outage occurring ahead of the standby section of MCC1 will momentarily shut down all equipment connected to it.

The automatic transfer from normal power to standby power, and the subsequent manual return to normal power, causes an interruption of services to all loads connected to this system. The fans will be arranged to restart automatically. Lighting and alarm circuit breakers will remain closed through an interruption of service and require no operator action to reset.

4.2.3.3 Lighting

The lighting levels will be designed for 50 foot candles at work stations, 30 fc in work areas and 10 fc in aisles or corridors in accordance with ERDA 6301. Fluorescent lighting luminaires with energy-saving ballasts and lamps will be utilized in the office and rooms with low ceilings. High pressure sodium fixtures (HPS) with prismatic glass reflectors will be utilized in other locations for energy conservation. Special lighting designed for remote servicing and constructed to permit decontamination will be provided in the cell. The building exterior doorways will be illuminated with wall-mounted HPS fixtures.

Emergency lighting will be provided by fully automatic battery units, wall mounted near doors and stairways. Certain building lighting fixtures will be connected to the emergency lighting panelboard.

4.2.3.4 Lightning Protection

Lightning protection with a UL Master Label will be provided.

4.2.3.5 Grounding

A No. 4/0 AWG soft drawn bare copper ground loop, with 3/4 inch by 10 foot copper-clad steel ground rods, will be provided. The grounding counterpoise around the building will be connected to the Site duct bank ground.

4.2.3.6 Telephone

The telephone system will be installed in conduit within the building and a 3 inch conduit only will be extended and capped 5 ft outside the building. Telephone cabinets will be provided, as required. The telephone system wiring will be by Others.

4.2.3.7 Public Address and Intercom

No intercom or public address is required in the building. A cell monitoring system will be provided.

4.2.3.8 Fire Alarm and Evacuation Alarm

The building fire alarm and evacuation alarm will be compatible with and connected to the Site system.

SECTION 5

FEASIBILITY EVALUATIONS

5.1 GENERAL

The purpose of this Section is to discuss and compare the feasibility of developing a viable commercial production scale process for Ion Implantation/Sputtering and for Zeolite Encapsulation within the next five years. The basis for this evaluation is a discussion of advancements which may be required beyond commercially available state-of-the-art equipment and process components.

5.2 ION IMPLANTATION/SPUTTERING

The Ion Implantation/Sputtering process has been developed by Battelle, Pacific Northwest Laboratories, for a wide spectrum of applications and for the specific application of krypton encapsulation. Process equipment has been designed, constructed, and operated by Battelle at laboratory and bench scales. The Encapsulation Facility would use equipment scaled up by only 1.8 over existing operating equipment. The commercial equipment would be somewhat different from laboratory equipment, in that all connections will be at the top of the target/substrate assembly, and that connections will seal automatically/remotely, but these differences are not considered to be serious technical concerns. There is a concern that some of the process equipment, particularly the target/sputtering assemblies, the in-cell sputtering heads, and the current limiters for the power supplies, are not commercially available equipment, nor are they anticipated to be commercially available within five years. These components will require additional development to allow design as special fabrications for a commercial facility.

The estimated cost of target/substrate assemblies is based on development of a source for these special fabrications, which does not presently exist economically or in sufficient production capacity. It is reasonable to assume, however, that a source for target/substrate assemblies could be developed within a five year period.

5.3 ZEOLITE ENCAPSULATION

The Zeolite Encapsulation process for encapsulation of krypton has been developed by Exxon Nuclear Idaho Company, Inc., Idaho National Engineering Laboratory. The process equipment is, with minor modifications, an application of currently available hot isostatic pressing equipment. Laboratory testing has been performed at a small scale, although equipment for the Encapsulation Facility is a commercially available equipment size. Some process components are not now commercially available, such as solenoid operated high pressure valves and control valves. It is reasonable to assume, however, that such components would be available due to normal technological development by the time the Encapsulation Facility is constructed, or suitable alternates, such as air operated high pressure valves which are presently commercially available, would be used.

The preconceptual design is based on the use of zeolite rather than vycor, although vycor has an apparently higher encapsulation efficiency for krypton, due to the much higher relative cost of vycor. It is conceivable that the production cost of vycor relative to zeolite may decrease, resulting in lower operating cost of the facility.

The estimated equipment costs are based on the application of industrial high pressure codes and standards, as existing commercial equipment is not available in accordance with nuclear codes (e.g. ASME Section III). It is also not anticipated that hot isostatic pressing equipment will be produced to nuclear codes in the future. It is reasonable to assume, however, that if application of nuclear codes and standards is required (see also Section 6 of this report), a source for such equipment could be developed within a five year period.

5.4 CONCLUSIONS

Based on these discussions, either alternate could result in a viable commercial production scale process within five years. No attempt has been made to assess the relative cost of development of the processes. Each process has its own associated risks and concerns. None of the concerns seem to be insurmountable, and the risks associated with each process appear to be of the same relative magnitude.

SECTION 6

LICENSIBILITY

The Krypton Encapsulation Facility will be licensed by the U.S. Nuclear Regulatory Commission (NRC), and will comply with the applicable federal regulations and NRC Regulatory guides. Federal regulations 10 CFR Part 50, "Licensing of Production and Utilization Facilities", and 10 CFR Part 100, "Reactor Siting Criteria", will provide the general design criteria for the commercial nuclear fuel reprocessing plant and for the encapsulation facility. Facilities utilizing either of the alternate encapsulation processes should not have difficulty in complying with existing criteria, however, NRC Regulatory Guides for handling and processing waste gases are still in preparation.

A fundamental criterion for the application of more stringent requirements is the consequence of a postulated accident at the site boundary. Since each facility could have as much as 3.74×10^6 Curies of radioactive Krypton-85 in storage (60 days lag storage) the requirements for this portion of the facility may be very stringent, although gas storage pressures are only moderate (500 PSIG). The actual requirements will depend on wind dispersion calculations and other factors for determining site boundary consequences, and since the requirements are identical for the two alternate facilities, these requirements have no impact on a comparative evaluation. Feed gas storage would be required so that a failure of process equipment in the encapsulation facility would not impact continued operation of the balance of the reprocessing plant. Since the Ion Implantation/Sputtering Facility would utilize multiple trains of process equipment, failure of one train would not effect encapsulation production, and equipment for feed gas storage may not be required.

The Ion Implantation/Sputtering Facility should have very few other safety-related components. During processing, the radioactive gas is maintained at a high vacuum, such that very little gas could be released during a postulated accident. Processing radioactive gases in this manner would be preferred from a safety standpoint.

The Zeolite Encapsulation Facility will have as much as 45,000 Curies of radioactive gas at very high pressure (14,700 PSIA) contained within the process equipment at a given time. It is likely that the process equipment, particularly the Hot Isostatic Press, would be required to meet high nuclear quality standards as safety-related equipment. Currently available commercial equipment, although adequate from an industrial safety standpoint, would require considerable modification to meet nuclear safety requirements. These additional requirements may have an impact on the cost of the Zeolite Encapsulation Facility.

No attempt has been made to assess the relative cost of licensing of the encapsulation facilities. The consequences of a postulated accident at the site boundary, and the resulting requirements which would be imposed are unknown at this time. The Zeolite Encapsulation Facility, however, would seem to require a higher risk due to the impact of nuclear safety requirements on the ultimate cost of the facility.

SECTION 7

LIFE CYCLE COSTING ANALYSIS

7.1 BASIS AND APPROACH

The Ion Implantation/Sputtering Facility and the Zeolite Encapsulation Facility were evaluated and compared on a life cycle cost basis, following the procedures of the "Life-Cycle Cost Manual for the Federal Energy Management Program," NBS Handbook 135, ("hereinafter referred to as the "Handbook"). In following the Handbook procedures, the total present value of the facility is determined, using a 7 percent per year discount rate for annual costs. For this analysis, a useful life of 30 years with no remaining salvage value was used.

The following cost categories were included in the analysis:

- 1) Initial Capital Investment
- 2) Annual Energy Cost
- 3) Annual Recurring (non-fuel) Costs
 - a) Operating Manpower Cost
 - b) Operating Materials Cost
- 4) Annual Non-Recurring Costs
 - a) Replacement/Maintenance Materials Cost
 - b) Insurance Cost

7.1.1 INITIAL CAPITAL INVESTMENT

In accordance with the Handbook, all initial capital investment is assumed to take place at the start of the base year, which is the year in which the analysis takes place. Furthermore, in determining the present value of the initial capital investment, the estimated actual investment is reduced by 10 percent. Therefore, the initial capital investment is 90 percent of the estimated Total Job Cost for the facilities, as shown in Appendix E.

7.1.2 ANNUAL ENERGY COST

The initial annual cost for energy is determined by the product of the estimated annual energy consumption, and the current regional energy cost. Table C-2 of the Handbook gives \$0.037/KW-hr. as the current energy cost for the region of Oak Ridge, Tennessee (Region 4). The Handbook estimates the inflation of energy relative to other costs, and

computes the present value for each annual expenditure using a 7 percent per year discount rate. The sum of present values of annual energy expenditures is the adjusted Uniform Present Worth Factor (UPW*). The Handbook, however, uses a maximum life of 25 years. Following the procedures of the Handbook for 30 years, the UPW*, adjusted for increases in energy costs, is estimated to be 13.48. The present value of the annual energy cost for the life of the facility is then the initial annual cost multiplied by the UPW*. The total life cycle energy cost is shown in Table 7-1.

7.1.3 ANNUAL RECURRING COSTS

The present value of annual recurring (non-fuel) costs is determined by multiplying the annual cost in current dollars by the unadjusted UPW. The UPW for a plant life of 30 years, using a 7 percent per year discount rate, is calculated to be 12.41.

7.1.3.1 Operating Manpower Cost

The determination of life cycle costs for operating manpower is shown in Table 7-2. Operating manpower was estimated in terms of manhours per operating year. The current manpower cost is based on an assumed current rate of \$25/manhour.

7.1.3.2 Operating Materials Cost

The determination of life cycle costs for operating materials is shown in Table 7-3. Attachment 7A provides the details used in determining the current annual cost for operating materials.

7.1.4 ANNUAL NON-RECURRING COSTS

Annual non-recurring costs are those costs which vary year-to-year. The present value of a given expenditure during a given year is the expenditure in current dollars, multiplied by the Single Payment Present Worth Factor (SPW). The SPW for each year can be calculated using a 7 percent discount rate. The life cycle cost is then the sum of the present values of the annual expenditures.

7.1.4.1 Replacement/Maintenance Materials Costs

The annual cost for replacement/maintenance materials was estimated as a varying percentage of the initial direct equipment costs. The determination of life cycle costs for replacement/maintenance materials is shown in Table 7-4.

7.1.4.2 Insurance Costs

The annual cost for replacement insurance of the facility was estimated at 0.3 percent of the replacement value. Replacement value was determined based on the estimated Total Job Cost, shown in Appendix E, and using sum-of-the-years depreciation for the life

of the facility. Insurance costs for liability and damage to the external environment, if any, are assumed to be the same for each facility, and are not included in this analysis. The determination of life cycle costs for replacement insurance is shown in Table 7-5.

7.1.5 SALVAGE

The Handbook calls for subtracting the present worth of the salvage value of the facility to determine the total life cycle cost. For this analysis, the salvage value is zero.

7.2 ION IMPLANTATION/SPUTTERING

Life cycle costs for the Ion Implantation/Sputtering Facility are summarized in Table 7-6. The total present value of all included life cycle costs is \$26,430,684.

7.3 ZEOLITE ENCAPSULATION

Life cycle costs for the Zeolite Encapsulation Facility are summarized in Table 7-7. The total present value of all included life cycle costs is \$21,900,883.

7.4 CONCLUSIONS

On a 30 year basis, the total life cycle cost for the Zeolite Encapsulation Facility is \$4,529,801 less than for the Ion Implantation/Sputtering Facility, or a total savings of 16.5%. Additional investment for initial capital and replacement/maintenance materials (items 1 and 5 in Tables 7-6 and 7-7) is \$4,785 for the Zeolite Encapsulation Facility. Life cycle savings for energy and all other operating and maintenance costs (items 2, 3, 4, and 6 in Tables 7-6 and 7-7) is \$4,525,016. The life cycle savings-to-investment ratio is 946 in favor of Zeolite Encapsulation over Ion Implantation/Sputtering.

TABLE 7-1
LIFE CYCLE ENERGY COSTS

	<u>Ion Implantation/Sputtering</u>	<u>Zeolite Encapsulation</u>
Estimated Demand Power Load, KVA	539	258
Load Factor	85%	85%
Hours/Year	7,200	7,200
Energy Consumption, KW-Hr./Yr.	3,880,800	1,857,600
Current (1981) Energy Cost, \$/KW-hr	0.037	0.037
Current (1981) Annual Energy Cost	\$ 143,590	\$ 68,731
Adjusted UPW*	13.48	13.48
Total Present Value of Life Cycle Energy Costs	\$1,935,588	\$ 926,494

TABLE 7-2
LIFE CYCLE OPERATING MANPOWER COSTS

<u>Personnel/Basis</u>	<u>Ion Implantation/Sputtering</u>	<u>Zeolite Encapsulation</u>
Operators 2 x 8 hr/day x 300 days/yr x 3 shifts	14,400 MH	14,400 MH
Supervisor 1 x 8 hr/day x 300 days/yr.	2,400 MH	2,400 MH
Welding & Inspection 1.5 hr./weld	460 MH	900 MH
Janitorial 2.5 hr./day x 360	900 MH	900 MH
Maintenance Scheduled 2 x 8 x 60	960 MH	960 MH
Unscheduled 0.2 x 8 x 300	480 MH	480 MH
HP/Fire/Hygiene 0.75 x 8 x 300	1,800 MH	1,800 MH
<hr/> Total Operating Manpower	<hr/> 21,400 MH/Yr.	<hr/> 21,840 MH/Yr.
Current (1981) Annual Manpower Cost (\$25/MH)	\$535,000	\$546,000
<hr/> UPW	<hr/> 12.41	<hr/> 12.41
Total Present Value of Life Cycle Manpower Costs	\$6,639,350	\$6,775,860

TABLE 7-3
LIFE CYCLE OPERATING MATERIALS COSTS

	<u>Ion Implantation/Sputtering</u>	<u>Zeolite Encapsulation</u>
Current (1981) Annual Costs of operating Materials		
Substrate/Containers	\$ 585,000	\$ 301,700
Helium	9,800	7,200
Welding Supplies	1,500	1,000
Decon Chemicals	5,000	5,000
Other	15,000	15,000
Total Current (1981) Annual Cost of Operating Materials	\$ 616,300	\$ 329,900
UPW	12.41	12.41
Total Present Value of Life Cycle Operating Materials Costs	\$7,648,283	\$4,094,059

TABLE 7-4

LIFE CYCLE REPLACEMENT/MAINTENANCE MATERIALS COST

Yr.	% of Initial Direct Equip.	Estimated Annual Costs (1981)		SPW	Present Value of Annual Costs	
		Ion Implant./ Sputtering	Zeolite Encapsulation		Ion Implant./ Sputtering	Zeolite Encapsulation
1	2	\$ 29,600	\$ 37,900	0.93	\$27,528	\$35,247
2	2	29,600	37,900	0.87	25,752	32,973
3	2	29,600	37,900	0.82	24,272	31,078
4	2	29,600	37,900	0.76	22,496	28,804
5	2	29,600	37,900	0.71	21,016	26,909
6	3	44,400	56,900	0.67	29,748	38,123
7	3	44,400	56,900	0.62	27,528	35,278
8	3	44,400	56,900	0.58	25,752	33,002
9	3	44,400	56,900	0.54	23,976	30,726
10	3	44,400	56,900	0.51	22,644	29,019
11	4	59,200	75,800	0.48	28,416	36,384
12	4	59,200	75,800	0.44	26,048	33,352
13	4	59,200	75,800	0.42	24,864	31,836
14	4	59,200	75,800	0.39	23,088	29,562
15	4	59,200	75,800	0.36	21,312	27,288
16	6	88,800	113,700	0.34	30,192	38,658
17	6	88,800	113,700	0.32	28,416	36,384
18	6	88,800	113,700	0.30	26,640	34,110
19	6	88,800	113,700	0.28	24,864	31,836
20	6	88,800	113,700	0.26	23,088	29,562
21	6	88,800	113,700	0.24	21,312	27,288
22	6	88,800	113,700	0.23	20,424	26,151
23	6	88,800	113,700	0.21	18,648	23,877
24	6	88,800	113,700	0.20	17,760	22,740
25	6	88,800	113,700	0.18	15,984	20,466
26	8	118,400	151,600	0.17	20,128	25,772
27	8	118,400	151,600	0.16	18,944	24,256
28	8	118,400	151,600	0.15	17,760	22,740
29	8	118,400	151,600	0.14	16,576	21,224
30	8	118,400	151,600	0.13	15,392	19,708
Total Present Value of Life Cycle Replacement/ Maintenance Costs					\$690,568	\$884,353

TABLE 7-5
LIFE CYCLE REPLACEMENT INSURANCE COSTS

Yr.	% of Initial Value Remaining (sum of years depreciation)	Estimated Annual Costs (1981) (\$0.003/\$)		SPW	Present Value of Annual Costs	
		Ion Implant./ Sputtering	Zeolite Encapsulation		Ion Implant./ Sputtering	Zeolite Encapsulation
1	100.0	\$16,060	\$15,720	0.93	\$14,936	\$14,620
2	93.5	15,010	14,700	0.87	13,059	12,789
3	87.3	14,020	13,720	0.82	11,496	11,250
4	81.3	13,050	12,780	0.76	9,918	9,713
5	75.5	12,120	11,870	0.71	8,605	8,428
6	69.9	11,220	10,990	0.67	7,517	7,363
7	64.5	10,360	10,140	0.62	6,423	6,287
8	59.4	9,540	9,340	0.58	5,533	5,417
9	54.4	8,730	8,550	0.54	4,714	4,617
10	49.7	7,980	7,810	0.51	4,070	3,983
11	45.2	7,260	7,110	0.48	3,485	3,413
12	40.9	6,570	6,430	0.44	2,891	2,829
13	36.8	5,910	5,780	0.42	2,482	2,428
14	32.9	5,280	5,170	0.39	2,059	2,016
15	29.2	4,690	4,590	0.36	1,688	1,652
16	25.8	4,140	4,060	0.34	1,408	1,380
17	22.6	3,630	3,550	0.32	1,162	1,136
18	19.6	3,150	3,080	0.30	945	924
19	16.8	2,700	2,640	0.28	756	739
20	14.2	2,280	2,230	0.26	593	580
21	11.8	1,890	1,850	0.24	454	444
22	9.7	1,556	1,520	0.23	358	350
23	7.7	1,240	1,210	0.21	260	254
24	6.0	960	940	0.20	192	188
25	4.5	720	710	0.18	130	128
26	3.2	510	500	0.17	87	85
27	2.2	350	350	0.16	56	56
28	1.3	210	200	0.15	32	30
29	0.6	100	100	0.14	14	14
30	0.2	30	30	0.13	4	4

\$105,327 \$103,117

TABLE 7-6

ION IMPLANTATION/SPUTTERING LIFE CYCLE COSTS

1.	Present Value of Initial Capital Investment (90% of Total Estimated Job Cost)	\$ 9,306,000
2.	Present Value of Life Cycle Energy Costs (Table 7-1)	1,935,588
3.	Present Value of Life Cycle Operating Manpower Costs (Table 7-2)	6,639,350
4.	Present Value of Life Cycle Operating Materials Costs (Table 7-3)	7,648,283
5.	Present Value of Life Cycle Replacement/Maintenance Materials Costs (Table 7-4)	690,568
6.	Present Value of Life Cycle Replacement Insurance Costs (Table 7-5)	105,327
		<hr/>
	Total Present Value of All Included Life Cycle Costs	\$26,430,684

TABLE 7-7

ZEOLITE ENCAPSULATION LIFE CYCLE COSTS

1.	Present Value of Initial Capital Investment (90% of Total Estimated Job Cost)	\$ 9,117,000
2.	Present Value of Life Cycle Energy Costs (Table 7-1)	926,494
3.	Present Value of Life Cycle Operating Manpower Costs (Table 7-2)	6,775,860
4.	Present Value of Life Cycle Operating Materials Costs (Table 7-3)	4,094,059
5.	Present Value of Life Cycle Replacement/Maintenance Materials Costs (Table 7-4)	884,353
6.	Present Value of Life Cycle Replacement Insurance Costs (Table 7-5)	103,117
		<hr/>
	Total Present Value of All Included Life Cycle Costs	\$21,900,883

ATTACHMENT 7A
ANNUAL COST OF OPERATING MATERIALS

TITLE KRYPTON ENCAPSULATION SHEET NO. 1 OF 4
JOB NO. 6154-3 DEPARTMENT _____ AUTHOR R. WILKINSON DATE 6/13/81

REV	CHECKER	DATE	REV	CHECKER	DATE	REV	CHECKER	DATE

OPERATING MATERIALS (1981 \$/YEAR)

SUMMARY

ZEOLITE ENCAP. ION IMPL./SPUT.

SUBSTRATE/CONTAINERS	\$ 301,700	\$ 585,000
HELIUM	7,200	9,800
WELDING SUPPLIES	1,000	1,500
DECON CHEMICALS	5,000	5,000
OTHER	15,000	15,000
	<hr/>	<hr/>
TOTAL	\$ 329,900	\$ 616,300

TITLE KRYPTON ENCAPSULATION SHEET NO. 2 OF 4
 JOB NO. 6154-3 DEPARTMENT _____ AUTHOR R. WILKINSON DATE 6/13/81

REV	CHECKER	DATE	REV	CHECKER	DATE	REV	CHECKER	DATE

OPERATING MATERIALS

1. ZEOLITE ENCAPSULATION

a. SUBSTRATE & CONTAINERS (600/YR.)

1). ZEOLITE (# 3.35/LB)

$$600 \times 7750 \text{ g/BATCH} \left(\frac{1}{454} \right) = 10,240 \text{ LB/YR.}$$

$$= \$34,300$$

2). CONTAINER, 7 IN. ϕ $\times$ 14 IN., T-316L S.S. $\times$ $\frac{3}{16}$ " WALL

$$\text{EST. } \$135/\text{EA.} \times 600 = \$81,000$$

3). ENDCAPS 2 @ 7 IN. O.D. $\times$ $\frac{1}{4}$ "

$$\text{EST } \$40/\text{EA} \times 2 \times 600 = \$48,000$$

4). OVERPACK 8" C.S. PIPE $\times$ 16" LONG W/ PIPE CAPS

$$\text{EST } \$45/\text{EA} \times 600 = \$27,000$$

5). ASSEMBLY, 4 MH. $\times$ \$30/MH. $\times$ 600 = \$72,000

6). QA, QC, SHIPPING, ETC. @ 15% \$39,400

TOTAL \$301,700

(~ \$500 EA.)

TITLE KRYPTON ENCAPSULATIONSHEET NO. 3 OF 4JOB NO. 6154-3 DEPARTMENT _____ AUTHOR R. WILKINSON DATE 9/13/81

REV	CHECKER	DATE	REV	CHECKER	DATE	REV	CHECKER	DATE

- b. HELIUM (PURGE & TEST) EST. 3 CF/UNIT
EST. \$4 / CF $\times$ 600 $\times$ 3 \$ 7,200
- c. WELDING SUPPLIES (EST.) \$ 1,000
- d. DECON CHEMICALS (EST.) \$ 5,000
- e. OTHER (EST.) \$ 15,000

2. ION IMPLANTATION / SPUTTERING

a) SUBSTRATE & CONTAINERS (305/YR.)

1). NICKEL (15509 g/EA @ \$3.25/LB)

$$\frac{15509}{454} \times 3.25 \times 305 = \$ 33,860$$

2). LANTHANUM (4123 g/EA @ \$27.30/LB)

$$\frac{4123}{454} \times 27.30 \times 305 = \$ 75,620$$

3). TARGET (6" STD. WT. C.S. PIPE $\times$ 12" LONG W/ CAP)

$$305 (8.75 + 24.20) = \$ 10,050$$

4). SUBSTRATE (10" SCH. 40S, T-316L SS $\times$ 12" LONG W/ CAPS)

$$305 (110 + 280) = \$ 118,950$$

5). FILAMENT & ANODES (EST) \$ 9,150

6). INSULATORS (EST) \$ 12,200

7). TUBING & CONNECTORS (EST) \$ 18,300

8). FABRICATION & ASSEMBLY (EST)

$$25.2 \text{ MH.} \times \$30/\text{MH.} \times 305 = \$ 230,580$$

9). QA, QC, SHIPPING, ETC @ 15% \$ 76,290

TOTAL \$ 585,000
(#1920 EA)

TITLE KRYPTON ENCAPSULATIONSHEET NO. 4 OF 4JOB NO. 6154-3 DEPARTMENT _____AUTHOR R. WILKINSONDATE 6/13/81

REV	CHECKER	DATE	REV	CHECKER	DATE	REV	CHECKER	DATE

b. HELIUM (PURGE & TEST)

EST 8 CF / UNIT

= 2440 @ \$4 / CF

\$ 9,800 / YR

c. WELDING SUPPLIES (EST)

1,500 / YR

d. DECON CHEMICALS (EST)

5,000 / YR

e. OTHER (EST)

15,000 / YR

APPENDICES

- A. Drawing List and Drawings
- B. Major Equipment List
- C. Outline Specifications
- D. Calculations
- E. Cost Estimates

APPENDIX A

DRAWING LIST AND DRAWINGS

Ion Implantation/Sputtering Facility

Dwg. No. 6154-3-II-PR-1	Process Flow Diagram
M-1	Piping and Instrumentation Diagram
A-1	Ground Floor Plan
A-2	Second Floor Plan
A-3	Building Sections
V-1	HVAC Flow Diagram
E-1	Electrical Single Line Diagram
P-1	Piping Plan
P-2	Piping Isometric
P-3	Drainage Plan

Zeolite Encapsulation Facility

Dwg. No. 6154-3-HP-PR-2	Process Flow Diagram
M-2	Piping and Instrumentation Diagram
A-4	Ground Floor Plan
A-5	Building Sections
V-2	HVAC Flow Diagram
E-2	Electrical Single Line Diagram
P-4	Piping Plan
P-5	Piping Isometric
P-6	Drainage Plan
P-7	Lag Storage Tanks

NO.	DATE	REVISED	BY	DATE
1	10/1/70			
THE RALPH M. PARSONS COMPANY ARCHITECTS-ENGINEERS PASADENA, CALIFORNIA				
U.S. DEPARTMENT OF ENERGY IDAHO OPERATIONS OFFICE IDAHO FALLS, IDAHO				
ES KRYPTON ENCAPSULATION ION IMPLANTATION/SPUTTERING PRECONCEPTUAL DESIGN PROCESS FLOW SKETCH				
INDEX CODE NUMBER 61E4-3-II-PR-1				

60

47

WALL LEGEND

- REINFORCED CONCRETE
- CONCRETE BLOCK
- METAL STUD WITH 2x4 STUDS

NO. DATE		REVISIONS	
BY		DATE	
THE RALPH M. PARSONS COMPANY ARCHITECTS-ENGINEERS PASADENA, CALIFORNIA			
U.S. DEPARTMENT OF ENERGY ISLAND OPERATIONS OFFICE ISLAND FALLS, IDAHO			
KRYPTON ENCAPSULATION PRECONCEPTUAL DESIGN ION IMPLANTATION/SPUTTERING GROUND FLOOR PLAN			
PROJECT NO.		DATE ISSUED	
NO. 654-D-11-A-1		1964	

4

48

INDEX CODE NUMBER

REVISIONS	DATE	BY	DATE
1			
THE RALPH M. PARSONS COMPANY ARCHITECTS-ENGINEERS PASADENA, CALIFORNIA			
U.S. DEPARTMENT OF ENERGY RESEARCH OPERATIONS OFFICE IDAHO FALLS, IDAHO			
CRYPTON ENCAPSULATION PRECONCEPTUAL DESIGN ION IMPLANTATION/SPUTTERING SECOND FLOOR PLAN			
PROJECT NO.		G154-B-11-A-2	

5

SECTION A-A

SECTION B-B

NO. 1 SITE		REVISED		DATE	
DESIGNED BY		THE RALPH M. PARSONS COMPANY		ARCHITECTS-ENGINEERS	
DRAWN BY		U.S. DEPARTMENT OF ENERGY		IDAHO OPERATIONS OFFICE	
CHECKED BY		IDAHO FALLS, IDAHO			
APPROVED BY		CRYSTON ENCAPSULATION		PRECONCEPTUAL DESIGN	
SCALE		ION IMPLANTATION / SPUTTERING		BUILDING SECTIONS	
DATE		G154-3-11-A-3

AIR FLOW DIAGRAM

NO. 1 DATE		REVISED		APP. 10-1-1965	
BY		DATE		1. L&L, JAMES L. L&L	
DESIGNED		BY		THE RALPH M. PARSONS COMPANY	
DRAWN		BY		ARCHITECTS-ENGINEERS	
CHECKED		BY		PASADENA, CALIF. 91106-15	
APPROVED		BY		U.S. DEPARTMENT OF ENERGY	
APPROVALS		DATE		IDAHO OPERATIONS OFFICE	
SCALE		DATE		IDAHO FALLS, IDAHO	
SHEET		DATE		KRYPTON ENCAPSULATION	
				PRECONCEPTUAL DESIGN	
				ION IMPLANTATION / SPUTTERING	
				HVAC FLOW DIAGRAM	
INDEX CODE NUMBER		SCALE		DATE ISSUED	
NONE		NONE		G154-3-II-V-1

7-28-51

[illegible]

[illegible]

FEED GAS SYSTEM

PROCESS COOLING WATER SYSTEM

INDEX	COOL NUMBER	DATE	REVISION
1	1	10/1/78	1
2	2	10/1/78	1
3	3	10/1/78	1
4	4	10/1/78	1

REVISIONS		DATE	BY
1	10/1/78	1	1
THE RALPH M. PARSONS COMPANY ARCHITECTS-ENGINEERS PASADENA, CALIFORNIA			
U.S. DEPARTMENT OF ENERGY ISLAND OPERATIONS OFFICE ISLAND FALLS, ISLAND			
KRYPTON ENCAPSULATION PRECONCEPTUAL DESIGN ION IMPLANTATION/SPUTTERING ISOMETRICS			
PROJECT NUMBER		6154-3-11-P-2

BULK
SUBSTRATE

NEW SOLID ENCAPSULATION
SUBSTRATE
CAPSULE

LO
CON
SEA

DISPERSED GAS
MIXTURE

DISPERSED GAS
MIXTURE

DISPERSED GAS MIXTURE
AIR TANK

DISPERSED GAS MIXTURE
LAG STORAGE

PRESSURE LET DOWN
INTERIM HOLD FGS
(NON ROUTINE)

DESIGNED BY	DATE	REVISIONS	DATE
DRAWN BY	DATE	1. LDC	DATE
CHECKED BY	DATE		
APPROVED BY	DATE		
THE RALPH M. PARSONS COMPANY ARCHITECTS-ENGINEERS PASADENA, CALIFORNIA			
U.S. DEPARTMENT OF ENERGY ISAND OPERATIONS OFFICE COAND FALLS, IDAHO			
KRYPTON ENCAPSULATION PRECONCEPTUAL DESIGN ZEOLITE ENCAPSULATION PROCESS FLOW DIAGRAM			
G154-3-HP-PR-2			

21

PRE
FILE

FROM RAS
RECOVER
FACILITY

26

FACILITY INVENTORY
INPUT
MEASUREMENT

(FGR)

AS

VENT

IA

FIRE
EXTINGUISHING

ACTIVATION
OF FIRE
EXTINGUISHING

AIR

STEAM

VENT

CELL
PRESSURE

SUMP
LIQUID
SAMPLER

SUMP TRA

RE GAS

FE

FT

ZZ

SUMP

AIR

SOLVED ON/OFF
VALVES ON INLET/OUTLET
OF O LAG STORAGE CYLINDERS
TYPICAL OF 16

SOLVED ON/OFF
VALVES ON INLET/OUTLET
OF 2 LAG STORAGE CYLINDERS
TYPICAL OF 4

GAS FROM HIP
TO DUMP

PIPING & INSTRUMENTATION DIAGRAM

PRECONCEPTUAL DESIGN

85 KRYPTON ENCAPSULATION

HIGH PRESSURE

20 7/3/01

6154-3-HP-M-2

SECTION C-C

SECTION D-D

REV. DATE		BY	DATE
REVISIONS		1	10/10/68
DESIGNED		1	10/10/68
CHECKED		1	10/10/68
APPROVED		1	10/10/68
DRAWN		1	10/10/68
SCALE		1	10/10/68
DATE ISSUED		1	10/10/68
THE RALPH M. PARSONS COMPANY ARCHITECTS-ENGINEERS 1000 CALIFORNIA STREET, SUITE 100 SAN FRANCISCO, CALIFORNIA 94104			
U.S. DEPARTMENT OF ENERGY RESEARCH OPERATIONS OFFICE IDAHO FALLS, IDAHO			
KRYPTON ENCAPSULATION PRECONCEPTUAL DESIGN ZEOLITE ENCAPSULATION BUILDING SECTIONS			
PROJECT NO.		6154-D-M-A-5	

INCHES CODE NUMBER	
1	2
3	4
5	6
7	8
9	10

FLOW DIAGRAM

INDEX CODE NUMBER	DATE
1	
2	
3	
4	
5	
6	
7	
8	
9	
10	

NO. 1	DATE	REVISED	BY	DATE
THE RALPH M. PARSONS COMPANY ARCHITECTS-ENGINEERS REDWOOD CITY, CALIFORNIA				
U.S. DEPARTMENT OF ENERGY ISLAND OPERATIONS OFFICE (1540 FALLS, 1540)				
KRYPTON ENCAPSULATION PRECONCEPTUAL DESIGN ZEOLITE ENCAPSULATION HVAC FLOW DIAGRAM				
INDEX CODE NUMBER	DATE	BY	DATE	DATE
1				
2				
3				
4				
5				
6				
7				
8				
9				
10

DIAGRAM SYMBOLS

ABBREVIATIONS

COND	CONDENSATE
HPS	HIGH PRESSURE STEAM
LPS	LOW PRESSURE STEAM
DECON	DECONTAMINATION SOLUTION
HPC	HIGH PRESSURE COMPRESSED AIR
PF&M	PRESSURIZED FEED GAS MIX
CLCWS	CLOSED LOOP COOLING WATER SUPPLY
CLCWR	CLOSED LOOP COOLING WATER RETURN
CWS	COOLING WATER SUPPLY (SITE)
CWR	COOLING WATER RETURN (SITE)
IGS	ISOSTATIC GAS SUPPLY
VAC	VACUUM
PSV	PRESSURE SAFETY VALVE
RD	RUPTURE DISC
PEW	PROCESS EQUIPMENT WASTE

NOTES:

1. FOR ISOMETRICS OF PROCESS PIPING SYSTEMS SEE DWG SK-P-2
2. FOR CONTAMINATED & SANITARY WASTE SYSTEMS SEE DWG SK-P-3

NO. / DATE		REVISED		DATE	
<p>THE RALPH M. PARSONS COMPANY ARCHITECTS-ENGINEERS PASADENA, CALIFORNIA</p> <p>U.S. DEPARTMENT OF ENERGY TRANS OPERATIONS OFFICE IDAHO FALLS, IDAHO</p> <p>KRYPTON ENCAPSULATION PRECONCEPTUAL DESIGN ZEOLITE ENCAPSULATION</p> <p>PIPING PLAN</p>					
INDEX CODE NUMBER		SCALE		DATE ISSUED	
6154-3-HP-P-4

[illegible]

62

VIEW A

NO.	DATE	REVISION	BY	DATE
1	10/1/78	1	W. L. K.	10/1/78
THE RALPH M. PARSONS COMPANY ARCHITECTS-ENGINEERS PASADENA, CALIFORNIA				
U.S. DEPARTMENT OF ENERGY RESEARCH OPERATIONS OFFICE IDAHO FALLS, IDAHO				
KRYPTON ENCAPSULATION PRECONCEPTUAL DESIGN ZEOLITE ENCAPSULATION LAG STORAGE TANKS				
INDEX CODE NUMBER 6154-3-HP-P-7		PROJECT NO. 6154-3

WALL LEGEND

- REINFORCED CONCRETE
- CONCRETE BLOCK
- 3\"/> METAL STUDS WITH
SELECTUM BOARD

REVISIONS		DATE	
NO.	DATE	BY	DATE
1	10/10/77	DAVID FALLER	10/10/77
THE RALPH M. PARSONS COMPANY		ARCHITECTS-ENGINEERS	
1000 CALIFORNIA STREET, SUITE 1000		SAN FRANCISCO, CALIFORNIA 94104	
U.S. DEPARTMENT OF ENERGY		IDAHO OPERATIONS OFFICE	
1000 WEST 1000 NORTH		IDAHO FALLS, IDAHO 83401	
CRYSTON ENCAPSULATION		PRECONCEPTUAL DESIGN	
LEOLITE ENCAPSULATION		GROUND FLOOR PLAN	
C/DA-3-HP-A-1		REV. 10	

APPENDIX B

MAJOR EQUIPMENT LISTS

- B-1 ION IMPLANTATION/SPUTTERING
- B-2 ZEOLITE ENCAPSULATION

APPENDIX B-1

ION IMPLANTATION/SPUTTERING MAJOR EQUIPMENT LIST

<u>Equipment No.</u>	<u>Name</u>
KEF-II-TK1	Sump Catch Tank
KEF-II-TK101	Decontamination Solution Make-Up Tank
KEF-II-TK2	Pressurize Feed Gas Mixture Lag Storage Tanks (8 required)
KEF-II-TK3	Pressurized Feed Gas Mixture Run Tank
KEF-II-TK4	Low Pressure Feed Gas Mixture Run Tank
KEF-II-TK5	Pressure Relief Accumulator
KEF-II-AG1	Sump Catch Tank Agitator
KEF-II-AG101	Decontamination Solution Make-Up Tank Agitator
KEF-II-COM1&2	Feed Gas Compressor (2 required)
KEF-II-P101	Decontamination Solution Pump
KEF-II-P1&2	Closed Loop Cooling Water Pump (2 required)
KEF-II-VP1&2	Sputtering Chamber Vacuum Pump (2 required)
KEF-II-VP3&4	Krypton Vacuum Pump (2 required)
KEF-II-HE1	Pressurized Feed Gas Cooler
KEF-II-HE2	Closed Loop Cooling Water Heat Exchanger
KEF-II-F1	Pressurized Feed Gas Filter
--	Sump Liquid Sampler
--	Sump Catch Tank Liquid Sampler
--	Sump Eductor
--	Sump Catch Tank Eductor
KEF-II-SC1-8	Sputtering Chamber (8 required)

APPENDIX B-1 (cont'd)

ION IMPLANTATION/SPUTTERING
MAJOR EQUIPMENT LIST

<u>Equipment No.</u>	<u>Name</u>
--	Mini-Trailer Robo-Carrier
--	5T/2-1/2T Bridge Crane
--	Automatic Welder
--	Leak Detector
--	Master-Slave Manipulator (4 required)
--	2T Monorail Hoist

APPENDIX B-2

ZEOLITE ENCAPSULATION
MAJOR EQUIPMENT LIST

<u>Equipment No.</u>	<u>Name</u>
KEF-HP-TK1	Sump Catch Tank
KEF-HP-TK101	Decontamination Solution Make-Up Tank
KEF-HP-TK2	Pressurized Feed Gas Mixture Lag Storage Tanks (8 required)
KEF-HP-TK3	Pressurized Feed Gas Mixture Run Tanks (2 required)
KEF-HP-TK4	Isostatic Gas Run Tanks (2 required)
KEF-HP-TK102	Isostatic Gas Supply Cylinders (3 required)
KEF-HP-TK5	Pressure Relief Accumulator
KEF-HP-AG1	Sump Catch Tank Agitator
KEF-HP-AG101	Decontamination Solution Make-Up Tank Agitator
KEF-HP-COM1&2	Feed Gas Mixture Compressors (2 required)
KEF-HP-COM3&4	HIP Krypton Feed Compressor (2 required)
KEF-HP-COM5&6	HIP Isostatic Gas Compressor (2 required)
KEF-HP-P101	Decontamination Solution Pump
KEF-HP-P1&2	Closed Loop Cooling Water Pump (2 required)
KEF-HP-VP1&2	Krypton Vacuum Pump (2 required)
KEF-HP-VP3&4	Helium Vacuum Pump (2 required)
KEF-HP-HE1	Pressurized Feed Gas Cooler
KEF-HP-HE2	Closed Loop Cooling Water Heat Exchanger
KEF-HP-F1	Pressurized Feed Gas Filter

APPENDIX B-2 (cont'd)

ZEOLITE ENCAPSULATION
MAJOR EQUIPMENT LIST

<u>Equipment No.</u>	<u>Name</u>
--	Sump Liquid Sampler
--	Sump Catch Tank Liquid Sampler
--	Sump Eductor
--	Sump Catch Tank Eductor
KEF-HP-AF1&2	Substrate Activation Furnace (2 required)
KEF-HP-HIP1	Hot Isostatic Press
--	Mini-Trailer Robo-Carrier (2 required)
--	5T/2-1/2T Bridge Crane
--	Automatic Welder
--	Leak Detector
--	Master-Slave Manipulator (4 required)
--	2T Monorail Hoist

APPENDIX C

OUTLINE SPECIFICATIONS

- C-1 ION IMPLANTATION/SPUTTERING
- C-2 ZEOLITE ENCAPSULATION

APPENDIX C-1

ION IMPLANTATION/SPUTTERING OUTLINE SPECIFICATIONS

- 1.0 EARTHWORK
- 2.0 STRUCTURAL
- 3.0 ARCHITECTURAL
- 4.0 EQUIPMENT
- 5.0 HEATING, VENTILATING, AND AIR CONDITIONING SYSTEMS
- 6.0 PLUMBING
- 7.0 ELECTRICAL
- 8.0 PIPING MATERIALS
- 9.0 COATING AND WRAPPING
- 10.0 FIRE PROTECTION

APPENDIX C-1
ION IMPLANTATION/SPUTTERING
OUTLINE SPECIFICATIONS

1.0 EARTHWORK

Earthwork shall include the removal of all vegetation, trash and debris, and excavation for foundations. Trash and debris shall be removed to a sanitary land fill. Excavated material suitable for backfilling shall be stock piled on site for later use. Cuts over 4 feet high shall be shored or have side slopes a minimum of 1-1/2 to 1. Backfilling of excavated areas shall be compacted to 95 percent of maximum dry density in accordance with ASTM D 1557, Method D.

2.0 STRUCTURAL

2.1 CONCRETE

2.1.1 Applicable Publications. Concrete shall conform to ACI-318, "Building Code Requirements for Reinforced Concrete", and to the requirements of the following publications of the American Concrete Institute. These publications will be used to the extent they are applicable:

ACI-304 "Recommended Practice for Measuring, Mixing and Placing Concrete"

ACI-305 "Recommended Practice for Hot Weather Concreting"

ACI-306 "Recommended Practice for Cold Weather Concreting"

ACI-308 "Recommended Practice for Curing Concrete"

ACI-315 "Manual of Standard Practice for Detailing Reinforced Concrete Structures"

ACI-347 "Recommended Practice for Concrete Formwork"

2.1.2 Concrete Formwork. Forms shall be constructed to conform, within the tolerances specified, to the required shapes, dimensions, lines, elevations, and positions of the cast-in-place concrete members as indicated. Forms shall be supported, braced, and maintained sufficiently rigid to prevent deformation under load.

2.1.3 Cast-In-Place Concrete. Concrete shall be standard density concrete (150 pounds per cubic foot) unless noted otherwise. The minimum compressive strength of concrete will be 3000 psi at 28 days. Portland Cement shall conform to ASTM C150. Reinforcing steel shall conform to ASTM A615, Grade 60. Wire mesh for slabs shall conform to ASTM A 185.

2.1.4 Grout. Grout shall be sufficiently fluid to ensure complete filling of all sections of units or areas requiring grout, but not so thin as to allow segregation of aggregate. All grouting shall be done in accordance with manufacturer's printed instructions. Grout shall be a non-shrink type.

2.2 METALS

2.2.1 Applicable Publications. The requirements of the following publications shall be used to the extent they are applicable:

American Institute of Steel Construction (AISC)
"Specification for the Design, Fabrication and
Erection of Structural Steel for Buildings"

American Institute of Steel Construction (AISC)
"Specification for Structural Joints Using ASTM
A325 and A490 Bolts"

American Welding Society (AWS) "Structural Welding
Code" (AWS D1.1)

2.2.2 Structural Steel. Structural steel shall conform to ASTM A36. Fabrication and erection shall conform to AISC "Specification for the Design, Fabrication and Erection of Structural Steel for Buildings".

2.2.3 Bolting. Structural steel connections shall conform to "Specification for Structural Joints Using ASTM A325 or A490 Bolts". Structural stainless steel connections shall be similar to structural steel type connections, except that the mechanical properties of the bolts, nuts, and washers shall conform to the latest revision of ASTM A193 for Class 2, Grade B8, Type 304.

2.2.4 Welding. E308L electrode series shall be used to weld 304L stainless steel. Welding shall conform to the AWS Structural Welding Code, AWS D1.1, for carbon steel, to the ASME Boiler and Pressure Vessel Code for stainless steel, and to the requirements of the latest revisions of the following publications to the extent they are applicable:

"Specification for Corrosion-Resisting Chromium and
Chromium-Nickel Steel Covered Welding Electrodes", AWS
A5.9

"Specification for Corrosion-Resisting Chromium and
Chromium-Nickel Steel Welding Rods and Bare
Electrodes", AWS A5.9

"Specification for Flux-Cored Corrosion-Resisting
Chromium and Chromium-Nickel Steel Electrodes", AWS
A5.22

"Specification for Aluminum and Aluminum Alloy Welding
Rods and Bare Electrodes", AWS A5.10

2.2.5 Masonry. Masonry units shall conform to ASTM C90, Grade N, Type I for 8 inch or 12 inch block. Reinforcing steel for masonry construction shall conform to ASTM A615, Grade 60 for deformed billet steel bars.

3.0 ARCHITECTURAL

3.1 WOODS AND PLASTICS

3.1.1 Rough Carpentry

Rough carpentry shall be nailers, blocking, striping, and miscellaneous. Any member in contact with concrete or masonry shall be pressure preservative treated.

3.1.2 Finish Carpentry

Finish carpentry shall be built-in wood shelving, cabinets, hardwood shower seats, etc.

3.2 THERMAL AND MOISTURE PROTECTION

3.2.1 Preformed Metal Siding

Ribbed siding panels, 22 gauge, lap type joint with insulation.

3.2.2 Building Insulation

Building insulation shall be U.L. listed with flame spread under 25 and smoke developed and fuel contributed under 50. Insulation shall be in thicknesses as indicated on the drawings.

3.2.3 Inverted Roof System

Dow Chemical Co., 3-1/2 inch thick styrofoam RM brand insulation shall be placed directly over the roofing membrane.

a. Built up Roofing

Roofing shall be 3-ply, 20 year bondable type, applied directly over substrate, John-Mansville or equal.

b. Polyester Formed Fabric

Dow Chemical Co. approved fabric shall be placed loosely over the insulation.

c. Crushed Stone

A crushed stone ballast of 1-1/2 inch shall be placed over the polyester formed fabric. Stone top covering shall be 3/4 inch to 1 inch in diameter.

3.2.4 Sheet Metal

Parapet flashing, counter flashing, base flashing, and flashing at roof penetrations shall be 24 and 22 Ga galvanized steel.

3.2.5 Sealants and Caulking

Sealants and caulking shall be silicone, polysulphide or polyurethane base, non-saf, gun-approved as pourable, selected as best suitable for applicable conditions.

3.3 DOORS AND WINDOWS

3.3.1 Metal Doors and Frames

Doors and frames shall be standard commercial type, conforming to the Steel Door Institute (SDI) standards as follows:

Doors: Flush panel, seamless; interior doors 18 gauge; exterior doors 16 gauge, galvanized.

Frames: Full welded or knock down construction; interior frames 16 gauge; exterior doors 14 gauge, galvanized.

Fire rated doors and frames, where required, shall conform to the requirements of U.L. and shall bear the appropriate label. All interior doors shall have 6 inch x 2 foot wire glass vision lites except doors leading to toilets, lockers and janitor rooms.

Explosion proof doors shall be able to withstand 1-PSI.

3.3.2 Finish Hardware

Finish hardware shall include mortise-type latchsets, locksets, exit devices, hinges, closers, thresholds, flushbolts, pulls, push/kick plates, door holders, and shall be heavy duty as manufactured by Sargent and Co. or equal. Exposed surfaces of hardware shall have a satin finish or as selected. All building exits shall be provided with panic exit devices.

3.4 FINISHES

3.4.1 Metal Studs

Except as otherwise noted all metal studs shall be 4 inches x 20 gauge, non-bearing screwable type, punched for utility lines, complete with top and bottom runners.

3.4.2 Gypsum Board

Gypsum board shall be 5/8 inch thick tapered edge throughout. Water resistant gypsum board shall be used in toilet rooms and janitors room. Type "X" shall be used in 1-hour fire rated areas.

3.4.3 Ceramic Tile

Ceramic tile work shall include regular Portland cement sitting beds and ceramic tile floors, wainscots and walls. Tilework and installation shall conform to the American National Standards Institute (ANSI) and the Tile Council of America (TCA).

3.4.4 Acoustical Ceilings

Acoustical ceilings shall be suspended exposed metal "T" grid system with lay-in acoustical units. Exposed "T" members shall be aluminum or steel with applied matte white enamel finish. Acoustical units shall be 24 inches x 48 inches x 5/8 inches. Acoustical material shall be U.L. listed with flame spread under 25 and smoke developed and fuel contributed under 50.

3.4.5 Cement Plaster

Cement plaster shall be installed on metal lath and steel framing on walls and ceilings where scheduled, including all necessary trim and accessories.

3.4.6 Resilient Flooring

a. Floor coverings in the Decon area, air lock and gallery shall be 200 vinyl chloride, 2 mm thick flooring as distributed by Dynamit Nobel of America Inc., or approved equal. Material shall be manufactured as a homogenous polyvinyl chloride with the pattern and color extending through the butt thickness and shall conform to Federal Specifications SS-T-312, L-F475, and ASTM E84. Material shall have chemical resistance to acids, bases, dye stuffs, and solvents and shall be noncombustible or self-extinguishing. Installation shall be made as a monolithic, seamless floor by heat welding and fusion, or by butt welding edges of material sheets together. Flooring shall be butt welded directly to 6" high Mipolam flexible vinyl cove.

b. All other areas such as offices and hallways shall have vinyl asbestos tile flooring as manufactured by Armstrong Cork Co. or equal. The tiles shall be 12 inches x 12 inches x 1/8 inch commercial quality. The base shall be four inches high top set vinyl cove base with pre-formed internal and external corners.

3.4.7 Painting

Except as excluded herein, all surfaces of new work shall be properly prepared, primed, and finished, including walls, ceilings, miscellaneous exposed materials, equipment, piping, hangers, conduits, grilles, etc., which normally require painting.

The following items shall not be painted:

- Surfaces receiving a special protective coating
- Concrete floors
- Anodized aluminum, chromed, or stainless metals
- Factory-finished items and equipment

The following items shall be primed or shop-coated prior to delivery to job site:

- Metal doors and frames
- Structural steel
- Miscellaneous metal work

Paints, primers, and finishes shall be ready-mixed and equal to first-line products as manufactured by:

Devoe and Reynolds, Inc.
 Pratt and Lambert, Inc.
 E. I. DuPont de Nemours and Co.
 Rust-Oleum Corporation
 Glidden Company
 Benjamin Moore and Co.

a. Painting Schedule. All painting shall be two coats applied over a primer coat. The primer coat shall be appropriate for the surfaces to be painted and compatible with the types of finish coat used.

b. Interior Surfaces

<u>Surface</u>	<u>Finish</u>
Concrete	1 coat masonry flock filler 2 coats interior alkyd semigloss enamel
Galvanized Metal	1 coat zinc dust-zinc oxide primer 1 coat interior enamel undercoat 1 coat interior alkyd semigloss enamel

Ferrous Metal	1 coat zinc, iron oxide, alkyd resin-type metal primer 1 coat enamel undercoat 1 coat alkyd semigloss enamel
---------------	---

c. Exterior Surfaces

<u>Surface</u>	<u>Finish</u>
Ferrous Metal	1 coat alkyd-oil resin-type metal primer 2 coats semigloss enamel
Galvanized Metal	1 coat zinc dust-zinc oxide primer 2 coats semigloss enamel

3.4.8 Special Coatings

Special coatings shall be Ameron system decontaminable special protective coating for floors, walls, and ceilings, or equal.

Concrete floors:

Prime sealer	Nu-Klad 108
Intermediate coat	Amercoat 66
Top coat	Amercoat 66 (2 coats)

Concrete Walls:

Prime sealer	Nu-Klad 108
Filler	Nu-Klad 114
Intermediate coat	Amercoat 66
Top coat	Seal gloss Amercoat 66

Structural Steel, Decking, Carbon Steel Doors and

Frames:

Primer	Amercoat 77
Cleaner (for galvanized)	Galvaprep
Intermediate coat	Amercoat 66
Top coat	Amercoat 66

Protective Coating for Stainless Steel Embedded in

Concrete:

Double coating	Thurmalox 70
----------------	--------------

3.5 SPECIALTIES

3.5.1 Metal Toilet Partitions

Ceiling hung toilet partitions and wall hung urinal screen shall be products of Sanymetal Products or equal, "Century Type" with a baked enamel finish.

3.5.2 Toilet Accessories

Toilet accessories shall be products of Bobrick Washroom Equipment Co., or equal, including:

- a. Mirror
- b. Soap dispenser
- c. Towel dispenser and waste receptacle
- d. Sanitary napkin dispenser
- e. Toilet tissue dispenser
- f. Seat cover dispenser

3.5.3 Louvers

Louvers shall be products of Construction Specialties, Inc., or equal, mullion type louvers Model 4100 standard blade or as applicable and shall be constructed of extruded aluminum, 6063-T52 alloy, furnished with 1/2 inch mesh birdscreen.

3.5.4 Signs and Directories

Signs shall be products of Vomar Products, Inc., or equal.

3.5.5 Lockers and Benches

Lockers and benches shall be the products of Lyon Metal Products, or equal.

a. Lockers. Lockers shall be single tier-type, 12 inches wide, 18 inches deep, 72 inches high with baked enamel finish. Lockers shall be curb mounted.

b. Benches. Benches shall be constructed of hardwood seats, finished with three coats of plastic sealer mounted on enameled steel pedestals.

4.0 EQUIPMENT

4.1 PROCESS EQUIPMENT

4.1.1 Sump Catch Tank

Equipment No. KEF-II-TK1. 42 in. diameter by 6 ft.-6 in. tall, constructed of ASME SA-240 Grade 304L stainless steel. Design and fabrication per ASME Boiler and Pressure Vessel Code, Section VIII, Division 1 at 15 PSIG and 100°F. Capacity shall be 500 gallons. Equipped with an electric motor driven agitator (Equip. No. KEF-II-AG1) and an internal spray header for decontamination solutions with inlet, outlet, vent, and instrumentation connections and agitator mount.

4.1.2 Decontamination Solution Make-Up Tank

Equipment No. KEF-II-TK101. 42 in. diameter by 4 ft.-0 in. tall, constructed of ASME SA-240 Grade 304L stainless steel. Design and fabrication per ASME Boiler and Pressure Vessel Code, Section VIII, Division 1 at 15 PSIG and 200°F. Capacity shall be 300 gallons. Equipped with an electric motor driven agitator (Equip. No. KEF-II-AG101) and a steam heating coil with inlet, outlet, vent, and instrumentation connections and agitator mount.

4.1.3 Pressurized Feed Gas Mixture Lag Storage Vessels, Pressurized Feed Gas Mixture Run Tank, Low Pressure Feed Gas Mixture Run Tank

Equipment No. KEF-II-TK2 (eight required), KEF-II-TK3 (one required), and KEF-II-TK4 (one required). 12 in. nominal diameter pipe (Sch. 80S) by 12 ft.-0 in. long, constructed of ASME SA-312 Grade TP316L stainless steel. Design and fabrication per ASME Boiler and Pressure Vessel Code, Section VIII, Division 1 at 1270 PSIG and 300°F. Capacity shall be 9.5 cubic feet. Equipped with inlet, outlet, and instrumentation connections. The ten vessels shall be stacked two wide by five high in a structural steel frame as shown on Drawing No. P-6.

4.1.4 Pressure Relief Accumulator

Equipment No. KEF-II-TK5. 18 in. nominal diameter pipe (Sch. 40S) by 4 ft.-6 in. long, constructed of ASME SA-312 Grade TP316L stainless steel. Design and fabrication per ASME Boiler and Pressure Vessel Code, Section VIII, Division 1 at 500 PSIG and 200°F. Capacity shall be 8 cubic feet. Equipped with inlet, outlet, and instrumentation connections.

4.1.5 Feed Gas Mixture Compressor

Equipment No. KEF-II-COM1&2 (two required). Single stage, diaphragm type with hydraulic fluid providing the pulsating motion to compress Krypton-85 gas from an inlet pressure of 340 psig at 70°F, to a discharge pressure of 500 psig. Compressor displacement shall be 1 CFM at 400 rpm. A triple diaphragm shall be used with a detection system to

indicate either compressed gas or hydraulic fluid leakage through the diaphragm. Parts in contact with krypton shall be Type 316 stainless steel, other parts may be manufacturer's standard for the application. The compressor shall be electric motor belt driven. Maximum compressor speed shall be 400 rpm, electric motor speed shall be 1800 rpm. The electric motor shall be 460V, 3 phase, 60 Hertz. Each compressor and drive shall be assembled and mounted on a structural frame.

4.1.6 Decontamination Solution Pump

Equipment No. KEF-II-P101. Centrifugal, horizontal, electric motor driven pump. Motor speed shall be 1800 rpm. Parts in contact with decontamination solutions shall be Type 316 stainless steel. Pump capacity shall be 50 gpm with 40 feet TDH.

4.1.7 Closed Loop Cooling Water Pump

Equipment No. KEF-II-P1&2 (two required). Centrifugal, horizontal, electric motor driven pump. Motor speed shall be 1800 rpm. Pump material shall be ductile iron. Pump capacity shall be 100 gpm with 60 feet TDH.

4.1.8 Krypton Vacuum Pump

Equipment No. KEF-II-V1&2 (two required). Cam and piston, compound vacuum pump, capable of displacing 3 CFM minimum at 10^{-2} Torr. Metals in contact with the process shall be Type 316 stainless steel. Other materials in contact with the process shall be compatible with Krypton-85. Pump shall be motor driven, single or three phase, 230/460V, 60 hertz. Maximum motor speed shall be 1800 rpm.

4.1.9 Pressurized Feed Gas Cooler

Equipment No. KEF-II-HE1. Shell and tube type heat exchanger with 20,000 BTU/hr. duty. Materials in contact with krypton gas shall be Type 316 stainless steel, other materials may be carbon steel. Design and fabrication per ASME Boiler and Pressure Vessel Code, Section VIII, Division 1, and TEMA R requirements. Design pressure for gas side shall be 600 PSIG, with 200°F inlet temperature and 110°F maximum outlet temperature. Design pressure for water side shall be 100 PSIG, with 95°F inlet temperature.

4.1.10 Closed Loop Cooling Water Heat Exchanger

Equipment No. KEF-II-HE2. Shell and tube type heat exchanger with 2,000,000 BTU/hr. duty. Materials shall be carbon steel with admiralty tubes. Design and fabrication per ASME Boiler and Pressure Vessel Code, Section VIII, Division 1, and TEMA R requirements. Design pressure shall be 100 PSIG, with closed loop water inlet temperature 130°F and outlet temperature 95°F, and cooling water inlet temperature 85°F.

4.1.11 Pressurized Feed Gas Filter

Equipment No. KEF-II-F1. Inlet filter with removable sintered metal element. Filter rating shall be 2 micron with 2 CFM flow and 500 PSIG pressure, with no more than 10 PSI pressure drop. Materials in contact with Krypton-85 shall be Type 316 stainless steel.

4.1.12 Sump Liquid Sampler Sump Cath Tank Liquid Sampler

Manually initiated, isolating, plunger type, air powered, solenoid valve actuated liquid sampler.

4.1.13 Sump Eductor Sump Catch Tank Eductor

Air or steam operated liquid eductor, 30 gpm transfer rate, Type 304L stainless steel.

4.1.14 Sputtering Heads

(Eight required). Pedestal mounted vertical connector assembly, in groups of four, with guide pins, remotely operated, insulated connectors for target, substrate, filament, and anode power, target and jacket cooling water supply and return, and gas and air supply, constructed of Type 316 stainless steel.

4.1.15 Shielded Cooling Jackets

(Eight required). Lead and Type 316 stainless steel-clad cooling jacket assembly with guide pins, guide holes, and seals to mate with target/substrate assembly and with sputtering head, and with insulated connections for cooling water supply and return.

4.2 MECHANICAL EQUIPMENT

4.2.1 Mini-Trailer Robo-Carrier

(2 required). Remotely operated, automatically controlled electric cart and platform lift assembly, with vertical and horizontal canister cradles, with pneumatic push/pull piston, and with pre-programmed positioning capability.

4.2.2 In-Cell Bridge Crane

Remotely operated bridge crane with 12-ft. 0-in. span and 5-ton top mounted trolley and hoist, and with two 1/2-ton underslung auxiliary trollies and hoist, as manufactured by Edder Corp. or Approved Equal.

4.2.3 Remote Welder

Fully remote automatic welding station as manufactured by Astro-Arc or Dimetrics Corporation or Approved Equal.

4.2.4 Leak Detection System

Fully remote automatic leak detection system with automatically calibrated helium detector.

4.2.5 Master-Slave Manipulators

(Four required). Model "F" type master-slave manipulators, for assistance and maintenance of automatic welder and remote leak detection system, as manufactured by Central Research or Approved Equal.

5.0 HEATING, VENTILATING, AND AIR CONDITIONING SYSTEMS

5.1 SUPPLY FANS

Supply fans shall be single-width, single-inlet, non-overloading centrifugal type with airfoil blades, V-belt drive and TEFC motors, AMCA Class II construction, and variable inlet vortex vane damper capacity control. Capacity shall be 5000 cfm at 3-inches wg static pressure and 5-hp. Fans shall be Buffalo Forge Co. type BL-Aerofoil, size 400, or Approved Equal.

5.2 EXHAUST FANS

Exhaust fans shall be designed and constructed to operate continuously prior to, after, but not necessarily during an Operating Basis Earthquake (OBE). Fans shall be single-width, single-inlet non-loading centrifugal type with airfoil blades, V-belt drive and TEFC motors, AMCA Class III construction, and variable inlet vortex vane damper capacity control. Capacity shall be 5000 cfm at 10-inches wg static pressure and 15 hp. Fans shall be Buffalo Forge Co. type BL-Aerofoil, size 365, or Approved Equal.

5.3 VENT FANS

Vent fans shall be tubular in-line flow type having an airfoil centrifugal wheel. The fans shall be V-belt driven by a TEFC motor mounted on the tubular fan housing. Capacity shall be 18000 cfm at 1.0-inches wg static pressure and 15 hp. One of the fans shall be provided with variable inlet vortex vane damper capacity control. Fans shall be New York Blower Co. Tubular Acoustafol type, size T-309, or Approved Equal.

5.4 POWER ROOF VENTILATORS

Power roof ventilators shall be low silhouette, all aluminum construction, spun housing type. Fans shall be centrifugal type with direct drive. Capacity shall be 150 cfm at 0.38 inches wg static pressure.

5.5 PREHEAT COILS

Preheat coils shall be 2-row, non-freeze, finned tube, low pressure steam type. Coil capacity shall be 5000 cfm and 315,000 Btu/hr at 15 psig steam pressure, with -20°F entering and +40°F leaving air temperatures.

5.6 HEATING COILS

Heating coils shall be 1-row, finned tube type designed for modulating control with steam at 15 psig pressure.

5.6.1 Contaminated Areas

Heating coil serving the Load-out, Gas Storage, and Substrate areas shall have a capacity of 550 cfm and 25,000 Btu/hr with +40°F entering and 90°F leaving air temperatures. Coil face area shall be 1.0 square feet.

Heating coil serving the Process Cell shall have a capacity of 3150 cfm and 85,000 Btu/hr with +40°F entering and 70°F leaving air temperatures. Coil face area shall be 5.0 square feet.

5.6.2 Non-Contaminated Areas

Heating coil serving the Office, Health/Physics, Operating Gallery, and Vestibule shall have a capacity of 1170 cfm and 53,000 Btu/hr with +40°F entering and +90°F leaving air temperature. Coil face area shall be 2.0 square feet.

5.7 COOLING COIL

Cooling coil shall be finned tube type for direct expansion refrigerant service. Coil shall be provided with a liquid refrigerant distributor. Coil capacity shall be 1170 cfm and 30,000 Btu/hr. Coil shall have a face area of 2.5 square feet and be six rows deep.

5.8 SUPPLY AIR FILTER BOXES

Supply air filter boxes shall be the side loading type containing a guide track for prefilters and a separate guide track for high efficiency filters. Prefilters shall have an efficiency of 30% per ASHRAE Standard 52-76. High efficiency filters shall have an efficiency of 90% per ASHRAE Standard 52-76. Filter boxes shall be Farr Co. side loading model 3P Universal Glide/Pack with type 30/30 prefilters and type HP-200 high efficiency filters, or Approved Equal. Filter box capacity shall be 5000 cfm and shall have 4-24" x 24" x 4" prefilters and 4-24" x 24" x 12" high efficiency filters.

5.9 EXHAUST AIR HEPA FILTER PLENUMS

Filter plenums shall contain two stages of side loading, bag-out HEPA filters and provisions for remote in-place DOP testing of each HEPA filter. Filter plenums and filters shall be as manufactured by Flanders Filter, Inc. Each plenum shall consist of the following:

- 1) Upstream first test section, T-I, including DOP injection port, DOP diffusers, and upstream challenge aerosol concentration sample port.
- 2) First stage of HEPA filters in a model E-4, side loading, bag-out housing.
- 3) Center combination test section, T-C, including DOP injection port, DOP diffusers, and sample port for measuring first stage downstream sample concentration or second stage upstream sample concentration.
- 4) Second stage of HEPA filters in a model E-4, side loading bag-out housing.
- 5) Last test section, T-O, including DOP diffusers and sample port for measuring second stage downstream concentration.

Capacity of each filter plenum shall be 6000 cfm. Each filter shall be 24" x 24" x 11-1/2" and arranged in the plenum 2-wide by 3-high.

5.10 SPRAY COOLING CHAMBER

A spray water chamber shall be provided upstream of each exhaust air HEPA filter plenum. Each spray chamber shall be of stainless steel all welded construction. One bank of spray nozzles shall be provided together with moisture eliminators, and drain sump. Capacity shall be 5000 cfm with a face area of 10 square feet.

5.11 UNIT HEATERS

Unit heaters shall be horizontal suspended type with steam heating coil, propeller fan, and adjustable discharge air louvers. Capacity shall be 50,000 Btu/hr with 15 psig steam pressure. Unit heaters shall be Trane Co. model 60-S, or approved equal.

5.12 AIR COOLED CONDENSING UNIT

Air cooled condensing unit shall be for split system service and shall include an air cooled condenser, hermetic refrigerant compressor, and automatic control system. The unit shall have a capacity of 30,000 Btu/hr with 95°F ambient air. Unit shall be Carrier Corp. model 38GS042, or approved equal.

6.0 PLUMBING

6.1 SCOPE OF WORK

The Contractor shall provide all labor, materials, equipment, and tools necessary for the installation of interior plumbing piping, plumbing fixtures, and plumbing piping extending out to 5 ft from the building where a break is made between plumbing and exterior sewage, drainage, and water piping materials.

The work shall include, but shall not be limited to the following:

6.1.1 System

Furnishing and installing a complete plumbing system consisting of soil, waste and vent lines and hot and cold water distribution.

6.1.2 Fixtures, Trim, and Accessories

Furnishing and installing plumbing fixtures, trim and accessories.

6.1.3 Sewer and Water Lines

Furnishing and installing sewer and water lines from building to 5 ft-0 in. outside of building.

6.1.4 Flashing

Furnishing and installing flashing and counterflashing for items of this system.

6.2 MATERIALS OF CONSTRUCTION

6.2.1 Waste and Vent

Above ground 1-1/2 in. and smaller shall be Schedule 40 galvanized steel pipe with coated cast iron drainage type screwed fittings. 2 in. and larger shall be service weight cast iron soil pipe and fittings (Bell and Spigot Type or No-Hub).

6.2.2 Sewer

Below grade or slab shall be Bell and Spigot service weight cast iron soil pipe with neoprene compression gaskets to ASTM C 564. Above grade shall be standard weight cast iron Bell & Spigot or No-Hub.

6.2.3 Domestic Hot and Cold Water Piping

Materials shall be Schedule 40 galvanized carbon steel pipe and fittings to ASTM A 120 with 300 lb rating. Hot water piping shall be insulated.

6.2.4 Steel Pipe Unions

Galvanized 300 lb malleable iron, railroad ground joint type.

6.2.5 Valves

Valves shall be gate valves 150 lb. Screwed bronze ISRS, Crane No. 431 or Approved Equal, or ball valves 300 lb. Screwed brass with TFE seals, Pacific No. 1-B or Approved Equal.

6.2.6 Partition Stops

Repcal B98 or Approved Equal, loose key type, hose bibb, with flange.

6.2.7 Strainer

Sporlan or Approved Equal.

6.2.8 Sleeves

Sleeves shall be of 24 gauge galvanized iron or steel, for use wherever pipes pass through concrete floors and foundations.

6.3 PLUMBING FIXTURES

6.3.1 Water Closet. American Standard No. 2502.011 white vitreous china, siphon jet wall hung, Sloan Royal No. 110 flush valve, white open front seat less cover. J. R. Smith No. 100 carrier.

6.3.2 Urinal (Mark - UR). American Standard No. 6500.011 white vitreous china, wall hung, Sloan Royal NO. 186-11 flush valve with 1-1/4 in. top spud, wall and spud flanges, vacuum breaker, with adjustable floor support.

6.3.3 Lavatory (Mark - L-1). American Standard No. 0350.132 20 by 18, wall hung, white vitreous china, No. 2248.284 faucet with pop-up drain, No. 2303.063 loose key angle stop supply pipes, No. 4401.014 adjustable P-Trap. Adjustable type concealed lavatory, floor support carrier, with four point locking.

6.3.4 Shower (SH). Sloan Royal No. AC-10 Ac-to-matic with 3 gpm flow control. Stainless steel, built-in mixing valve with 1/2 in. inlet ports.

6.3.5 Floor drain (FD-1). Josam 30000A cast iron body, nickel bronze strainer.

6.3.6 Roof Drain (RD). Josam 21000 Series, large dome, bottom outlet with standard clamp ring and gravel stop, gasket, dome, and body and to include deck clamp, drain receiver, and stationary extension collar.

6.3.7 Overflow Drain (OD). Josam 21000-16 Series, large dome, bottom outlet with standard clamp ring and gravel stop, gasket, dome, and body and to include deck clamp, drain receiver, and stationary extension collar.

6.3.8 Cleanouts (types)

(1) Ordinary: Zurn A-1305

(2) Floor Type: Zurn Z-1326-1 or Z-1326-10, for setting with top flush and square with floor.

(3) Wall Type: Zurn with Z-1310 chrome plated cover plate.

6.3.9 Water Hammer Arresters (WHA). Water hammer arresters shall be Zurn Shocktrol 1700 Series, Smith 5000 Series, or Approved Equal.

6.3.10 Roof Drainage. Piping for the roof drainage system will be carbon steel, hot-dipped galvanized, ASTM A53, Gr "B", Std. Wt. threaded ends. Fittings will be 125# cast iron, ASTM A126, Grade B, hot-dipped galvanized, threaded ends.

6.4 EQUIPMENT

6.4.1 Electric Water Coolers

The cooler capacity shall be in accordance with Sunroc Model NSF-8-D or Approved Equal. The cabinet shall be constructed of 19-20 gauge welded stainless steel, with a removable front panel, a stainless steel base, and a Type 300 series stainless steel top. A chrome plated brass hand operated bubbler on a raised mount shall have a built-in pressure regulator. The Contractor shall furnish a reciprocating type hermetically sealed motor compressor with an air cooled condenser and a tube type cooling unit for Type 12 refrigerant, an insulated power cable, and an enclosed, adjustable thermostat. Electrical specifications are 1/4 hp, 115 V, 60 Hz, single phase. The cooler shall bear the Underwriters Laboratory (UL) label.

6.4.2 Electrical Water Heaters

The heater shall bear the Underwriters Laboratory (UL) label. Each heater shall have a steel glass lined tank with a magnesium anode, 4 bolt flange, inconel sheathed, rod-type heating element with

pre-wired terminal leads, and immersion type thermostat switching a magnetic contactor(s). The heater shall have a minimum 3 inch glass fiber insulation with a round steel shell. Each heater shall be provided with an ASME rated temperature and pressure relief valve.

7.0 ELECTRICAL

This section applies to all electrical equipment and components, which will be used on the Ion Implantation/Sputtering Facility. All items are commercially available and shall comply with applicable codes and standards. The power and services required are available from the existing Site utilities. Conduit only will be stubbed out 5 ft from the building for 13.8 kV normal and 480 volt standby power connections.

7.1 CONDUIT

All conduit systems shall be UL approved, rigid steel, zinc-coated or 304L seamless stainless steel, Schedule 40 pipe. The minimum conduit size shall be 3/4 in. for power, unless otherwise noted, and 1/2 in. for exposed communication, control and instrumentation. Insulated bushings shall be provided at all terminals, where hubs are not used. Flexible metallic conduit shall be liquid tight. Expansion type conduit fittings shall be used across building expansion joints.

7.2 WIREWAYS AND AUXILIARY GUTTERS

Wireways and auxiliary gutters used in dry locations shall be preformed with screw type covers.

7.3 CABLES, 5 kV

The 5 kV dc target cables shall be No. 8 AWG, non-shielded, single-conductor Class B, concentric-stranded copper conductors, ethylene-propylene rubber insulation, Okonite Okoguard Okoseal, or equal. Cross-link polyethylene insulation is not acceptable. The 3000 Vdc target system is solidly grounded.

7.4 BUILDING WIRE, 600 VOLT

Single conductors for power, lighting, and miscellaneous control shall be 600 volt, code type, 90°C, RHH-RHW, USE, FPL with chlorosulfonated, polyethylene jacket for No. 2 AWG and larger, Okonite Okolon, or equal. Type THHN-THWN shall be used for conductors smaller than No. 2 AWG. The minimum control wire size shall be No. 14 AWG, and No. 12 AWG for all other wiring. All conductors shall be stranded copper except that lighting and branch circuits with wiring No. 10 AWG and smaller may be solid. Aluminum wire is not acceptable.

7.5 HIGH RADIATION WIRE

All wiring, single or multi-conductor, within high radiation areas and through shielding walls shall be No. 12 AWG minimum, Class IE, 600 volt wire rated for 10^7 R minimum total integrated dosage, as manufactured by American Insulated Wire Corp., Boston Insulated Wire and Cable Co., PSC, Div. M.W. Riedel, or The Rockbestos Co. Wiring inside the high radiation areas shall be multi-conductor with a special chlorosulfonated, polyethylene overall jacket suitable for decontamination with water, nitric acid, oxalic acid, and Turco No. 4502.

7.6 UNIT SUBSTATION, 13.8 KV TO 480 VOLT

The indoor unit substation shall consist of a three-position, manually operated, 600 amp, 15 kV primary fused interrupter switch, a silicone insulating fluid transformer, a secondary main and feeder draw-out air circuit breakers. The rating and the equipment quantity shall be as shown on the Single Line Diagrams. The 480 volt breakers shall have static long time (L), short time (S), and ground (G) tripping characteristics. The buses shall be copper with silver plated joints and connections. A manually operated overhead hoist shall be provided to remove the 480 volt air circuit breakers.

7.7 DISTRIBUTION TRANSFORMERS

The quiet type distribution, three-phase transformers, rated 480-208Y/120 volt, shall be general purpose dry type in an indoor enclosure and shall have 220°C insulation temperature classification and 150°C winding temperature rise for 30 kVA and larger, and 185°C insulation temperature and 115°C winding temperature rise for 25 kVA and smaller. Full capacity NEMA standard taps shall be provided on the high voltage winding.

7.8 MOTORS

Motors shall be of sufficient size for the duty to be performed. All motors shall have full nameplate horsepower available with a service factor of 1.0 at 3000 ft elevation and 1.15 at sea level. Unless otherwise specified, all motors shall be totally enclosed, and shall have a continuous duty classification based on a 40°C, ambient temperature of reference. Crane and monorail motors shall be rated for 30 minute intermittent duty. Motors shall be the premium efficiency type. The motors shall have the following factory guaranteed minimum efficiencies in accordance with IEEE 112 Test Procedures and shall have the efficiency index letter stamped on the motor nameplate:

HP	% Efficiency	HP	% Efficiency	HP	% Efficiency
1	78.5	10	88.9	50	92.0
1 1/2	81.5	15	89.8	60	92.0
2	81.5	20	90.6	75	93.3
3	84.0	25	90.6	100	93.3
5	84.0	30	91.4	125	93.3
7 1/2	88.9	40	92.0	150	94.3

The motor insulation shall be Class F minimum. Motors in high radiation areas shall have Class H insulation and shall be rated for 2×10^7 R total minimum gamma radiation dosage. The high radiation area motors shall be suitably coated in the field with Crouse-Hinds "Corro-Free S-602" Cat. No. ETU2, or equal. The motor voltage rating shall be selected as follows:

1/2 hp through 150 hp: 460 volt, 3 phase, 60 hertz

1/3 hp and smaller: 115 volt, single phase, 60 hertz

Motors 1/4 hp and 1/3 hp in a batch process shall be rated 460 volts, 3 phase, 60 hertz. Polyphase motors shall be NEMA Design B minimum, squirrel cage type, having normal starting torque and low starting current; single-phase motors shall be capacitor start type, except that motors rated 1/6 hp and less may be split phase type. Gear motors shall be Class II or III, in accordance with the gear loading requirements. Motors 5 hp and larger shall have full load power factor of 0.85 minimum. Motors 5 hp and larger with a full load power factor less than 0.85 shall be corrected to at least 0.90, utilizing a power factor corrective device located at the motor. Two-speed motors shall be the two-winding type. Motors connected to the site standby power shall be capable of starting on a voltage reduction of 20 to 30 percent. A copper grounding lug shall be provided in terminal connection box of all 460 volt, 3 phase motors.

7.9 STARTERS

Combination magnetic starters with 120 volt transformer and control shall be provided for 460 volt, 3 phase motors that are 1/2 hp through 150 hp, and manual starters shall be provided for all 115 volt, single phase motors smaller than 1/2 hp.

7.10 MOTOR CONTROL CENTERS

The motor control center (MCC1) and split bus motor control center MCC2 shall be 277/480 V, 3 phase, 4 wire, 60 hertz, free-standing, dead-front, dead-rear, copper bus only, NEMA Class II, Type B wiring consisting of vertical sections containing phase busing, terminals, copper ground bus, wireways, and housing modular plug-in type equipment drawers behind interlocked hinged doors Westinghouse Type Five Star, or equal. The enclosures shall be NEMA 1. All operating handles and controls shall be externally operable. An individual, 480-120 volt control transformer with secondary fuse shall be provided for each motor starter. Each starter shall have a HAND-OFF-AUTO selector switch in the cover. The motor control center shall be braced for a minimum of 22,000 ampere symmetrical short circuit. The automatic transfer switch, with solid state control

and located in the standby section of the motor control center MCC2, shall be rated 260 amp, 480 volt, 3 phase, 3 pole, 60 Hz, and suitable to withstand a 22,000 amp short-circuit fault. Upon power failure, the transfer switch shall automatically start the Site diesel generator system. The return to normal power shall be manual. In the event the standby power fails and normal power is available, the transfer switch shall have an override to transfer automatically to normal power. Two each tandem pilot lights shall be provided to indicate the contact position. The transfer switch shall be ASCO Model 940326099 with accessories 6C, 9A, 9B and 28, or equal.

7.11 PANELBOARDS

The panelboards shall be dead front, copper bus, 4 wire, circuit breaker type. Circuit breakers shall be E Frame minimum and rated for ac or dc operation. The circuit breakers shall have a minimum interrupting rating of 10,000 rms symmetrical amperes for 208 volt panelboards and 14,000 rms symmetrical amperes for 277/480 volt lighting panelboards. A ground bus with screw terminals shall be provided. Neutral buses shall be isolated. Enclosures shall be NEMA 1, surface mounted. Panelboards of sizes and ratings, as shown on the drawings, shall be provided to serve the ventilating, lighting, and miscellaneous power loads. Ground fault interrupter (GFI) breakers rated 120 Vac only shall be provided, as required by National Electrical Code.

7.12 RECEPTACLES

Convenience outlets shall conform with NEMA Standard configuration 5-15R and shall be 3 wire, duplex, grounding type, 120 Vac, 15 amp, Hubbell Cat. 5262, or equal.

Receptacles for 480 volt, 3 phase service shall be 60 amp, 4 pole, 3 wire type, with spring door and combined with a non-fused, heavy-duty, horsepower rated disconnect switch, Crouse-Hinds WSRD 63542 or equal. The mating male plugs shall be Crouse-Hinds APJ 6485, or equal, for 60 amp service.

7.13 HIGH RADIATION AREA CONNECTORS

The remote electromechanical manipulator operated, 304 stainless steel, connectors shall be rated for 10^7 R total integrated dosage minimum and 600 volts. The connector shall be suitably sealed for decontamination with nitric acid, oxalic acid and Turco No. 4502. The receptacle and plug assembly shall be Gulton Lormec Series 9588 and 9405 respectively, or equal.

7.14 SAFETY SWITCHES

Safety switches shall be the heavy-duty type, horsepower rated, 600 volt, 3 pole, with current rating and fusing, as shown on the drawings. The enclosure shall be NEMA 1.

7.15 TOGGLE SWITCHES

Toggle switches installed for the control of incandescent, high pressure sodium, and fluorescent lighting luminaires shall be heavy-duty, general purpose, UL approved devices. Toggle switches shall be specification grade, single-pole, Hubbell Cat No. 1221 or 1221-I, or equal.

7.16 LIMIT SWITCHES

The non-plug-in limit switches shall be heavy-duty type, 600 volts, 10 amp continuous rating contacts, single pole, double throw (SPDT) or electrically independent double pole, double throw (DPDT). The limit switches shall be Micro Switch Type HDLS Series, or equal.

7.17 BOXES AND FITTINGS

Outlet boxes shall be rust-resistant, cast-iron alloy boxes with threaded hubs or bosses for conduit connection. Pullboxes and their covers shall be constructed of galvanized steel.

7.18 RELAYS

Control relays shall be magnetically operated relays with 120 Vac coils, and contacts rated for 10 amp inductive at 120 volt continuous duty. Timing relays shall be magnetic relays with an adjustable pneumatic timing mechanism and a minimum 5 amp continuous contact rating.

7.19 GENERAL LIGHTING

Commercial type recessed fluorescent luminaires with acrylic lenses and high power factor and energy saving ETL, Class P ballasts and 4 ft, cool white, rapid start fluorescent lamps with wattage not to exceed 35 watts shall be used in offices, control room, toilet and similar areas. Ballasts shall not contain PCB capacitors. Industrial type fluorescent luminaires with upward component and porcelain enamel reflectors shall be utilized in other low bay areas. Lighting in the high bay areas shall utilize high pressure sodium (HPS) luminaires. Exterior HPS wall mounted luminaires shall be provided. Special cell HPS luminaires, suitable for remote removal, shall be provided, as required.

The emergency lighting shall be provided by fully automatic 120/277 V supply, lead calcium rechargeable batteries, Holophane Cat. No. M-12-2A-X, or equal.

7.20 LIGHTNING PROTECTION

Lightning protection, complete with UL Master "C" label, shall be provided.

7.21 GROUNDING

A No. 4/0 AWG soft drawn bare copper ground loop with 3/4 in. by 10 ft. copper-clad steel ground rods, shall be provided and connected to the Site duct bank ground system. One insulated instrumentation ground bus plate and cable shall

be furnished in the control room. The cable shall be connected to the facility ground system at only one point. The maximum facility ground resistance shall be five ohms. The lowest level of building reinforcing bar shall be grounded. The shielding window liners shall be grounded.

7.22 CATHODIC PROTECTION

Cathodic protection shall be provided for all direct buried metallic lines and underground tanks.

7.23 TERMINAL BOXES

Control terminal box enclosures shall be NEMA 1 sheet steel construction with hinged door, lock and steel equipment mounting panel(s). Barriers shall be steel, full depth and height, finished the same as the enclosures. The interior of the enclosure shall be finished with white enamel. The exterior shall be painted with color, as directed.

7.24 TERMINAL BLOCKS

All power and control wiring shall be terminated on accessible terminal blocks. The 600 volt, melamine, rail mounted, terminal blocks shall be Weidmuller Type SAK, or equal. A snap-in preprinted unique wire number marker shall be provided. Hand lettered terminal identification is not acceptable. Terminal connectors shall be the vibration proof, pressure clamp type.

7.25 TELEPHONE SYSTEM

Telephone cabinets shall be provided, as required. Conduit only shall be installed in the building, as required. The telephone system wiring will be by Others.

7.26 CELL SPEAKER SYSTEM

A cell speaker system shall be provided for monitoring audio sounds inside the cell. The system shall consist of a microphone with box mounted on a remotely removable Gulton plug in the cell and connected to a speaker in the control room.

7.27 FIRE ALARM DETECTION SYSTEM

The fire detection system shall include control panels, annunciators, initiating devices, signal conduits, and wire necessary for a complete and operational system. The final connection to the Site fire alarm system will be by Others. The system shall be Pyr-A-Larm System 3, or equal. The system shall consist of a multiplexer and enclosed terminal board, thermal detectors, manual stations, public address speakers, control panel audible devices, remote annunciator and control panels. The detection devices shall be capable of being interchanged without any changes required to the wiring, control panel or to the mounting base. The supervision shall not require additional wires other than the pair used for detection or alarm. The system shall be capable of being expanded at any time up to the maximum capacity of the system. The system shall be capable of

having ionization, thermal, and photoelectric detecting devices, control relays, and manual stations connected across the same pair of wires. The system shall be electrically supervised against both short and open wire faults in the detection circuit, the manual station alarm circuit, and an open in the system alarm and trouble relay coils. An open wiring fault occurring in these circuits shall cause an audible and visual trouble indication at the control panel. A fire alarm signal shall override trouble signals. In the event of a trouble signal resulting from trouble on an initiating zone, a fire signal from another zone shall appear on the panel and remain until the panel is reset, at which time the trouble signal will reappear. Alarm initiating zones shall be as shown on the drawings. A separate switch monitor shall be provided to control waterflow alarms separately from other alarm signals.

7.27.1 Alarm System

The system shall function as follows when any sprinkler flow switch operates, or thermal detector in the HVAC fire protection system operates:

- A. The main and remote annunciator panel alarm devices shall annunciate audible and visual indicators of a fire alarm.
- B. The visible indicator shall indicate the zone location and the device initiating the fire alarm. The audible indicator shall produce the same sound for all fire alarms.
- C. An alarm indicating lamp shall light in the base of the HVAC detector initiating the alarm.
- D. Panel locks into alarm until manually reset.
- E. Exhaust duct detector circuits shall be provided to energize the HVAC fire protection chamber fire water system for HEPA filters.
- F. Supply duct detector circuits shall be provided to shut down the supply fan(s).
- G. The alarm shall be manually transmitted as a voice alarm throughout the building over the fire alarm PA speakers.

7.27.2 Fire Supervisory Signals.

The supervisory alarm initiating devices shall include post indicator valve (PIV) switches, OS and Y valve switches, dry pipe system low air pressure switches, trouble signals from each of the Halon and CO₂ systems, and the Pyr-A-Larm Panel system trouble indicators. The supervisory alarm system shall function when any of these devices operate, as follows:

- A. The main control panel shall annunciate audible and visual indicators of a supervisory alarm. The audible indicator shall provide a different sound than the fire alarm audible indicator.
- B. The main panel locks the visual alarm indicator on, until manually reset. The audible indicator can be silenced by operating the alarm normal switch.
- C. The main panel relays the supervisory alarm signal via a separate transmitter to the Site fire supervisory alarm system.

7.28 EVACUATION ALARM SYSTEM

The evacuation system shall be completely independent of any other system. Speaker wiring may be installed in same conduit as fire alarm. No voice communication is required. The evacuation alarm system shall include an evacuation alarm panel, supervised public address speakers, initiating devices, a tone generator, signal conduits, and wire necessary for a complete and operational system. The system shall be Pyr-A-Larm System 3, or equal. No voice communication is required.

The system shall be electrically supervised against both short and open wire faults in the initiating circuit, the audible alarm circuit, and an open wire fault in the system alarm and trouble relay coils. An open wiring fault occurring in these circuits shall cause an audible and visual trouble indication at the control panel. A short in the initiating circuit and the audible alarm circuit shall cause an audible and visual trouble indicator at the control panel. The evacuation alarm signal shall override the trouble signals. In the event of a trouble signal resulting from trouble on an initiating zone, an evacuation signal from another zone shall appear on the panel and remain until the circuit is reset, at which time the trouble signal will reappear. If a second evacuation alarm signal is initiated after a prior signal has been silenced, the selected evacuation signal shall sound even if the control circuit has not been reset. The evacuation alarm system shall shut off automatically after 5 minutes.

The System 3 evacuation shall also provide the following functions:

- A. Receive "ALERT" and "EVACUATION" signals from the Site evacuation system.
- B. Provide local building status on "EVACUATION" mode only to the Site evacuation system.
- C. Provide alarm signal over two No. 14 AWG wires to the Health Physic office.
- D. Provide for remote monitoring of the building trouble status.

7.28.1 Local Alarm

This system shall provide an "ALERT" signal, with the panel mounted front cover switch in the "DOWN" position, consisting of continuous, non-varying audible siren tone or an "EVACUATION" signal, with the switch in the "UP" position, consisting of continuous cyclic audible siren tone the cycle to be "ON" for 5 seconds and "off" for 5 seconds. Each signal shall be initiated by operating any remote and one control room manual alarm switch. Any switch shall initiate the signal, but if more than one is operated at the same time, the switch turned to "EVACUATE" will take precedence over all other switches. Initiation of an "ALERT" or "EVACUATION" signal from any control point within the building shall be shown by an indicating light on the evacuation alarm panel. In addition, an audible panel alarm buzzer shall be actuated. The audible alarm can be silenced by operating the "ALARM-NORMAL" switch to the opposite position but the light shall remain on until all switches or contacts are returned to normal position.

7.28.2 Site Wide Alarm.

A separately maintained toggle switch with "Lock-out" pin in the "DOWN" position, located in the control room, shall provide the Site wide alarm system an "ALERT" signal with the switch in the "DOWN" position or an "EVACUATION" signal with the switch in the "UP" position over two No. 14 AWG wires to connection in the Security Building.

8.0 PIPING MATERIALS

8.1 SCOPE OF WORK

The Contractor shall provide labor, materials, equipment, and tools necessary to fabricate, test, inspect, document, deliver to the site, field fabricate and/or install, and field inspect and test all piping materials in the quantities defined and as located by the drawings, and in accordance with this specification.

8.2 OUTLINE SPECIFICATIONS

The Piping Service Classes to be used are

<u>Class</u>	<u>Service</u>
D	Process Equipment Waste
N	High Pressure Steam, Low Pressure Steam, Condensate, High Pressure Air, Vacuum
P	Low Pressure Air
Q	Cooling Water Supply And Return
V	Pressurized Feed Gas

[illegible]

SERVICE: Process Equipment Waste				CLASS D PAGE 1 OF 5	
RATING: 150# FACING: Raised Face MATERIAL: 304L Stainless Steel				CORROSION ALLOWANCE — PRESSURE LIMIT — Per B16.5 TEMPERATURE LIMIT — 100°F	
CODE NUMBER	EN- CODER	SIZE FROM TO	DESCRIPTION	NOTES	REV.
		2" and smaller	-----PIPE----- Stainless Steel, ASTM A312, Grade TP304L, Schedule 80S Threaded Ends		
		3" and larger	Stainless Steel, ASTM A312, Grade TP304L, Schedule 40S, Buttweld Ends		
		2" and smaller	-----FITTINGS----- 3000# 304L Stainless Steel, Threaded Ends, ASTM A182, Grade F304L, Schedule 80S		
		3" and larger	-----FITTINGS----- Seamless Stainless Steel, ASTM A403, Grade WP304L or ASTM A182 Grade F304L Buttweld Ends, Schedule 40S Bore		
		2" and smaller	-----THREADOLET----- 3000# 304L Stainless Steel, Threaded, ASTM A182, Grade		
		3" and larger	-----WELDOLETS----- Forged 304L Stainless Steel, ASTM A182, Grade F304L, Schedule 40 Bore		
		2" and smaller	-----SWAGE NIPPLES----- 304L Stainless Steel, ASTM A403, Grade WP304L Schedule 80 Bore, Threaded Ends		
		2" and smaller	-----UNIONS----- 3000# 304L, Stainless Steel, ASTM A182, Grade F304L, Schedule 80 Bore, Ground Joint Type, Integral Seats, Threaded Ends		
		2" and smaller	-----PLUGS----- 304L Stainless Steel, ASTM A182, Grade F304L, Round Head Type Threaded End		
		2" and smaller	-----CAPS----- 3000# 304L Stainless Steel, ASTM A182, Grade F304L, Threaded End		
		2" and smaller	-----FLANGES----- 150# ANSI, Raised Face, Threaded Type, 304L Stainless Steel, ASTM A182, Grade F304L Schedule 80S Bore		
THE RALPH M. PARSONS COMPANY			JOB NUMBER 6154-3	DOCUMENT NO. C-1	REV.

SERVICE			CLASS	D	
			PAGE 2	OF 5	
CODE NUMBER	ENCODER	SIZE FROM TO	DESCRIPTION	NOTES	REV
		3" and larger	<p>-----FLANGES CONT'D-----</p> <p>150# ANSI, Raised Face, Weld Neck Type 304L Stainless Steel ASTM A182 Grade F304L Schedule 40S Bore</p>		
		1" and larger	<p>-----ORIFICE FLANGES-----</p> <p>300# ANSI Raised Face Weld Neck Type, Forged Stainless Steel, ASTM A182 Grade F304L, Schedule 40S Bore with 1/2" Scrd Taps</p>		
		Header	<p>-----BRANCH CONNECTIONS-----</p> <p>Branch Use</p>		
		2" and smaller	Full or Reducing	Full or Reducing Tee	
		3" and larger	Full Size	Full Size Tee or Weldolet	
			2" and smaller	Thredolet	
			<p>-----PIPING INSTRUMENT CONNECTIONS-----</p> <p>Temperature Conn's 1-1/2" Flgd. Pressure Conn's 1/2" Threaded Orifice Tap Conn's 1/2" Threaded</p>		
			<p>-----GASKETS-----</p> <p>Spiral-Wound Metallic Type, T304L Stainless Steel Spiral Windings with Grafold Filler 1/8" Thick 304 Stainless Steel Centering Ring</p>		
			<p>-----BOLTING-----</p> <p>Stud Bolt, 304 Stainless Steel, ASTM A193 Grade B7 with 2 Heavy Hex Nuts, ASTM A194 Grade 2H</p>		
			<p>-----PIPE BENDS-----</p> <p>Bends (Minimum) 5 Times the Normal Diameter may be used in place of Threaded Fittings</p>		
		2" and smaller	<p>-----Y-STRAINERS-----</p> <p>316 Stainless Steel Body, ASTM A351, Grade CF8M, Threaded Ends, 316 or 304 Stainless Steel Screen with .045 Diameter Perforations, Threaded Blowoff Connection Acceptable Model Armstrong Fig. No. E7SC - 1/2" thru 1 1/4" Armstrong Fig. No. E7SC - 1 1/2" thru 2"</p>

SERVICE				CLASS	D
				PAGE 3	OF 5
CODE NUMBER	ENCODER	SIZE FROM TO	DESCRIPTION	NOTES	REV
		3" and larger	<p>-----Y-STRAINERS-----</p> <p>316 Stainless Steel Body, ASTM A351, Grade CF8M, Flanged Ends, 316 or 304 Stainless Steel Screen with .045 Diameter Performations, Threaded Blow-Off Connection Acceptable Model Armstrong Fig. No. E7FL-3" thru 10"</p>		
		1/2" - 3/4"	<p>-----STEAM TRAPS-----</p> <p>Steam Trap, Threaded Ends, Impulse Type, 1-1/4 CR - 1/2 Moly Body, Stainless Steel Bonnet, Seat, and Disc, Integral Strainer and Blow-Off Acceptable Model Yarway Fig. No. 720</p>		
			<p>-----THREAD COMPOUND-----</p> <p>Use "Liquid O Ring" for Pipe Threads</p>		
		2" and smaller	<p>-----GATE VALVES-----</p> <p>150# ANSI Threaded Ends OS&Y, Bolted Bonnet, Body & Bonnet - 316L Stainless Steel, Casting - ASTM A351, Grade CF3M, Forging ASTM 182, Grade F316L, Trim 316 Stainless Steel, Packing - Reinforced TFE, Bonnet Gasket - Reinforced TFE, Trim 316 Stainless Steel Acceptable Model Aloyco Fig. No. 110</p>		
		3" and larger	<p>-----GATE VALVES-----</p> <p>150# ANSI, Flanged Ends, OS&Y, Bolted Bonnet, Body and Bonnet 316 Stainless Steel, Casting - ASTM A351, Grade CF8M, Forging - ASTM A182, Grade F316, Packing Reinforced TFE, Bonnet Gasket, Reinforced TFE, Trim 316 Stainless Steel Acceptable Model Aloyco Fig. No. 117</p>

SERVICE				CLASS	D
				PAGE 4	OF 5
CODE NUMBER	ENCODER	SIZE FROM TO	DESCRIPTION	NOTES	REV
		2" and smaller	<p>-----GLOBE VALVE-----</p> <p>150# ANSI, Threaded Ends, OS&Y, Bolted Bonnet, Body and Bonnet 316L Stainless Steel, Casting ASTM A351, Grade CF3M, Forging ASTM A182, Grade F316L, Packing Reinforced TFE, Bonnet Gasket - Reinforced TFE, Trim 316 Stainless Steel</p> <p>Acceptable Model</p> <p>Aloyco Fig. No. 314</p>		
		3" and larger	<p>150# ANSI - Flanged Ends, RF, OS&Y, Bolted Bonnet, Body and Bonnet 316 Stainless Steel Casting ASTM A351, Grade CF8M, Forging ASTM A182, Grade F316 Packing Reinforced TFE, Bonnet Gasket - Reinforced TFE, Trim 316 Stainless Steel</p> <p>Acceptable Model</p> <p>Aloyco Fig. No. 317</p>		
		2" and	<p>-----BALL VALVES-----</p> <p>150# ANSI, Threaded Ends, Handle Operated, Body and Ends, 316L Stainless Steel, Castings ASTM A351, Grade CF3M, Forgings ASTM A182, Grade F316, Seats and Seals Reinforced TFE, Trim 316 Stainless Steel</p> <p>Acceptable Model</p> <p>Worcester Controls</p> <p>Fig. No. W5966TSES7</p>		
		3" and 4"	<p>-----BALL VALVES-----</p> <p>150# ANSI Flanged Ends, Handle Operated, Body and Ends, 316 Stainless Steel, Castings - ASTM A351, Grade CF8M, Forgings ASTM A182, Grade F316, Seats and Seals - Reinforced TFE, Trim 316 Stainless Steel</p> <p>Acceptable Model</p> <p>Hills-McCanna Fig. No. S15156RS6</p>		
		2" and smaller	<p>-----CHECK VALVES-----</p> <p>150# ANSI, Threaded Ends, Swing Type, Bolted Bonnet, Body and Bonnet 316L Stainless Steel Castings ASTM A351, Grade CF3M, Forgings ASTM A182, Grade F316L, Bonnet Gasket Reinforced TFE, Trim 316 Stainless Steel</p> <p>Acceptable Model</p> <p>Powell Fig. No. 2341</p>
THE RALPH M. PARSONS COMPANY			JOB NUMBER	DOCUMENT NO	REV.
Page 33 of 48			6154-3	C-1	

SERVICE				CLASS	
				D	
				PAGE 5 OF 5	
CODE NUMBER	ENCODER	SIZE FROM TO	DESCRIPTION	NOTES	REV
		3" and larger	<p>-----CHECK VALVES-----</p> <p>150# ANSI - Flanged Ends - RF Swing Type, Bolted Bonnet, Body and Bonnet 316 Stain- less Steel, Castings ASTM A351, Grade CF8M, Forgings ASTM A182, Grade F316, Bonnet Gasket - Reinforced TFE, Trim 316 Stainless Steel Acceptable Model Aloyco Fig. No. 377</p>

THE RALPH M. PARSONS COMPANY	Page 34 of 48	JOB NUMBER	DOCUMENT NO	REV.
		6154-3	C-1	

SERVICE: High Pressure Steam, Low Pressure Steam, Condensate, High Pressure Air, Vacuum				CLASS PAGE 1 OF 4	
RATING: 150# FACING: Raised Face MATERIAL: Carbon Steel				CORROSION ALLOWANCE — PRESSURE LIMIT — Per B16.5 TEMPERATURE LIMIT — 365°F	
CODE NUMBER	EN- CODER	SIZE FROM TO	DESCRIPTION	NOTES	REV
		2" and smaller	-----PIPE----- Carbon Steel, ASTM A53 Grade B, Extra Strong Threaded Ends		
		3" and larger	Carbon Steel, ASTM A53 Grade B, Standard Weight Beveled Ends		
		2" and smaller	-----FITTINGS----- 3000# Carbon Steel, Threaded Ends ASTM A105		
		3" and larger	-----FITTINGS----- Seamless or Welded Carbon Steel, Buttweld Ends, Standard Weight, ASTM A234 Grade WPB		
		2" and smaller	-----THREADOLETS----- 3000# Forged Carbon Steel, ASTM A105, Schedule 80 Bore, Conforming to Bonney Forge		
		3" and larger	-----WELDOLETS----- Forged Carbon Steel, Standard Weight, ASTM A105, Schedule 40 Bore, Conforming to Bonney Forge		
		2" and smaller	-----SWAGE NIPPLES----- Carbon Steel, Threaded Ends, ASTM A234, Grade WPB, Extra Strong		
		2" and smaller	-----UNIONS----- 3000# Forged Carbon Steel, ASTM A105, Schedule 80 Bore, Ground Joint Type with Integral Seats, Threaded Ends		
		2" and smaller	-----PLUGS----- Forged Carbon Steel, Round Head Type, Threaded End		
		2" and smaller	-----CAPS----- 3000# Forged Carbon Steel, ASTM A105, Schedule 80 Bore, Threaded		
		2" and smaller	-----FLANGES----- 150# ANSI, Raised Face Ends, Carbon Steel, ASTM A105, Threaded XS Bore		
THE RALPH M. PARSONS COMPANY			JOB NUMBER 6154-3	DOCUMENT NO C-1	REV.

SERVICE				CLASS	N
				PAGE 2	OF 4
CODE NUMBER	ENCODER	SIZE FROM TO	DESCRIPTION	NOTES	REV
		3" and larger	150# ANSI, Raised Face Slip-On Type, Carbon Steel, ASTM A105		
		1" and larger	150# ANSI, Raised Face Blind Flange, Carbon Steel ASTM A105		
		1" and larger	-----ORIFICE FLANGES----- 300# ANSI, Raised Face Weld-Neck Type, Forged Carbon Steel, ASTM A105 Bore to Match Pipe, with 1/2" Scrd Taps		
		Header	-----BRANCH CONNECTIONS----- Branch		
		2" and smaller	Full or Reduced Size	Use	
		3" and larger	Full Size	Full or Reducing Tee	
			2" and smaller	Full Size Tee	
			Threadolet		
			-----PIPING INSTRUMENT CONNECTIONS----- Primary Instrument Conn's to Piping		
			Temperature Conn's	1-1/2" Fldg	
			Pressure Conn's	1/2" Threaded	
			Orifice Tap Conn's	1/2" Threaded	
			-----GASKETS----- Grafoil Flange Gasket, Flat Ring, 1/16" thick, John Crane or Approved Equal		
			-----BOLTING----- Alloy Stud Bolt, ASTM A193 Grade B7 with 2 Heavy Hex Nuts, ASTM A194 Grade 2H		
		2" and smaller	-----Y-STRAINER----- 600#, Carbon Steel Body, ASTM A216, Grade WCB, Threaded Ends, 304 Stainless Steel Screen with 0.45 Diameter Perforations		
			Acceptable Model		
			Armstrong Fig. No. B15C		
		3" and larger	-----Y-STRAINER----- 150# ANSI, Raised Face Flanged Ends, Carbon Steel Body, ASTM A216 Grade WCB, 304 Stainless Steel Screen with 0.045" Diameter Perforations		
			Acceptable Model:		
			Armstrong Fig. No. B1FL

SERVICE				CLASS	N
				PAGE 3	OF 4
CODE NUMBER	ENCODER	SIZE FROM TO	DESCRIPTION	NOTES	REV
		1/2" - 3/4"	<p>-----STEAM TRAPS-----</p> <p>Steam Trap, Screwed Ends, Impulse Type, 1-1/4 Cr-1/2 Moly Body, Stainless Steel Bonnet, Seat and Disc, Integral Strainer and Blow-off Acceptable Model: Yarway Fig. No. 720</p> <p>-----THREAD COMPOUND-----</p> <p>Use "Liquid O Ring" for Pipe Threads</p>		
		2" and smaller	<p>-----GATE VALVES-----</p> <p>800# Threaded Ends, OS&Y Seal Welded Bonnet, Body and Bonnet, Carbon Steel, Forgings - ASTM A105, Trim F6 Acceptable Model Vogt Fig. No. 2801 thru 2808</p>		
		3" and larger	<p>-----GATE VALVES-----</p> <p>150# ANSI Flanged Ends, Raised Face OS&Y Bolted Bonnet, Body and Bonnet Carbon Steel, Castings - ASTM A216, Grade WCB, Forgings ASTM A105, Trim No. 4 Acceptable Model Pacific Fig. No. 150-4</p>		
		2" and smaller	<p>-----GLOBE VALVES-----</p> <p>800# Threaded Ends, OS&Y Seal Welded Bonnet, Body and Bonnet, Carbon Steel, Forgings - ASTM A105, Trim F6 Acceptable Model Vogt Fig. No. 2821 thru 2828</p>		
		3" and larger	<p>-----GLOBE VALVES-----</p> <p>150# ANSI Flanged Ends, Raised Face OS&Y Bolted Bonnet, Body and Bonnet Carbon Steel, Castings - ASTM A216, Grade WCB, Forgings ASTM A105, Trim No. 4 Acceptable Model Pacific Fig. No. 160-4</p>		
		2" and smaller	<p>-----CHECK VALVES-----</p> <p>800# Threaded Ends, Bolted Bonnet Horizontal Piston Type, Body and Bonnet, Carbon Steel, Forgings - ASTM A105, Trim F6 Acceptable Model Vogt Fig. No. 701 thru 708</p>

THE RALPH M. PARSONS COMPANY	Page 37 of 48	JOB NUMBER	DOCUMENT NO	REV.
		6154-3	C-1	

SERVICE				CLASS N	
				PAGE 4	OF 4
CODE NUMBER	ENCODER	FROM SIZE TO	DESCRIPTION	NOTES	REV
		3" and larger	<p>-----CHECK VALVES CONT'D-----</p> <p>150# ANSI Flanged Ends, Raised Face Bolted Bonnet, Swing Type, Body and Bonnet Carbon Steel, Castings - ASTM A216, Grade WCB, Forgings ASTM A105, Trim No. 4 Acceptable Model Pacific Fig. No. 180-4</p>		
		2" and smaller	<p>-----BALL VALVES-----</p> <p>150# ANSI, Threaded Ends, Handle Operated, Body and Ends, Carbon Steel, Castings, ASTM A216, Grade WCB, SEats and Seals, Reinforced TFE, Trim 316 Stainless Steel Acceptable Model Worcester Controls Fig. No. W5944RSE</p>		
		2" and smaller	<p>-----PLUG VALVES-----</p> <p>300# Threaded Ends Carbon Steel Body, Cover, Plug, and Cover Bolts, Castings ASTM A216, Grade WCB, Teflon or Approved Equal Sleeve and Diaphragm, Wrench Operated, Extra Strong Bore Acceptable Model Tufline Fig. No. 0366SE Non. Lubricated</p>

THE RALPH M. PARSONS COMPANY	Page 38 of 48	JOB NUMBER 6154-3	DOCUMENT NO C-1	REV.
	ENG-PM-1B			

SERVICE: Low Pressure Air				CLASS PAGE 1 P OF 3	
RATING: 125# FACING: Flat Face MATERIAL: Carbon Steel				CORROSION ALLOWANCE — PRESSURE LIMIT — Per B16.1 TEMPERATURE LIMIT — 200°F	
CODE NUMBER	EN-CODER	SIZE FROM TO	DESCRIPTION	NOTES	REV
		2" and smaller	-----PIPE----- Carbon Steel, ASTM A53, Grade B, Schedule 40 Bore, Threaded Ends		
		3" and larger	Carbon Steel, ASTM A53, Grade B, Standard Weight, Beveled Ends		
		2" and smaller	-----FITTINGS----- 150# Malleable Iron, ASTM A47, Threaded Ends		
		3" and larger	Seamless Carbon Steel ASTM A234, Grade WPB Standard Weight, Beveled Ends		
		2" and smaller	-----THREADOLET----- 3000# Carbon Steel, ASTM A105, Conforming to Bonnet Forge		
		2" and smaller	-----SWAGE NIPPLES----- Carbon Steel, Thread Both Ends, ASTM A53, Grade B, Schedule 40 Bore		
		2" and smaller	-----UNIONS----- 150# Malleable Iron, ASTM A197, Ground Joint Type with Integral Seats, Threaded Ends		
		2" and smaller	-----PLUGS----- Carbon Steel, ATM A105 Round Head Type, Threaded		
		2" and smaller	-----CAPS----- 3000# Forged Carbon Steel, ASTM A105, Schedule 40 Bore, Threaded		
			-----THREAD COMPOUND----- Use "Liquid O Ring" for Pipe Threads		
			-----PIPE BENDS----- Bend (Minimum 5 times the normal diameter) may be used in place of Threaded Fittings		
		2" and smaller	-----FLANGES----- 150# ANSI, Flat Face, Threaded Ends, Carbon Steel, ASTM A105 Schedule 40 Bore		
THE RALPH M. PARSONS COMPANY			JOB NUMBER 6154-3	DOCUMENT NO C-1	REV.

SERVICE						CLASS	P								
						PAGE 2	OF 3								
CODE NUMBER	ENCODER	SIZE FROM TO	DESCRIPTION			NOTES	REV.								
		3" and larger	150# ANSI, Flat Face, Slip-On Type, Carbon Steel, ASTM A105, Schedule 40 Bore												
		1/2" and larger	150# ANSI, Flat Face Blind Flange Carbon Steel ASTM A105												
		1" and larger	-----ORIFICE FLANGES----- 300# ANSI, Raised Face, Weld-Neck Type, Carbon Steel, ASTM A105, Schedule 40 Bore with 1/2 Scrd Taps												
		2" and smaller 3" and larger	-----BRANCH CONNECTIONS----- <table><tr><td>Branch</td><td>Use</td></tr><tr><td>Full or Reduced Size</td><td>Full or Reducing Tee</td></tr><tr><td>Full Size</td><td>Full size tee</td></tr><tr><td>2" and smaller</td><td>Threadolet</td></tr></table>			Branch	Use	Full or Reduced Size	Full or Reducing Tee	Full Size	Full size tee	2" and smaller	Threadolet		
Branch	Use														
Full or Reduced Size	Full or Reducing Tee														
Full Size	Full size tee														
2" and smaller	Threadolet														
			-----PIPING INSTRUMENT CONNECTIONS--- Primary Instr. Conn's to Piping Temperature Conn's 1" Scrd Pressure Conn's 1/2" Scrd												
			-----GASKETS----- Grafoil Flange Gasket, Flat Ring, 1/16" thick, John Crane or Approved Equal												
			-----BOLTING----- Hex Head Machine Bolt with Hex Nut, ASTM A307 Grade B												
		2" and smaller	-----Y-STRAINER----- 300" - Bronze Body ASTM B-62 Threaded Ends, 304 or 55 Screen with 0.045 Perforations Acceptable Model Armstrong Fig. No. F7SC-300												
		3" and larger	150# ANSI, Flanged, Raised Face, Carbon Steel Body, ASTM A216, Grade WCB, 304 S.S. Screen with 0.045 Diameter Perforations Acceptable Model Armstrong Fig. No. BIFL												
			-----THREAD COMPOUND----- Thread Compound use "Liquid O Ring" for Pipe Threads

THE RALPH M. PARSONS COMPANY	Page 40 of 48	JOB NUMBER 6154-3	DOCUMENT NO C-1	REV.
--	---------------	----------------------	--------------------	------

SERVICE					CLASS		PAGE 3		P OF 2	
CODE NUMBER	ENCODER	FROM	SIZE TO	DESCRIPTION	NOTES	REV				
			2" and smaller	-----GATE VALVES----- 150# Threaded Ends, Rising Stem, Integral Seat, Body and Bonnet - Bronze ASTM B62, Trim Manufacturer's Standard Acceptable Model Crane Fig. No. 431						
			3" and larger	-----GATE VALVES----- 125# ANSI Flanged Ends, Flat Face, OS&Y, Bolted Bonnet Body and Bonnet Cast Iron, ASTM A126, Class B, Trim Bronze Acceptable Model Crane Fig. No. 465 1/2						
			2" and smaller	-----GLOBE VALVES----- 200# Threaded Ends, Rising Stem, Union Bonnet, Integral Seat, Body and Bonnet - Bronze ASTM B61 - Trim Bronze Acceptable Model Crane Fig. No. 70						
			3" and larger	-----GLOBE VALVES----- 125# ANSI Flanged Ends, Flat Face, OS&Y, Bolted Bonnet Body and Bonnet Cast Iron, ASTM A126, Class B, Trim Bronze Acceptable Model Crane Fig. No. 351						
			2" and smaller	-----CHECK VALVES----- 200# Threaded Ends, Swing Type, Screwed Bonnet, Body and Bonnet Bronze ASTM B61, Trim Bronze Acceptable Model Crane Fig. No. 36						
			3" and larger	-----CHECK VALVES----- 125# ANSI, Flanged, Flat Face, Swing Type, Bolted Bonnet, Body and Bonnet Cast Iron - ASTM A126, Class B, Trim Bronze Acceptable Model Crane Fig. No. 373						
			2" and smaller	-----BALL VALVES----- 300# - Threaded Ends, Handle Operated Body Bronze ASTM B61, Ball Stem and External Parts - Bronze, Seat and Body Seal FE Acceptable Model Jamesbury Fig. No. A11TT						
RMP THE RALPH M. PARSONS COMPANY					JOB NUMBER		DOCUMENT NO		REV	
Page 41 of 48					6154-3		C-1			

SERVICE: Cooling Water Supply and Return				CLASS PAGE 1 OF 3	
RATING: 125# FACING: Flat Face MATERIAL: Carbon Steel		CORROSION ALLOWANCE — PRESSURE LIMIT — Per B16.1 TEMPERATURE LIMIT — 200°F			
CODE NUMBER	EN-CODER	SIZE FROM TO	DESCRIPTION	NOTES	REV.
		2" and smaller	-----PIPE----- Carbon Steel, Galvanized, ASTM A120, Extra Strong, Threaded and Coupled Ends		
		3" and larger	Carbon Steel, ASTM A53, Grade B, Standard Weight, Beveled Ends		
		2" and smaller	-----FITTINGS----- 300# Galvanized Malleable Iron, Threaded Ends, ASTM A197		
		3" and larger	Black, Seamless or Welded Carbon Steel, Buttweld Ends, Standard Weight, ASTM A284, Grade WPB		
		2" and smaller	-----SWAGE NIPPLES----- 300# Galvanized Malleable Iron ASTM A197, Threaded Ends		
		2" and smaller	-----UNIONS----- 300# Galvanized Malleable Iron ASTM A197, Ground Joint Type with Bronze to Iron Seat, Threaded Ends		
		2" and smaller	-----PLUGS----- 300# Galvanized Malleable Iron ASTM A197, Solid Square Head Type, Threaded End		
		2" and smaller	-----FLANGES----- 150# ANSI, Flat Face Screwed Flange, Galvanized Steel, ASTM A105 150# ANSI, Flat Face Blind Flange, Galvanized Steel, ASTM A105		
		3" and larger	150# ANSI, Flat Face Slip-on Type, Carbon Steel, ASTM A105 150# ANSI, Flat Face Blind Flanges, Carbon Steel ASTM A105		
THE RALPH M. PARSONS COMPANY			JOB NUMBER 6154-3	DOCUMENT NO. C-1	REV.

SERVICE				CLASS	Q
				PAGE 2	OF 3
CODE NUMBER	ENCODER	SIZE FROM TO	DESCRIPTION	NOTES	REV
		2" and smaller 3" and larger	<p>-----ORIFICE FLANGES----- 300# ANSI, Raised Face Weld-Neck Type, Forged Carbon Steel, ASTM A105 with 1/2" Scrd Taps Extra Strong Bore Standard Weight Bore</p>		
		2" and smaller 3" and larger	<p>-----BRANCH CONNECTIONS----- Branch <u>Use</u> Full or Reduced Size Full or Reducing Tee Full Size Full size tee 2" and smaller Threadolet</p>		
			<p>-----PIPING INSTRUMENT CONNECTIONS--- Primary Instr. Conn's to Piping Temperature Conn's 1" Scrd Pressure Conn's 1/2" Scrd Secondary Piping Use this class</p>		
			<p>-----GASKETS----- Grafoil Flange Gasket, Flat Ring, 1/16" thick, John Crane or Approved Equal.</p>		
			<p>-----BOLTING----- Hex Head Machine Bolt with Hex Nut, ASTM A307 Grade B</p>		
			<p>-----THREAD COMPOUND----- Use "Liquid O Ring" for Pipe Threads</p>		
		2" and smaller	<p>-----GATE VALVES----- 150# Threaded Ends, Rising Stem, Integral Seat, Body and Bonnet - Bronze ASTM B62, Trim Manufactures Standard Acceptable Model Crane Fig. No. 431</p>		
		3" and larger	<p>-----GATE VALVES----- 125# ANSI - Flanged Ends, Flat Face, OS&Y Bolted Bonnet, Body and Bonnet Cast Iron ASTM A126, Class B, Trim Bronze Acceptable Model Crane Fig. No. 465 1/2</p>
THE RALPH M. PARSONS COMPANY Page 43 of 48				JOB NUMBER 6154-3	DOCUMENT NO C-1
ENG-PM-18				REV.	

SERVICE			CLASS 3		PAGE 3 OF 3	
CODE NUMBER	ENCODER	SIZE FROM TO	DESCRIPTION	NOTES	REV	
		2" and smaller	<p>-----GLOBE VALVE-----</p> <p>200# Threaded Ends, Rising Stem, Union Bonnet, Integral Seat, Body and Bonnet - Bronze ASTM B61 - Trim Bronze Acceptable Model Crane Fig. No. 70</p>			
		3" and larger	<p>125# ANSI - Flanged Ends, Flat Face, OS&Y Bolted Bonnet, Body and Bonnet Cast Iron ASTM A126, Class B, Trim Bronze Acceptable Model Crane Fig. No. 351</p>			
		2" and smaller	<p>-----CHECK VALVES-----</p> <p>200# Threaded Ends, Swing Type, Screwed Bonnet, Body and Bonnet Bronze, ASTM B61, Trim Bronze Acceptable Model Crane Fig. No. 36</p>			
		3" and larger	<p>-----CHECK VALVES-----</p> <p>125# ANSI, Flanged, Flat Face, Swing Type, Bolted Bonnet, Body and Bonnet Cast Iron, ASTM A126, Class B, Trim Bronze Acceptable Model Crane Fig. No. 373</p>			
		2" and smaller	<p>-----BALL VALVES-----</p> <p>300# Threaded Ends, Handle Operated, Body Bronze, ASTM B61, Ball, Stem and External Parts - Bronze, Seat and Body Seal TFE Acceptable Model Jamesbury Fig. No. A11TT</p>

THE RALPH M. PARSONS COMPANY

Page 44 of 48

JOB NUMBER

6154-3

DOCUMENT NO

C-1

REV.

ENG-PM-1B

SERVICE: Pressurized Feed Gas				CLASS PAGE 1 OF 2	
RATING: 300# FACING: Raised Face MATERIAL: Stainless Steel		CORROSION ALLOWANCE — Per B16.5 PRESSURE LIMIT — 2000F TEMPERATURE LIMIT —			
CODE NUMBER	EN- CODER	SIZE FROM TO	DESCRIPTION	NOTES	REV.
		1/2" - 10"	-----PIPE----- Stainless Steel, ASTM A312 Grade TP316L, Schedule 40S, Beveled Ends		
		1/2" - 10"	-----FITTINGS----- Seamless Stainless Steel, ASTM A403 Grade WP316L, Buttwelding Ends Schedule 40S		
		1/2" - 10"	-----FLANGES----- 300# ANSI, Raised Face Weld-Neck Type, Forged Stainless Steel ASTM A182 Grade F316, Schedule 40S Bore		
		2" - 10"	-----ORIFICE FLANGES----- 300# ANSI, Raised Face Weld-Neck Type, Forged Stainless Steel ASTM A182 Grade F316, Schedule 40S Bore, with 1/2" Socketweld Taps		
		Header 1/2" - 10"	-----BRANCH CONNECTIONS----- Branch Use Full or Reducing Full or Reducing Tees		
			-----PIPING INSTRUMENT CONNECTIONS----- Primary Instrument Connections to Piping Temperature Conn's 1-1/2" Flgd Pressure Conn's 1/2" BW Orifice Tap Connections 1/2" SW		
		1/2" - 10"	-----GASKETS----- Grafoil Flange Gasket, Flat Ring, 1/16" Thick, John Crane or Approved Equal		
			-----BOLTS----- Alloy Stud Bolts, ASTM A193 Grade B7, with 2 Heavy Hex Nuts, ASTM A194 Grade 2H

THE RALPH M. PARSONS COMPANY

Page 45 of 48

JOB NUMBER

6154-3

DOCUMENT NO

C-1

REV.

SERVICE				CLASS	V
				PAGE 2	OF 2
CODE NUMBER	ENCODER	SIZE FROM TO	DESCRIPTION	NOTES	REV
		1/2" - 6"	<p>-----GLOBE VALVES-----</p> <p>300# ANSI, Buttweld Ends, OS&Y, Bolted Bonnet, 316 Stainless Steel Body, 316 Stainless Steel Trim, Grafoil Packing, Sch 40S Bore</p> <p>Acceptable Model:</p> <p>Aloyco Fig. No. 2316A or 2316</p>		
		1/2" - 6"	<p>300# ANSI, Raised Face Flanged Ends, OS&Y Bolted Bonnet, 316 Stainless Steel Body and Trim, Grafoil Packing</p> <p>Acceptable Model</p> <p>Aloyco Fig. No. 2317A or 2317</p>		
		1/2" - 4" 6" only	<p>-----BALL VALVES-----</p> <p>300 ANSI, Buttweld Ends, 316 S.S. Body, Ball, Stem, and External Parts, Polyfill or Approved Equal Seat, Metal "S" Gasket or Approved Equal Body Seal, Lever Operated</p> <p>Schedule 40S Bore</p> <p>Acceptable Model: Worcester Controls</p> <p>Fig. No. W5966PMBWS7 (1/2" - 4")</p> <p>Fig. No. W4566PMBWS7 (6" only)</p>		
		1/2" - 3"	<p>-----PLUG VALVE-----</p> <p>300# ANSI, Butt-Weld Ends, 316 Stainless Steel Body, Cover, and Plug, Stainless Steel Cover Bolts, UHMW Polyethylene or Approved Equal Sleeve and Diaphragm, Wrench Operated, Sch 40S Bore</p>		
		4" - 10"	<p>Ditto, except Enclosed Gear Operated</p> <p>Acceptable Model:</p> <p>Tuflin Fig. No. 1366BW, Non-lubricated</p>		
		1/2" - 10"	<p>-----CHECK VALVES-----</p> <p>300# ANSI, Buttweld Ends, Swing Type, Bolted Cover, 316 Stainless Steel Body, 316 Stainless Steel Trim, Sch 40S Bore</p> <p>Acceptable Model:</p> <p>Aloyco Fig. No. 2376</p>

THE RALPH M. PARSONS COMPANY	Page 46 of 48	JOB NUMBER	DOCUMENT NO	REV.
			6154-3	C-1	

9.0 COATING AND WRAPPING

9.1 SCOPE OF WORK

The Contractor shall provide all material, labor, equipment, and tools necessary for the preparation and application of corrosion resistant coatings for exterior surfaces of carbon and stainless steel pipe, flanges, valves, and fittings in direct buried service.

9.2 MATERIALS OF CONSTRUCTION

The following materials or Approved Equal are acceptable:

<u>MATERIALS</u>	<u>MANUFACTURER</u>	<u>MFR's CODE</u>	<u>SERVICE TEMPERATURE</u>
Tape Primer	Polyken Div	No. 927	-30°F to 200°F
Primary Tape	of the	No. 980	-30°F to 200°F
Filler Tap	Kendall Co.,	No. 931	-30°F to 200°F
Joint Tape	Boston, Mass.	No. 930	-30°F to 200°F

9.3 EQUIPMENT

The pipe wrapping shall be electrically inspected with a Tinker & Razor Model AP or APW or Approved Equal holiday detector set at a minimum dc voltage of 150 times the mil thickness of the coating to detect any wrapping flaws.

10.0 FIRE PROTECTION

10.1 SCOPE OF WORK

This Specification establishes the requirements for the design, fabrication, and installation including furnishing labor, materials, tools, and equipment, and performing operations necessary for engineering, detailing, inspection, testing, documentation, delivery to jobsite and installing Underwriters Laboratories (UL) and/or Factory Mutual (FM) approved automatic fire sprinkler systems, fire hose cabinets, and fire hose racks.

10.2 MATERIALS OF CONSTRUCTION

Sprinkler heads for offices and other finished areas shall be UL and/or FM approved, pendant type with ceiling plate, a temperature rating of 212 deg F, and a standard 1/2-inch orifice size. Sprinkler heads for all other areas shall be UL and/or FM approved brass upright type, with a standard 1/2-inch orifice size and a temperature rating of 212 deg F except near heat sources where the temperature rating shall be in accordance with NFPA Standard No. 13, Table 3-16.6.4.

Water flow detectors shall be provided and installed according to NFPA Standard No. 72A. Wiring and conduits shall be provided and installed by the Contractor.

Piping shall comply with the ANSI and ASTM standards. Pipe hangers shall be in accordance with requirements of the Underwriters' Laboratories, Inc., for use in sprinkler systems.

Pipe:	Carbon Steel, ASTM A 53, Grade B, Standard Weight
Screwed Fittings:	Cast Iron ASTM A 126 conforming to ANSI B16.4 & B16.1 or Malleable Iron, ASTM A 197 conforming to ANSI B16.3
Flanges:	Cast Iron ASTM A 126 conforming to ANSI B16.1
Couplings and Unions:	As per NFPA Standard No. 13
Valves:	(1) Class 175 WWP Iron Body, Bronze Mounted, OS&Y Gate Valves for all sizes larger than 2 inches (2) Class 175 WWP Iron Body Swing Alarm Check Valve (3) Class 175 WWP Iron Body Dry Pipe Valve

10.3 EQUIPMENT

10.3.1 Alarm Check Valves

The alarm check valves shall be Viking Model F-1 Alarm Check Valve with retarding chambers and complete trim packages, or Approved Equal. A water motor gong local alarm shall be included with each wet pipe system.

10.3.2 Fire Hose Racks, Fire Hose and Extinguisher Cabinets

Fire hose racks and fire hose cabinets shall be of the surface mounted type and shall be provided and installed at the approximate locations shown on the drawings. All fire hose racks and cabinets shall be installed in compliance with NFPA Standard No. 14 for Class II service and NFPA Standard No. 13 for combined systems. All fire hose cabinets shall be sized to house a 2-1/2 gallon water-type fire extinguisher in addition to the hose and appurtenances.

APPENDIX C-2

ZEOLITE ENCAPSULATION OUTLINE SPECIFICATIONS

- 1.0 EARTHWORK
- 2.0 STRUCTURAL
- 3.0 ARCHITECTURAL
- 4.0 EQUIPMENT
- 5.0 HEATING, VENTILATING, AND AIR CONDITIONING SYSTEMS
- 6.0 PLUMBING
- 7.0 ELECTRICAL
- 8.0 PIPING MATERIALS
- 9.0 COATING AND WRAPPING
- 10.0 FIRE PROTECTION

APPENDIX C-2
ZEOLITE ENCAPSULATION
OUTLINE SPECIFICATIONS

1.0 EARTHWORK

Earthwork shall include the removal of all vegetation, trash and debris, and excavation for foundations. Trash and debris shall be removed to a sanitary land fill. Excavated material suitable for backfilling shall be stock piled on site for later use. Cuts over 4 feet high shall be shored or have side slopes a minimum of 1-1/2 to 1. Backfilling of excavated areas shall be compacted to 95 percent of maximum dry density in accordance with ASTM D 1557, Method D.

2.0 STRUCTURAL

2.1 CONCRETE

2.1.1 Applicable Publications. Concrete shall conform to ACI-318, "Building Code Requirements for Reinforced Concrete", and to the requirements of the following publications of the American Concrete Institute. These publications will be used to the extent they are applicable:

ACI-304 "Recommended Practice for Measuring, Mixing and Placing Concrete"

ACI-305 "Recommended Practice for Hot Weather Concreting"

ACI-306 "Recommended Practice for Cold Weather Concreting"

ACI-308 "Recommended Practice for Curing Concrete"

ACI-315 "Manual of Standard Practice for Detailing Reinforced Concrete Structures"

ACI-347 "Recommended Practice for Concrete Formwork"

2.1.2 Concrete Formwork. Forms shall be constructed to conform, within the tolerances specified, to the required shapes, dimensions, lines, elevations, and positions of the cast-in-place concrete members as indicated. Forms shall be supported, braced, and maintained sufficiently rigid to prevent deformation under load.

2.1.3 Cast-In-Place Concrete. Concrete shall be standard density concrete (150 pounds per cubic foot) unless noted otherwise. The minimum compressive strength of concrete will be 3000 psi at 28 days. Portland Cement shall conform to ASTM C150. Reinforcing steel shall conform to ASTM A615, Grade 60. Wire mesh for slabs shall conform to ASTM A 185.

2.1.4 Grout. Grout shall be sufficiently fluid to ensure complete filling of all sections of units or areas requiring grout, but not so thin as to allow segregation of aggregate. All grouting shall be done in accordance with manufacturer's printed instructions. Grout shall be a non-shrink type.

2.2 METALS

2.2.1 Applicable Publications. The requirements of the following publications shall be used to the extent they are applicable:

American Institute of Steel Construction (AISC)
"Specification for the Design, Fabrication and
Erection of Structural Steel for Buildings"

American Institute of Steel Construction (AISC)
"Specification for Structural Joints Using ASTM
A325 and A490 Bolts"

American Welding Society (AWS) "Structural Welding
Code (AWS D1.1)"

2.2.2 Structural Steel. Structural steel shall conform to ASTM A36. Fabrication and erection shall conform to AISC "Specification for the Design, Fabrication and Erection of Structural Steel for Buildings".

2.2.3 Bolting. Structural steel connections shall conform to "Specification for Structural Joints Using ASTM A325 or A490 Bolts". Structural stainless steel connections shall be similar to structural steel type connections, except that the mechanical properties of the bolts, nuts, and washers shall conform to the latest revision of ASTM A193 for Class 2, Grade B8, Type 304.

2.2.4 Welding. E308L electrode series shall be used to weld 304L stainless steel. Welding shall conform to the AWS Structural Welding Code, AWS D1.1, for carbon steel, to the ASME Boiler and Pressure Vessel Code for stainless steel, and to the requirements of the latest revisions of the following publications to the extent they are applicable:

"Specification for Corrosion-Resisting Chromium and
Chromium-Nickel Steel Covered Welding Electrodes", AWS
A5.9

"Specification for Corrosion-Resisting Chromium and
Chromium-Nickel Steel Welding Rods and Bare
Electrodes", AWS A5.9

"Specification for Flux-Cored Corrosion-Resisting
Chromium and Chromium-Nickel Steel Electrodes", AWS
A5.22

"Specification for Aluminum and Aluminum Alloy Welding
Rods and Bare Electrodes", AWS A5.10

2.2.5 Masonry. Masonry units shall conform to ASTM C90, Grade N, Type I for 8 inch or 12 inch block. Reinforcing steel for masonry construction shall conform to ASTM A615, Grade 60 for deformed billet steel bars.

3.0 ARCHITECTURAL

3.1 WOODS AND PLASTICS

3.1.1 Rough Carpentry

Rough carpentry shall be nailers, blocking, striping, and miscellaneous. Any member in contact with concrete or masonry shall be pressure preservative treated.

3.1.2 Finish Carpentry

Finish carpentry shall be built-in wood shelving, cabinets, hardwood shower seats, etc.

3.2 THERMAL AND MOISTURE PROTECTION

3.2.1 Preformed Metal Siding

Ribbed siding panels, 22 gauge, lap type joint with insulation.

3.2.2 Building Insulation

Building insulation shall be U.L. listed with flame spread under 25 and smoke developed and fuel contributed under 50. Insulation shall be in thicknesses as indicated on the drawings.

3.2.3 Inverted Roof System

Dow Chemical Co., 3-1/2 inch thick styrofoam RM brand insulation shall be placed directly over the roofing membrane.

a. Built up Roofing

Roofing shall be 3-ply, 20 year bondable type, applied directly over substrate, John-Mansville or equal.

b. Polyester Formed Fabric

Dow Chemical Co. approved fabric shall be placed loosely over the insulation.

c. Crushed Stone

A crushed stone ballast of 1-1/2 inch shall be placed over the polyester formed fabric. Stone top covering shall be 3/4 inch to 1 inch in diameter.

3.2.4 Sheet Metal

Parapet flashing, counter flashing, base flashing, and flashing at roof penetrations shall be 24 and 22 Ga galvanized steel.

3.2.5 Sealants and Caulking

Sealants and caulking shall be silicone, polysulphide or polyurethane base, non-saf, gun-approved as pourable, selected as best suitable for applicable conditions.

3.3 DOORS AND WINDOWS

3.3.1 Metal Doors and Frames

Doors and frames shall be standard commercial type, conforming to the Steel Door Institute (SDI) standards as follows:

Doors: Flush panel, seamless; interior doors 18 gauge; exterior doors 16 gauge, galvanized.

Frames: Full welded or knock down construction; interior frames 16 gauge; exterior doors 14 gauge, galvanized.

Fire rated doors and frames, where required, shall conform to the requirements of U.L. and shall bear the appropriate label. All interior doors shall have 6 inch x 2 foot wire glass vision lites except doors leading to toilets, lockers and janitor rooms.

Explosion proof doors shall be able to withstand 1-PSI.

3.3.2 Finish Hardware

Finish hardware shall include mortise-type latchsets, locksets, exit devices, hinges, closers, thresholds, flushbolts, pulls, push/kick plates, door holders, and shall be heavy duty as manufactured by Sargent and Co. or equal. Exposed surfaces of hardware shall have a satin finish or as selected. All building exits shall be provided with panic exit devices.

3.4 FINISHES

3.4.1 Metal Studs

Except as otherwise noted all metal studs shall be 4 inches x 20 gauge, non-bearing screwable type, punched for utility lines, complete with top and bottom runners.

3.4.2 Gypsum Board

Gypsum board shall be 5/8 inch thick tapered edge throughout. Water resistant gypsum board shall be used in toilet rooms and janitors room. Type "X" shall be used in 1-hour fire rated areas.

3.4.3 Ceramic Tile

Ceramic tile work shall include regular Portland cement sitting beds and ceramic tile floors, wainscots and walls. Tilework and installation shall conform to the American National Standards Institute (ANSI) and the Tile Council of America (TCA).

3.4.4 Acoustical Ceilings

Acoustical ceilings shall be suspended exposed metal "T" grid system with lay-in acoustical units. Exposed "T" members shall be aluminum or steel with applied matte white enamel finish. Acoustical units shall be 24 inches x 48 inches x 5/8 inches. Acoustical material shall be U.L. listed with flame spread under 25 and smoke developed and fuel contributed under 50.

3.4.5 Cement Plaster

Cement plaster shall be installed on metal lath and steel framing on walls and ceilings where scheduled, including all necessary trim and accessories.

3.4.6 Resilient Flooring

a. Floor coverings in the Decon area, air lock and gallery shall be 200 vinyl chloride, 2 mm thick flooring as distributed by Dynamit Nobel of America Inc., or approved equal. Material shall be manufactured as a homogenous polyvinyl chloride with the pattern and color extending through the butt thickness and shall conform to Federal Specifications SS-T-312, L-F475, and ASTM E84. Material shall have chemical resistance to acids, bases, dye stuffs, and solvents and shall be noncombustible or self-extinguishing. Installation shall be made as a monolithic, seamless floor by heat welding and fusion, or by butt welding edges of material sheets together. Flooring shall be butt welded directly to 6" high Mipolam flexible vinyl cove.

b. All other areas such as offices and hallways shall have vinyl asbestos tile flooring as manufactured by Armstrong Cork Co. or equal. The tiles shall be 12 inches x 12 inches x 1/8 inch commercial quality. The base shall be four inches high top set vinyl cove base with pre-formed internal and external corners.

3.4.7 Painting

Except as excluded herein, all surfaces of new work shall be properly prepared, primed, and finished, including walls, ceilings, miscellaneous exposed materials, equipment, piping, hangers, conduits, grilles, etc., which normally require painting.

The following items shall not be painted:

- Surfaces receiving a special protective coating
- Concrete floors
- Anodized aluminum, chromed, or stainless metals
- Factory-finished items and equipment

The following items shall be primed or shop-coated prior to delivery to job site:

- Metal doors and frames
- Structural steel
- Miscellaneous metal work

Paints, primers, and finishes shall be ready-mixed and equal to first-line products as manufactured by:

Devco and Reynolds, Inc.
Pratt and Lambert, Inc.
E. I. DuPont de Nemours and Co.
Rust-Oleum Corporation
Glidden Company
Benjamin Moore and Co.

a. Painting Schedule. All painting shall be two coats applied over a primer coat. The primer coat shall be appropriate for the surfaces to be painted and compatible with the types of finish coat used.

b. Interior Surfaces

<u>Surface</u>	<u>Finish</u>
Concrete	1 coat masonry flock filler 2 coats interior alkyd semigloss enamel
Galvanized Metal	1 coat zinc dust-zinc oxide primer 1 coat interior enamel undercoat 1 coat interior alkyd semigloss enamel

Ferrous Metal	1 coat zinc, iron oxide, alkyd resin-type metal primer 1 coat enamel undercoat 1 coat alkyd semigloss enamel
---------------	---

c. Exterior Surfaces

<u>Surface</u>	<u>Finish</u>
Ferrous Metal	1 coat alkyd-oil resin-type metal primer 2 coats semigloss enamel
Galvanized Metal	1 coat zinc dust-zinc oxide primer 2 coats semigloss enamel

3.4.8 Special Coatings

Special coatings shall be Ameron system decontaminable special protective coating for floors, walls, and ceilings, or equal.

Concrete floors:

Prime sealer	Nu-Klad 108
Intermediate coat	Amercoat 66
Top coat	Amercoat 66 (2 coats)

Concrete Walls:

Prime sealer	Nu-Klad 108
Filler	Nu-Klad 114
Intermediate coat	Amercoat 66
Top coat	Seal gloss Amercoat 66

Structural Steel, Decking, Carbon Steel Doors and

Frames:

Primer	Amercoat 77
Cleaner (for galvanized)	Galvaprep
Intermediate coat	Amercoat 66
Top coat	Amercoat 66

Protective Coating for Stainless Steel Embedded in

Concrete:

Double coating	Thurmalox 70
----------------	--------------

3.5 SPECIALTIES

3.5.1 Metal Toilet Partitions

Ceiling hung toilet partitions and wall hung urinal screen shall be products of Sanymetal Products or equal, "Century Type" with a baked enamel finish.

3.5.2 Toilet Accessories

Toilet accessories shall be products of Bobrick Washroom Equipment Co., or equal, including:

- a. Mirror
- b. Soap dispenser
- c. Towel dispenser and waste receptacle
- d. Sanitary napkin dispenser
- e. Toilet tissue dispenser
- f. Seat cover dispenser

3.5.3 Louvers

Louvers shall be products of Construction Specialties, Inc., or equal, mullion type louvers Model 4100 standard blade or as applicable and shall be constructed of extruded aluminum, 6063-T52 alloy, furnished with 1/2 inch mesh birdscreen.

3.5.4 Signs and Directories

Signs shall be products of Vomar Products, Inc., or equal.

3.5.5 Lockers and Benches

Lockers and benches shall be the products of Lyon Metal Products, or equal.

a. Lockers. Lockers shall be single tier-type, 12 inches wide, 18 inches deep, 72 inches high with baked enamel finish. Lockers shall be curb mounted.

b. Benches. Benches shall be constructed of hardwood seats, finished with three coats of plastic sealer mounted on enameled steel pedestals.

4.0 EQUIPMENT

4.1 PROCESS EQUIPMENT

4.1.1 Sump Catch Tank

Equipment No. KEF-HP-TK1. 42 in. diameter by 6 ft.-6 in. tall, constructed of ASME SA-240 Grade 304L stainless steel. Design and fabrication per ASME Boiler and Pressure Vessel Code, Section VIII, Division 1 at 15 PSIG and 100°F. Capacity shall be 500 gallons. Equipped with an electric motor driven agitator (Equip. No. KEF-HP-AG1) and an internal spray header for decontamination solutions with inlet, outlet, vent, and instrumentation connections and agitator mount.

4.1.2 Decontamination Solution Make-Up Tank

Equipment No. KEF-HP-TK101. 42 in. diameter by 4 ft.-0 in. tall, constructed of ASME SA-240 Grade 304L stainless steel. Design and fabrication per ASME Boiler and Pressure Vessel Code, Section VIII, Division 1 at 15 PSIG and 200°F. Capacity shall be 300 gallons. Equipped with an electric motor driven agitator (Equip. No. KEF-HP-AG101) and a steam heating coil with inlet, outlet, vent, and instrumentation connections and agitator mount.

4.1.3 Pressurized Feed Gas Mixture Lag Storage Vessels, Pressurized Feed Gas Mixture Run Tank, Isostatic Run Tank

Equipment No. KEF-HP-TK2 (eight required), KEF-HP-TK3 (two required), and KEF-HP-TK4 (two required). 12 in. nominal diameter pipe (Sch. 80S) by 12 ft.-0 in. long, constructed of ASME SA-312 Grade TP316L stainless steel. Design and fabrication per ASME Boiler and Pressure Vessel Code, Section VIII, Division 1 at 1270 PSIG and 300°F. Capacity shall be 9.5 cubic feet. Equipped with inlet, outlet, and instrumentation connections. The ten vessels shall be stacked two wide by five high in a structural steel frame as shown on Drawing No. P-6.

4.1.4 Fresh Isostatic Gas Supply Cylinders

Equipment No. KEF-HP-TK101, (three required) 9 in. nominal diameter by 4 ft. 4 in. tall, constructed of carbon steel. Design pressure 2490 PSIG at 100°F. Capacity shall be 1.54 cubic feet each. Assembled with manifold, individual shut-off valves, pressure reducing station, and inlet and outlet pressure indicators.

4.1.5 Pressure Relief Accumulator

Equipment No. KEF-HP-TK5. 18 in. nominal diameter pipe (Sch. 80S) by 4 ft.-6 in. long, constructed of ASME SA-312 Grade TP316L stainless steel. Design and fabrication per ASME Boiler and Pressure Vessel Code, Section VIII, Division 1 at 900 PSIG and 200°F. Capacity shall be 8 cubic feet. Equipped with inlet, outlet, and instrumentation connections.

4.1.6 Feed Gas Mixture Compressor

Equipment No. KEF-HP-COM1&2 (two required). Single stage, diaphragm type with hydraulic fluid providing the pulsating motion to compress Krypton-85 gas from an inlet pressure of 340 psig at 70°F, to a discharge pressure of 500 psig. Compressor displacement shall be 1 CFM at 400 rpm. A triple diaphragm shall be used with a detection system to indicate either compressed gas or hydraulic fluid leakage through the diaphragm. Parts in contact with krypton shall be Type 316 stainless steel, other parts may be manufacturer's standard for the application. The compressor shall be electric motor belt driven. Maximum compressor speed shall be 400 rpm, electric motor speed shall be 1800 rpm. The electric motor shall be 460V, 3 phase, 60 Hertz. Each compressor and drive shall be assembled and mounted on a structural frame.

4.1.7 Decontamination Solution Pump

Equipment No. KEF-HP-P101. Centrifugal, horizontal, electric motor driven pump. Motor speed shall be 1800 rpm. Parts in contact with decontamination solutions shall be Type 316 stainless steel. Pump capacity shall be 50 gpm with 40 feet TDH.

4.1.8 Closed Loop Cooling Water Pump

Equipment No. KEF-HP-P1&2 (two required). Centrifugal, horizontal, electric motor driven pump. Motor speed shall be 1800 rpm. Pump material shall be ductile iron. Pump capacity shall be 100 gpm with 60 feet TDH.

4.1.9 Krypton Vacuum Pump Helium Vacuum Pump

Equipment No. KEF-HP-VP 1 & 2 (two required), and Equipment No. KEF-HP-VP 3 & 4 (two required). Cam and piston, compound vacuum pump, capable of displacing 3 CFM minimum at 10^{-2} Torr. Metals in contact with the process shall be Type 316 stainless steel. Other materials in contact with the process shall be compatible with radioactive Krypton-85. Pump shall be motor driven, single or three phase, 230/460V, 60 hertz. Maximum motor speed shall be 1800 rpm.

4.1.10 Pressurized Feed Gas Cooler

Equipment No. KEF-HP-HE1. Shell and tube type heat exchanger with 20,000 BTU/hr. duty. Materials in contact with krypton gas shall be Type 316 stainless steel, other materials may be carbon steel. Design and fabrication per ASME Boiler and Pressure Vessel Code, Section VIII, Division 1, and TEMA R requirements. Design pressure for gas side shall be 600 PSIG, with 200°F inlet temperature and 110°F maximum outlet temperature. Design pressure for water side shall be 100 PSIG, with 95°F inlet temperature.

4.1.11 Closed Loop Cooling Water Heat Exchanger

Equipment No. KEF-HP-HE2. Shell and tube type heat exchanger with 200,000 BTU/hr. duty. Materials shall be carbon steel with admiralty tubes. Design and fabrication per ASME Boiler and Pressure Vessel Code, Section VIII, Division 1, and TEMA R requirements. Design pressure shall be 100 PSIG, with closed loop water inlet temperature 130°F and outlet temperature 95°F, and cooling water inlet temperature 85°F.

4.1.12 Pressurized Feed Gas Filter

Equipment No. KEF-HP-F1. Inlet filter with removable sintered metal element. Filter rating shall be 2 micron with 2 CFM flow and 500 PSIG pressure, with no more than 10 PSI pressure drop. Materials in contact with Krypton-85 shall be Type 316 stainless steel.

4.1.13 Sump Liquid Sampler Sump Catch Tank Liquid Sampler

Manually initiated, isolating, plunger type, air powered, solenoid valve actuated liquid sampler.

4.1.14 Sump Eductor Sump Catch Tank Eductor

Air or steam operated liquid eductor, 30 gpm transfer rate, Type 304L stainless steel.

4.1.15 Hot Isostatic Press

Equipment No. KEF-HP-HIP1. Top loading, single level, graphite, natural convection style hot isostatic pressing furnace with isolated dual gas differential pressure control capability, 30 liter vessel capacity, 8.8 liter container capacity, with electric internal furnace and water cooled pressure vessel shell. Includes top vessel plug, movable plug yoke, pressure control gas system, feed compressors KEF-HP-COM 3 & 4 and KEF-HP-COM 5 & 6, and vacuum pump. Operating pressure 14,700 PSIG at 700°C, 50 kW maximum power, 41,000 BTU/hr heat input, design per ASME Boiler and Pressure Vessel Code, Section VIII, Division 1.

4.1.16 Substrate Activation Furnace

Equipment No. KEF-HP-AF1 (two required). Electric resistance heated furnace with capacity for 8.8 liter substrate container, 40 kW heat input.

4.2 MECHANICAL EQUIPMENT

4.2.1 Mini-Trailer Robo-Carrier

(2 required). Remotely operated, automatically controlled electric cart and platform lift assembly, with vertical and horizontal canister cradles, pneumatic push/pull piston, and pre-programmed positioning capability.

4.2.2 In-Cell Bridge Crane

Remotely operated bridge crane with 12-ft. 0-in. span and 5-ton top mounted trolley and hoist, and with two 1/2-ton underslung auxiliary trollies and hoist, as manufactured by Edder Corp. or Approved Equal.

4.2.3 Remote Welder

Fully remote automatic welding station as manufactured by Astro-Arc or Dimetrics Corporation or Approved Equal.

4.2.4 Leak Detection System

Fully remote automatic leak detection system with automatically calibrated helium detector.

4.2.5 Master-Slave Manipulators

(Four required). Model "F" type master-slave manipulators, for assistance and maintenance of automatic welder and remote leak detection system, as manufactured by Central Research or Approved Equal.

5.0 HEATING, VENTILATING, AND AIR CONDITIONING SYSTEMS

5.1 SUPPLY FANS

Supply fans shall be single-width, single-inlet, non-overloading centrifugal type with airfoil blades, V-belt drive and TEFC motors, AMCA Class II construction, and variable inlet vortex vane damper capacity control. Capacity shall be 2670 cfm at 3.0 inches wg static pressure and 3-hp. Fans shall be Buffalo Forge Co. type BL-Aerofoil, size 270, or Approved Equal.

5.2 EXHAUST FANS

Exhaust fans shall be designed and constructed to operate continuously prior to, after, but not necessarily during an Operating Basis Earthquake (OBE). Fans shall be single-width, enclosed radial blade centrifugal type, V-belt drive and TEFC motors, AMCA Industrial Exhauster class. Capacity shall be 2800 cfm at 10-inches wg static pressure and 10 hp. Fans shall be Buffalo Forge Co. Industrial Exhaust model, size 30 MV, or Approved Equal.

5.3 VENT FANS

Vent fans shall be single-width, single-inlet non-overloading centrifugal type with airfoil blades, V-belt drive and TEFC motors, AMCA class III construction, and variable inlet vortex vane damper capacity control. Capacity shall be 4000 cfm at 1-inch wg static pressure and 1-hp. Fan shall be Buffalo Forge Co. type BL-Aerofoil size 270, or approved equal.

5.4 POWER ROOF VENTILATORS

Power roof ventilators shall be low silhouette, all aluminum construction, spun housing type. Fans shall be centrifugal type with direct drive. Capacity shall be 100 cfm at 3/8 inches wg static pressure.

5.5 PREHEAT COILS

Preheat coils shall be 2-row, non-freeze, finned tube, low pressure steam type. Coil capacity shall be 2670 cfm and 168,000 Btu/hr at 15 psig steam pressure, with -20°F entering and +40°F leaving air temperatures.

5.6 HEATING COIL

Heating coils shall be the 1-row, finned tube type designed for modulating control with steam at 15 psig pressure.

5.6.1 Contaminated Areas

Heating coil serving the Load-out, Gas Storage, and Substrate areas shall have a capacity of 570 cfm and 26,000 Btu/hr with +40°F entering and 90°F leaving air temperatures. Coil face area shall be 1.0 square feet.

Heating coil serving the Assembly area shall have a capacity of 1180 cfm and 32,000 Btu/hr with +40°F entering and 70°F leaving air temperatures. Coil face area shall be 2.0 square feet.

5.6.2 Non-Contaminated Areas

Heating coil serving the Office, Health/Physics, Operating Gallery, and Vestibule shall have a capacity of 920 cfm and 41,400 Btu/hr with +40°F entering and +90°F leaving air temperature. Coil face area shall be 1.5 square feet.

5.7 COOLING COIL

Cooling coil shall be finned tube type for direct expansion refrigerant service. Coil shall be provided with a liquid refrigerant distributor. Coil capacity shall be 920 cfm and 24,000 Btu/hr. Coil shall have a face area of 2.0 square feet and be six rows deep.

5.8 SUPPLY AIR FILTER BOXES

Supply air filter boxes shall be the side loading type containing a guide track for prefilters and a separate guide track for high efficiency filters. Prefilters shall have an efficiency of 30% per ASHRAE Standard 52-76. High efficiency filters shall have an efficiency of 90% per ASHRAE Standard 52-76. Filter boxes shall be Farr Co. side loading model 3P Universal Glide/Pack with type 30/30 prefilters and type HP-200 high efficiency filters, or approved equal. Filter box capacity shall be 2670 cfm and shall have 2-24" x 24" x 4" prefilters and 2-24" x 24" x 12" high efficiency filters.

5.9 EXHAUST AIR HEPA FILTER PLENUMS

Filter plenums shall contain two stages of side loading, bag-out HEPA filters and provisions for remote in-place DOP testing of each HEPA filter. Filter plenums and filters shall be as manufactured by Flanders Filter, Inc. Each plenum shall consist of the following:

- 1) Upstream first test section, T-I, including DOP injection port, DOP diffusers, and upstream challenge aerosol concentration sample port.
- 2) First stage of HEPA filters in a model E-4, side loading, bag-out housing.
- 3) Center combination test section, T-C, including DOP injection port, DOP diffusers, and sample port for measuring first stage downstream sample concentration or second stage upstream sample concentration.
- 4) Second stage of HEPA filters in a model E-4, side loading bag-out housing.
- 5) Last test section, T-O, including DOP diffusers and sample port for measuring second stage downstream concentration.

Capacity of each filter plenum shall be 3000 cfm. Each filter shall be 24" x 24" x 11-1/2" and arranged in the plenum 3-wide by 1-high.

5.10 SPRAY COOLING CHAMBER

A spray water chamber shall be provided upstream of each exhaust air HEPA filter plenum. Each spray chamber shall be of stainless steel all welded construction. One bank of spray nozzles shall be provided together with moisture eliminators, and drain sump. Capacity shall be 2800 cfm with a face area of 5.6 square feet.

5.11 UNIT HEATERS

Unit heaters shall be horizontal suspended type with steam heating coil, propeller fan, and adjustable discharge air louvers. Capacity shall be 50,000 Btu/hr with 15 psig steam pressure. Unit heaters shall be Trane Co. model 60-S, or approved equal.

5.12 AIR COOLED CONDENSING UNIT

Air cooled condensing unit shall be for split system service and shall include an air cooled condenser, hermetic refrigerant compressor, and automatic control system. The unit shall have a capacity of 24,000 Btu/hr with 95°F ambient air. Unit shall be Carrier Corp. model 38GS024, or approved equal.

6.0 PLUMBING

6.1 SCOPE OF WORK

The Contractor shall provide all labor, materials, equipment, and tools necessary for the installation of interior plumbing piping, plumbing fixtures, and plumbing piping extending out to 5 ft from the building where a break is made between plumbing and exterior sewage, drainage, and water piping materials.

The work shall include, but shall not be limited to the following:

6.1.1 System

Furnishing and installing a complete plumbing system consisting of soil, waste and vent lines and hot and cold water distribution.

6.1.2 Fixtures, Trim, and Accessories

Furnishing and installing plumbing fixtures, trim and accessories.

6.1.3 Sewer and Water Lines

Furnishing and installing sewer and water lines from building to 5 ft-0 in. outside of building.

6.1.4 Flashing

Furnishing and installing flashing and counterflashing for items of this system.

6.2 MATERIALS OF CONSTRUCTION

6.2.1 Waste and Vent

Above ground 1-1/2 in. and smaller shall be Schedule 40 galvanized steel pipe with coated cast iron drainage type screwed fittings. 2 in. and larger shall be service weight cast iron soil pipe and fittings (Bell and Spigot Type or No-Hub).

6.2.2 Sewer

Below grade or slab shall be Bell and Spigot service weight cast iron soil pipe with neoprene compression gaskets to ASTM C 564. Above grade shall be standard weight cast iron Bell & Spigot or No-Hub.

6.2.3 Domestic Hot and Cold Water Piping

Materials shall be Schedule 40 galvanized carbon steel pipe and fittings to ASTM A 120 with 300 lb rating.

6.2.4 Steel Pipe Unions

Galvanized 300 lb malleable iron, railroad ground joint type.

6.2.5 Valves

Valves shall be gate valves 150 lb. Screwed bronze ISRS, Crane No. 431 or Approved Equal, or ball valves 300 lb. Screwed brass with TFE seals, Pacific No. 1-B or Approved Equal.

6.2.6 Partition Stops

Repcal B98 or Approved Equal, loose key type, hose bibb, with flange.

6.2.7 Strainer

Sporlan or Approved Equal.

6.2.8 Sleeves

Sleeves shall be of 24 gauge galvanized iron or steel, for use wherever pipes pass through concrete floors and foundations.

6.3 PLUMBING FIXTURES

6.3.1 Water Closet. American Standard No. 2502.011 white vitreous china, siphon jet wall hung, Sloan Royal No. 110 flush valve, white open front seat less cover. J. R. Smith No. 100 carrier.

6.3.2 Urinal (Mark - UR). American Standard No. 6500.011 white vitreous china, wall hung, Sloan Royal NO. 186-11 flush valve with 1-1/4 in. top spud, wall and spud flanges, vacuum breaker, with adjustable floor support.

6.3.3 Lavatory (Mark - L-1). American Standard No. 0350.132 20 by 18, wall hung, white vitreous china, No. 2248.284 faucet with pop-up drain, No. 2303.063 loose key angle stop supply pipes, No. 4401.014 adjustable P-Trap. Adjustable type concealed lavatory, floor support carrier, with four point locking.

6.3.4 Shower (SH). Sloan Royal No. AC-10 Ac-to-matic with 3 gpm flow control. Stainless steel, built-in mixing valve with 1/2 in. inlet ports.

6.3.5 Floor drain (FD-1). Josam 30000A cast iron body, nickel bronze strainer.

6.3.6 Roof Drain (RD). Josam 21000 Series, large dome, bottom outlet with standard clamp ring and gravel stop, gasket, dome, and body and to include deck clamp, drain receiver, and stationary extension collar.

6.3.7 Overflow Drain (OD). Josam 21000-16 Series, large dome, bottom outlet with standard clamp ring and gravel stop, gasket, dome, and body and to include deck clamp, drain receiver, and stationary extension collar.

6.3.8 Cleanouts (types)

(1) Ordinary: Zurn A-1305

(2) Floor Type: Zurn Z-1326-1 or Z-1326-10, for setting with top flush and square with floor.

(3) Wall Type: Zurn with Z-1310 chrome plated cover plate.

6.3.9 Water Hammer Arresters (WHA). Water hammer arresters shall be Zurn Shocktrol 1700 Series, Smith 5000 Series, or Approved Equal.

6.3.10 Roof Drainage. Piping for the roof drainage system will be carbon steel, hot-dipped galvanized, ASTM A53, Gr "B", Std. Wt. threaded ends. Fittings will be 125# cast iron, ASTM A126, Grade B, hot-dipped galvanized, threaded ends.

6.4 EQUIPMENT

6.4.1 Electric Water Coolers

The cooler capacity shall be in accordance with Sunroc Model NSF-8-D or Approved Equal. The cabinet shall be constructed of 19-20 gauge welded stainless steel, with a removable front panel, a stainless steel base, and a Type 300 series stainless steel top. A chrome plated brass hand operated bubbler on a raised mount shall have a built-in pressure regulator. The Contractor shall furnish a reciprocating type hermetically sealed motor compressor with an air cooled condenser and a

tube type cooling unit for Type 12 refrigerant, an insulated power cable, and an enclosed, adjustable thermostat. Electrical specifications are 1/4 hp, 115 V, 60 Hz, single phase. The cooler shall bear the Underwriters Laboratory (UL) label.

6.4.2 Electrical Water Heaters

The heater shall bear the Underwriters Laboratory (UL) label. Each heater shall have a steel glass lined tank with a magnesium anode, 4 bolt flange, inconel sheathed, rod-type heating element with pre-wired terminal leads, and immersion type thermostat switching a magnetic contactor(s). The heater shall have a minimum 3 inch glass fiber insulation with a round steel shell. Each heater shall be provided with an ASME rated temperature and pressure relief valve.

7.0 ELECTRICAL

This section applies to all electrical equipment and components, which will be used on the Ion Implantation/Sputtering Facility. All items are commercially available and shall comply with applicable codes and standards. The power and services required are available from the existing Site utilities. Conduit only will be stubbed out 5 ft from the building for 13.8 kV normal and 480 volt standby power connections.

7.1 CONDUIT

All conduit systems shall be UL approved, rigid steel, zinc-coated or 304L seamless stainless steel, Schedule 40 pipe. The minimum conduit size shall be 3/4 in. for power, unless otherwise noted, and 1/2 in. for exposed communication, control and instrumentation. Insulated bushings shall be provided at all terminals, where hubs are not used. Flexible metallic conduit shall be liquid tight. Expansion type conduit fittings shall be used across building expansion joints.

7.2 WIREWAYS AND AUXILIARY GUTTERS

Wireways and auxiliary gutters used in dry locations shall be preformed with screw type covers.

7.3 BUILDING WIRE, 600 VOLT

Single conductors for power, lighting, and miscellaneous control shall be 600 volt, code type, 90°C, RHH-RHW, USE, FPI with chlorosulfonated, polyethylene jacket for No. 2 AWG and larger, Okonite Okolon, or equal. Type THHN-THWN shall be used for conductors smaller than No. 2 AWG. The minimum control wire size shall be No. 14 AWG, and No. 12 AWG for all other wiring. All conductors shall be stranded copper except that lighting and branch circuits with wiring No. 10 AWG and smaller may be solid. Aluminum wire is not acceptable.

7.4 HIGH RADIATION WIRE

All wiring, single or multi-conductor, within high radiation areas and through shielding walls shall be No. 12 AWG minimum, Class IE, 600 volt wire rated for 10⁷ R minimum total integrated dosage, as manufactured by American Insulated Wire Corp., Boston Insulated Wire and Cable Co., PSC, Div. M.W. Riedel, or The Rockbestos Co. Wiring inside the high radiation areas shall be multi-conductor with a special chlorosulfonated, polyethylene overall jacket suitable for decontamination with water, nitric acid, oxalic acid, and Turco No. 4502.

7.5 UNIT SUBSTATION, 13.8 KV TO 480 VOLT

The indoor unit substation shall consist of a three-position, manually operated, 600 amp, 15 kV primary fused interrupter switch, a silicone insulating fluid transformer, a secondary main and feeder draw-out air circuit breakers. The rating and the equipment quantity shall be as shown on the Single Line Diagrams. The 480 volt breakers shall have static long time (L), short time (S), and ground (G) tripping characteristics. The buses shall be copper with silver plated joints and connections. A manually operated overhead hoist shall be provided to remove the 480 volt air circuit breakers.

7.6 DISTRIBUTION TRANSFORMERS

The quiet type distribution, three-phase transformers, rated 480-208Y/120 volt, shall be general purpose dry type in an indoor enclosure and shall have 220°C insulation temperature classification and 150°C winding temperature rise for 30 kVA and larger, and 185°C insulation temperature and 115°C winding temperature rise for 25 kVA and smaller. Full capacity NEMA standard taps shall be provided on the high voltage winding.

7.7 MOTORS

Motors shall be of sufficient size for the duty to be performed. All motors shall have full nameplate horsepower available with a service factor of 1.0 at 3000 ft elevation and 1.15 at sea level. Unless otherwise specified, all motors shall be totally enclosed, and shall have a continuous duty classification based on a 40°C, ambient temperature of reference. Crane and monorail motors shall be rated for 30 minute intermittent duty. Motors shall be the premium efficiency type. The motors shall have the following factory guaranteed minimum efficiencies in accordance with IEEE 112 Test Procedures and shall have the efficiency index letter stamped on the motor nameplate:

HP	% Efficiency	HP	% Efficiency	HP	% Efficiency
1	78.5	10	88.9	50	92.0
1 1/2	81.5	15	89.8	60	92.0
2	81.5	20	90.6	75	93.3
3	84.0	25	90.6	100	93.3
5	84.0	30	91.4	125	93.3
7 1/2	88.9	40	92.0	150	94.3

The motor insulation shall be Class F minimum. Motors in high radiation areas shall have Class H insulation and shall be rated for 2×10^7 R total minimum gamma radiation dosage. The high radiation area motors shall be suitably coated in the field with Crouse-Hinds "Corro-Free S-602" Cat. No. ETU2, or equal. The motor voltage rating shall be selected as follows:

1/2 hp through 150 hp: 460 volt, 3 phase, 60 hertz

1/3 hp and smaller: 115 volt, single phase, 60 hertz

Motors 1/4 hp and 1/3 hp in a batch process shall be rated 460 volts, 3 phase, 60 hertz. Polyphase motors shall be NEMA Design B minimum, squirrel cage type, having normal starting torque and low starting current; single-phase motors shall be capacitor start type, except that motors rated 1/6 hp and less may be split phase type. Gear motors shall be Class II or III, in accordance with the gear loading requirements. Motors 5 hp and larger shall have full load power factor of 0.85 minimum. Motors 5 hp and larger with a full load power factor less than 0.85 shall be corrected to at least 0.90, utilizing a power factor corrective device located at the motor. Two-speed motors shall be the two-winding type. Motors connected to the site standby power shall be capable of starting on a voltage reduction of 20 to 30 percent. A copper grounding lug shall be provided in terminal connection box of all 460 volt, 3 phase motors.

7.8 STARTERS

Combination magnetic starters with 120 volt transformer and control shall be provided for 460 volt, 3 phase motors that are 1/2 hp through 150 hp, and manual starters shall be provided for all 115 volt, single phase motors smaller than 1/2 hp.

7.9 MOTOR CONTROL CENTERS

The motor control center (MCC1) and split bus motor control center MCC2 shall be 277/480 V, 3 phase, 4 wire, 60 hertz, free-standing, dead-front, dead-rear, copper bus only, NEMA Class II, Type B wiring consisting of vertical sections containing phase busing, terminals, copper ground bus, wireways, and housing modular plug-in type equipment drawers behind interlocked hinged doors Westinghouse Type Five Star, or equal. The enclosures shall be NEMA 1. All operating handles and controls shall be externally operable. An individual, 480-120 volt control transformer with secondary fuse shall be provided for each motor starter. Each starter shall have a HAND-OFF-AUTO selector switch in the cover. The motor control center shall be braced for a minimum of 22,000 ampere symmetrical short circuit. The automatic transfer switch, with solid state control and located in the standby section of the motor control center MCC2, shall be rated 260 amp, 480 volt, 3 phase, 3 pole, 60 Hz, and suitable to withstand a 22,000 amp short-circuit fault. Upon power failure, the transfer switch shall automatically start the Site diesel generator system. The return to normal power shall be manual. In the event the standby power fails and normal power is available, the transfer switch shall have an override to transfer automatically to normal power. Two each tandem pilot lights shall be provided to indicate the contact position. The transfer switch shall be ASCO Model 940326099 with accessories 6C, 9A, 9B and 28, or equal.

7.10 PANELBOARDS

The panelboards shall be dead front, copper bus, 4 wire, circuit breaker type. Circuit breakers shall be E Frame minimum and rated for ac or dc operation. The circuit breakers shall have a minimum interrupting rating of 10,000 rms symmetrical amperes for 208 volt panelboards and 14,000 rms symmetrical amperes for 277/480 volt lighting panelboards. A ground bus with screw terminals shall be provided. Neutral buses shall be isolated. Enclosures shall be NEMA 1, surface mounted. Panelboards of sizes and ratings, as shown on the drawings, shall be provided to serve the ventilating, lighting, and miscellaneous power loads. Ground fault interrupter (GFI) breakers rated 120 Vac only shall be provided, as required by National Electrical Code.

7.11 RECEPTACLES

Convenience outlets shall conform with NEMA Standard configuration 5-15R and shall be 3 wire, duplex, grounding type, 120 Vac, 15 amp, Hubbell Cat. 5262, or equal.

Receptacles for 480 volt, 3 phase service shall be 60 amp, 4 pole, 3 wire type, with spring door and combined with a non-fused, heavy-duty, horsepower rated disconnect switch, Crouse-Hinds WSRD 63542 or equal. The mating male plugs shall be Crouse-Hinds APJ 6485, or equal, for 60 amp service.

7.12 HIGH RADIATION AREA CONNECTORS

The remote electromechanical manipulator operated, 304 stainless steel, connectors shall be rated for 10⁷ R total integrated dosage minimum and 600 volts. The connector shall be suitably sealed for decontamination with nitric acid, oxalic acid and Turco No. 4502. The receptacle and plug assembly shall be Gulton Lormec Series 9588 and 9405 respectively, or equal.

7.13 SAFETY SWITCHES

Safety switches shall be the heavy-duty type, horsepower rated, 600 volt, 3 pole, with current rating and fusing, as shown on the drawings. The enclosure shall be NEMA 1.

7.14 TOGGLE SWITCHES

Toggle switches installed for the control of incandescent, high pressure sodium, and fluorescent lighting luminaires shall be heavy-duty, general purpose, UL approved devices. Toggle switches shall be specification grade, single-pole, Hubbell Cat No. 1221 or 1221-I, or equal.

7.15 LIMIT SWITCHES

The non-plug-in limit switches shall be heavy-duty type, 600 volts, 10 amp continuous rating contacts, single pole, double throw (SPDT) or electrically independent double pole, double throw (DPDT). The limit switches shall be Micro Switch Type HDLS Series, or equal.

7.16 BOXES AND FITTINGS

Outlet boxes shall be rust-resistant, cast-iron alloy boxes with threaded hubs or bosses for conduit connection. Pullboxes and their covers shall be constructed of galvanized steel.

7.17 RELAYS

Control relays shall be magnetically operated relays with 120 Vac coils, and contacts rated for 10 amp inductive at 120 volt continuous duty. Timing relays shall be magnetic relays with an adjustable pneumatic timing mechanism and a minimum 5 amp continuous contact rating.

7.18 GENERAL LIGHTING

Commercial type recessed fluorescent luminaires with acrylic lenses and high power factor and energy saving ETL, Class P ballasts and 4 ft, cool white, rapid start fluorescent lamps with wattage not to exceed 35 watts shall be used in offices, control room, toilet and similar areas. Ballasts shall not contain PCB capacitors. Industrial type fluorescent luminaires with upward component and porcelain enamel reflectors shall be utilized in other low bay areas. Lighting in the high bay areas shall utilize high pressure sodium (HPS) luminaires. Exterior HPS wall mounted luminaires shall be provided. Special cell HPS luminaires, suitable for remote removal, shall be provided, as required.

The emergency lighting shall be provided by fully automatic 120/277 V supply, lead calcium rechargeable batteries, Holophane Cat. No. M-12-2A-X, or equal.

7.19 LIGHTNING PROTECTION

Lightning protection, complete with UL Master "C" label, shall be provided.

7.20 GROUNDING

A No. 4/0 AWG soft drawn bare copper ground loop with 3/4 in. by 10 ft. copper-clad steel ground rods, shall be provided and connected to the Site duct bank ground system. One insulated instrumentation ground bus plate and cable shall be furnished in the control room. The cable shall be connected to the facility ground system at only one point. The maximum facility ground resistance shall be five ohms. The lowest level of building reinforcing bar shall be grounded. The shielding window liners shall be grounded.

7.21 CATHODIC PROTECTION

Cathodic protection shall be provided for all direct buried metallic lines and underground tanks.

7.22 TERMINAL BOXES

Control terminal box enclosures shall be NEMA 1 sheet steel construction with hinged door, lock and steel equipment mounting panel(s). Barriers shall be steel, full depth and height, finished the same as the enclosures. The interior of the enclosure shall be finished with white enamel. The exterior shall be painted with color, as directed.

7.23 TERMINAL BLOCKS

All power and control wiring shall be terminated on accessible terminal blocks. The 600 volt, melamine, rail mounted, terminal blocks shall be Weidmuller Type SAK, or equal. A snap-in preprinted unique wire number marker shall be provided. Hand lettered terminal identification is not acceptable. Terminal connectors shall be the vibration proof, pressure clamp type.

7.24 TELEPHONE SYSTEM

Telephone cabinets shall be provided, as required. Conduit only shall be installed in the building, as required. The telephone system wiring will be by Others.

7.25 CELL SPEAKER SYSTEM

A cell speaker system shall be provided for monitoring audio sounds inside the cell. The system shall consist of a microphone with box mounted on a remotely removable Gulton plug in the cell and connected to a speaker in the control room.

7.26 FIRE ALARM DETECTION SYSTEM

The fire detection system shall include control panels, annunciators, initiating devices, signal conduits, and wire necessary for a complete and operational system. The final connection to the Site fire alarm system will be by Others. The system shall be Pyr-A-Larm System 3, or equal. The system shall consist of a multiplexer and enclosed terminal board, thermal detectors, manual stations, public address speakers, control panel audible devices, remote annunciator and control panels. The detection devices shall be capable of being interchanged without any changes required to the wiring, control panel or to the mounting base. The supervision shall not require additional wires other than the pair used for detection or alarm. The system shall be capable of being expanded at any time up to the maximum capacity of the system. The system shall be capable of having ionization, thermal, and photoelectric detecting devices, control relays, and manual stations connected across the same pair of wires. The system shall be electrically supervised against both short and open wire faults in the detection circuit, the manual station alarm circuit, and an open in the system alarm and trouble relay coils. An open wiring fault occurring in these circuits shall cause an audible and visual trouble indication at the control panel. A fire alarm signal shall override trouble signals. In the event of a trouble signal resulting from trouble on an initiating zone, a fire signal from another zone shall appear on the panel and remain until the panel is reset, at which time the trouble signal will

reappear. Alarm initiating zones shall be as shown on the drawings. A separate switch monitor shall be provided to control waterflow alarms separately from other alarm signals.

7.26.1 Alarm System

The system shall function as follows when any sprinkler flow switch operates, or thermal detector in the HVAC fire protection system operates:

- A. The main and remote annunciator panel alarm devices shall annunciate audible and visual indicators of a fire alarm.
- B. The visible indicator shall indicate the zone location and the device initiating the fire alarm. The audible indicator shall produce the same sound for all fire alarms.
- C. An alarm indicating lamp shall light in the base of the HVAC detector initiating the alarm.
- D. Panel locks into alarm until manually reset.
- E. Exhaust duct detector circuits shall be provided to energize the HVAC fire protection chamber fire water system for HEPA filters.
- F. Supply duct detector circuits shall be provided to shut down the supply fan(s).
- G. The alarm shall be manually transmitted as a voice alarm throughout the building over the fire alarm PA speakers.

7.26.2 Fire Supervisory Signals.

The supervisory alarm initiating devices shall include post indicator valve (PIV) switches, OS and Y valve switches, dry pipe system low air pressure switches, trouble signals from each of the Halon and CO₂ systems, and the Pyr-A-Larm Panel system trouble indicators. The supervisory alarm system shall function when any of these devices operate, as follows:

- A. The main control panel shall annunciate audible and visual indicators of a supervisory alarm. The audible indicator shall provide a different sound than the fire alarm audible indicator.
- B. The main panel locks the visual alarm indicator on, until manually reset. The audible indicator can be silenced by operating the alarm normal switch.

- C. The main panel relays the supervisory alarm signal via a separate transmitter to the Site fire supervisory alarm system.

7.27 EVACUATION ALARM SYSTEM

The evacuation system shall be completely independent of any other system. Speaker wiring may be installed in same conduit as fire alarm. No voice communication is required. The evacuation alarm system shall include an evacuation alarm panel, supervised public address speakers, initiating devices, a tone generator, signal conduits, and wire necessary for a complete and operational system. The system shall be Pyr-A-Larm System 3, or equal. No voice communication is required.

The system shall be electrically supervised against both short and open wire faults in the initiating circuit, the audible alarm circuit, and an open wire fault in the system alarm and trouble relay coils. An open wiring fault occurring in these circuits shall cause an audible and visual trouble indication at the control panel. A short in the initiating circuit and the audible alarm circuit shall cause an audible and visual trouble indicator at the control panel. The evacuation alarm signal shall override the trouble signals. In the event of a trouble signal resulting from trouble on an initiating zone, an evacuation signal from another zone shall appear on the panel and remain until the circuit is reset, at which time the trouble signal will reappear. If a second evacuation alarm signal is initiated after a prior signal has been silenced, the selected evacuation signal shall sound even if the control circuit has not been reset. The evacuation alarm system shall shut off automatically after 5 minutes.

The System 3 evacuation shall also provide the following functions:

- A. Receive "ALERT" and "EVACUATION" signals from the Site evacuation system.
- B. Provide local building status on "EVACUATION" mode only to the Site evacuation system.
- C. Provide alarm signal over two No. 14 AWG wires to the Health Physic office.
- D. Provide for remote monitoring of the building trouble status.

7.27.1 Local Alarm

This system shall provide an "ALERT" signal, with the panel mounted front cover switch in the "DOWN" position, consisting of continuous, non-varying audible siren tone or an "EVACUATION" signal, with the switch in the "UP" position, consisting of continuous cyclic audible siren tone the cycle to be "ON" for 5 seconds and "off" for 5 seconds. Each signal shall be initiated by operating any remote and one control room manual alarm switch. Any switch shall initiate the signal, but if more than one is operated at the same time, the switch turned to "EVACUATE" will take precedence over all other switches. Initiation of an "ALERT" or "EVACUATION" signal from any control point within the building shall

be shown by an indicating light on the evacuation alarm panel. In addition, an audible panel alarm buzzer shall be actuated. The audible alarm can be silenced by operating the "ALARM-NORMAL" switch to the opposite position but the light shall remain on until all switches or contacts are returned to normal position.

7.27.2 Site Wide Alarm.

A separately maintained toggle switch with "Lock-out" pin in the "DOWN" position, located in the control room, shall provide the Site wide alarm system an "ALERT" signal with the switch in the "DOWN" position or an "EVACUATION" signal with the switch in the "UP" position over two No. 14 AWG wires to connection in the Security Building.

8.0 PIPING MATERIALS

8.1 SCOPE OF WORK

The Contractor shall provide labor, materials, equipment, and tools necessary to fabricate, test, inspect, document, deliver to the site, field fabricate and/or install, and field inspect and test all piping materials in the quantities defined and as located by the drawings, and in accordance with this specification.

8.2 OUTLINE SPECIFICATIONS

The Piping Service Classes to be used are

<u>Class</u>	<u>Service</u>
D	Process Equipment Waste
N	High Pressure Steam, Low Pressure Steam, Condensate, High Pressure Air, Vacuum
P	Low Pressure Air
Q	Cooling Water Supply And Return
U	High Pressure Gas
V	Pressurized Feed Gas

C-2

[illegible]

SERVICE: Process Equipment Waste				CLASS PAGE 1 OF 5	
RATING: 150# FACING: Raised Face MATERIAL: 304L Stainless Steel				CORROSION ALLOWANCE — PRESSURE LIMIT — Per B16.5 TEMPERATURE LIMIT — 100°F	
CODE NUMBER	EN-CODER	SIZE FROM TO	DESCRIPTION	NOTES	REV
		2" and smaller	-----PIPE----- Stainless Steel, ASTM A312, Grade TP304L, Schedule 80S Threaded Ends		
		3" and larger	Stainless Steel, ASTM A312, Grade TP304L, Schedule 40S, Buttweld Ends		
		2" and smaller	-----FITTINGS----- 3000# 304L Stainless Steel, Threaded Ends, ASTM A182, Grade F304L, Schedule 80S		
		3" and larger	-----FITTINGS----- Seamless Stainless Steel, ASTM A403, Grade WP304L or ASTM A182 Grade F304L Buttweld Ends, Schedule 40S Bore		
		2" and smaller	-----THREADOLET----- 3000# 304L Stainless Steel, Threaded, ASTM A182, Grade		
		3" and larger	-----WELDOLETS----- Forged 304L Stainless Steel, ASTM A182, Grade F304L, Schedule 40 Bore		
		2" and smaller	-----SWAGE NIPPLES----- 304L Stainless Steel, ASTM A403, Grade WP304L Schedule 80 Bore, Threaded Ends		
		2" and smaller	-----UNIONS----- 3000# 304L, Stainless Steel, ASTM A182, Grade F304L, Schedule 80 Bore, Ground Joint Type, Integral Seats, Threaded Ends		
		2" and smaller	-----PLUGS----- 304L Stainless Steel, ASTM A182, Grade F304L, Round Head Type Threaded End		
		2" and smaller	-----CAPS----- 3000# 304L Stainless Steel, ASTM A182, Grade F304L, Threaded End		
		2" and smaller	-----FLANGES----- 150# ANSI, Raised Face, Threaded Type, 304L Stainless Steel, ASTM A182, Grade F304L Schedule 80S Bore		
THE RALPH M. PARSONS COMPANY			JOB NUMBER 6154-3	DOCUMENT NO. C-2	REV.

SERVICE				CLASS		D													
				PAGE 2		OF 5													
CODE NUMBER	ENCODER	SIZE FROM TO	DESCRIPTION	NOTES	REV														
		3" and larger	<p>-----FLANGES CONT'D-----</p> <p>150# ANSI, Raised Face, Weld Neck Type 304L Stainless Steel ASTM A182 Grade F304L Schedule 40S Bore</p>																
		1" and larger	<p>-----ORIFICE FLANGES-----</p> <p>300# ANSI Raised Face Weld Neck Type, Forged Stainless Steel, ASTM A182 Grade F304L Schedule 40S Bore, with 1/2" Scrd Taps</p>																
		Header 2" and smaller 3" and larger	<p>-----BRANCH CONNECTIONS-----</p> <table border="0"> <tr> <td>Branch</td> <td>Use</td> </tr> <tr> <td>Full or Reducing</td> <td>Full or Reducing Tee</td> </tr> <tr> <td>Full Size</td> <td>Full Size Tee or Weldolet</td> </tr> <tr> <td>2" and smaller</td> <td>Threadolet</td> </tr> </table> <p>-----PIPING INSTRUMENT CONNECTIONS-----</p> <table border="0"> <tr> <td>Temperature Conn's</td> <td>1-1/2" Flgd.</td> </tr> <tr> <td>Pressure Conn's</td> <td>1/2" Threaded</td> </tr> <tr> <td>Orifice Tap Conn's</td> <td>1/2" Threaded</td> </tr> </table> <p>-----GASKETS-----</p> <p>Spiral-Wound Metallic Type, T304L Stainless Steel Spiral Windings with Grafold Filler 1/8" Thick 304 Stainless Steel Centering Ring</p> <p>-----BOLTING-----</p> <p>Stud Bolt, 304 Stainless Steel, ASTM A193 Grade B7 with 2 Heavy Hex Nuts, ASTM A194 Grade 2H</p> <p>-----PIPE BENDS-----</p> <p>Bends (Minimum) 5 Times the Normal Diameter may be used in place of Threaded Fittings</p> <p>-----Y-STRAINERS-----</p> <p>316 Stainless Steel Body, ASTM A351, Grade CF8M, Threaded Ends, 316 or 304 Stainless Steel Screen with .045 Diameter Perforations, Threaded Blowoff Connection Acceptable Model Armstrong Fig. No. E7CS-1/2 thru 1 1/4 Armstrong Fig. No. E7SC 1 1/2" thru 2"</p>	Branch	Use	Full or Reducing	Full or Reducing Tee	Full Size	Full Size Tee or Weldolet	2" and smaller	Threadolet	Temperature Conn's	1-1/2" Flgd.	Pressure Conn's	1/2" Threaded	Orifice Tap Conn's	1/2" Threaded		
Branch	Use																		
Full or Reducing	Full or Reducing Tee																		
Full Size	Full Size Tee or Weldolet																		
2" and smaller	Threadolet																		
Temperature Conn's	1-1/2" Flgd.																		
Pressure Conn's	1/2" Threaded																		
Orifice Tap Conn's	1/2" Threaded																		
		2" and smaller

SERVICE				CLASS D	
				PAGE 3	OF 5
CODE NUMBER	ENCODER	SIZE FROM TO	DESCRIPTION	NOTES	REV
		3" and larger	<p>-----Y-STRAINERS-----</p> <p>316 Stainless Steel Body, ASTM A351, Grade CF8M, Flanged Ends, 316 or 304 Stainless Steel Screen with .045 Diameter Performations, Threaded Blow-Off Connection Acceptable Model Armstrong Fig. No. E7FL-3" thru 10"</p>		
		1/2" - 3/4"	<p>-----STEAM TRAPS-----</p> <p>Steam Trap, Threaded Ends, Impulse Type, 1-1/4 CR - 1/2 Moly Body, Stainless Steel Bonnet, Seat, and Disc, Integral Strainer and Blow-Off Acceptable Model Yarway Fig. No. 720</p>		
			<p>-----THREAD COMPOUND-----</p> <p>Use "Liquid O Ring" for Pipe Threads</p>		
		2" and smaller	<p>-----GATE VALVES-----</p> <p>150# ANSI Threaded Ends OS&Y, Bolted Bonnet, Body & Bonnet - 316L Stainless Steel, Casting - ASTM A351, Grade CF3M, Forging ASTM 182, Grade F316L, Trim 316 Stainless Steel, Packing - Reinforced TFE, Bonnet Gasket - Reinforced TFE, Trim 316 Stainless Steel Acceptable Model Aloyco Fig. No. 110</p>		
		3" and larger	<p>-----GATE VALVES-----</p> <p>150# ANSI, Flanged Ends, OS&Y, Bolted Bonnet, Body and Bonnet 316 Stainless Steel, Casting - ASTM A351, Grade CF8M, Forging - ASTM A182, Grade F316, Packing Reinforced TFE, Bonnet Gasket, Reinforced TFE, Trim 316 Stainless Steel Acceptable Model Aloyco Fig. No. 117</p>

THE RALPH M. PARSONS COMPANY Page 32 of 50	JOB NUMBER	DOCUMENT NO	REV.
		6154-3	C-2	

SERVICE				CLASS	D
				PAGE 4	OF 5
CODE NUMBER	ENCODER	SIZE FROM TO	DESCRIPTION	NOTES	REV
		2" and smaller	<p>-----GLOBE VALVE-----</p> <p>150# ANSI, Threaded Ends, OS&Y, Bolted Bonnet, Body and Bonnet 316L Stainless Steel, Casting ASTM A351, Grade CF3M, Forging ASTM A182, Grade F316L, Packing Reinforced TFE, Bonnet Gasket - Reinforced TFE, Trim 316 Stainless Steel</p> <p>Acceptable Model</p> <p>Aloyco Fig. No. 314</p>		
		3" and larger	<p>-----GLOBE VALVES-----</p> <p>150# ANSI - Flanged Ends, RF, OS&Y, Bolted Bonnet, Body and Bonnet 316 Stainless Steel Casting ASTM A351, Grade CF8M, Forging ASTM A182, Grade F316 Packing Reinforced TFE, Bonnet Gasket - Reinforced TFE, Trim 316 Stainless Steel</p> <p>Acceptable Model</p> <p>Aloyco Fig. No. 317</p>		
		2" and	<p>-----BALL VALVES-----</p> <p>150# ANSI, Threaded Ends, Handle Operated, Body and Ends, 316L Stainless Steel, Castings ASTM A351, Grade CF3M, Forgings ASTM A182, Grade F316, Seats and Seals Reinforced TFE, Trim 316 Stainless Steel</p> <p>Acceptable Model</p> <p>Worcester Controls</p> <p>Fig. No. W5966TSES7</p>		
		3" and 4"	<p>-----BALL VALVES-----</p> <p>150# ANSI Flanged Ends, Handle Operated, Body and Ends, 316 Stainless Steel, Castings - ASTM A351, Grade CF8M, Forgings ASTM A182, Grade F316, Seats and Seals - Reinforced TFE, Trim 316 Stainless Steel</p> <p>Acceptable Model</p> <p>Hills-McCanna Fig. No. S15156RS6</p>		
		2" and smaller	<p>-----CHECK VALVES-----</p> <p>150# ANSI, Threaded Ends, Swing Type, Bolted Bonnet, Body and Bonnet 316L Stainless Steel Castings ASTM A351, Grade CF3M, Forgings ASTM A182, Grade F316L, Bonnet Gasket Reinforced TFE, Trim 316 Stainless Steel</p> <p>Acceptable Model</p> <p>Powell Fig. No. 2341</p>

THE RALPH M. PARSONS COMPANY	Page 33 of 50	JOB NUMBER	DOCUMENT NO	REV
		6154-3	C-2	

SERVICE				CLASS	
				D	
				PAGE 5 OF 5	
CODE NUMBER	ENCODER	SIZE FROM TO	DESCRIPTION	NOTES	REV
		3" and larger	<p>-----CHECK VALVES-----</p> <p>150# ANSI - Flanged Ends - RF Swing Type, Bolted Bonnet, Body and Bonnet 316 Stain- less Steel, Castings ASTM A351, Grade CF8M, Forgings ASTM A182, Grade F316, Bonnet Gasket - Reinforced TFE, Trim 316 Stainless Steel Acceptable Model Aloyco Fig. No. 377</p>

SERVICE: High Pressure Steam, Low Pressure Steam, Condensate, High Pressure Air, Vacuum				CLASS PAGE 1 OF 4	
RATING: 150# FACING: Raised Face MATERIAL: Carbon Steel				CORROSION ALLOWANCE — Per B16.5 PRESSURE LIMIT — 365 OF TEMPERATURE LIMIT —	
CODE NUMBER	EN- CODER	SIZE FROM TO	DESCRIPTION	NO. ES	REV
		2" and smaller	-----PIPE----- Carbon Steel, ASTM A53 Grade B, Extra Strong Threaded Ends		
		3" and larger	Carbon Steel, ASTM A53 Grade B, Standard Weight Beveled Ends		
		2" and smaller	-----FITTINGS----- 3000# Carbon Steel, Threaded Ends ASTM A105		
		3" and larger	-----FITTINGS----- Seamless or Welded Carbon Steel, Butt weld Ends, Standard Weight, ASTM A234 Grade WPB		
		2" and smaller	-----THREADOLETS----- 3000# Forged Carbon Steel, ASTM A105, Schedule 80 Bore, Conforming to Bonney Forge		
		3" and larger	-----WELDOLETS----- Forged Carbon Steel, Standard Weight, ASTM A105, Schedule 40 Bore, Conforming to Bonney Forge		
		2" and smaller	-----SWAGE NIPPLES----- Carbon Steel, Threaded Ends, ASTM A234, Grade WPB, Extra Strong		
		2" and smaller	-----UNIONS----- 3000# Forged Carbon Steel, ASTM A105, Schedule 80 Bore, Ground Joint Type with Integral Seats, Threaded Ends		
		2" and smaller	-----PLUGS----- Forged Carbon Steel, Round Head Type, Threaded End		
		2" and smaller	-----CAPS----- 3000# Forged Carbon Steel, ASTM A105, Schedule 80 Bore, Threaded		
		2" and smaller	-----FLANGES----- 150# ANSI, Raised Face Ends, Carbon Steel, ASTM A105, Threaded XS Bore		
THE RALPH M. PARSONS COMPANY			JOB NUMBER 6154-3	DOCUMENT NO C-2	REV.

SERVICE			CLASS	N									
			PAGE 2	OF 4									
CODE NUMBER	ENCODER	SIZE FROM TO	DESCRIPTION	NOTES	REV								
		3" and larger	150# ANSI, Raised Face Slip-On Type, Carbon Steel, ASTM A105										
		1" and larger	150# ANSI, Raised Face Blind Flange, Carbon Steel ASTM A105										
		1" and larger	-----ORIFICE FLANGES----- 300# ANSI, Raised Face Weld-Neck Type, Forged Carbon Steel, ASTM A105 Bore to Match Pipe, with 1/2" Scr'd Taps										
		Header 2" and smaller 3" and larger	-----BRANCH CONNECTIONS----- <table><tr><td>Branch</td><td>Use</td></tr><tr><td>Full or Reduced Size</td><td>Full or Reducing Tee</td></tr><tr><td>Full Size</td><td>Full Size Tee</td></tr><tr><td>2" and smaller</td><td>Threadolet</td></tr></table>	Branch	Use	Full or Reduced Size	Full or Reducing Tee	Full Size	Full Size Tee	2" and smaller	Threadolet		
Branch	Use												
Full or Reduced Size	Full or Reducing Tee												
Full Size	Full Size Tee												
2" and smaller	Threadolet												
			-----PIPING INSTRUMENT CONNECTIONS----- Primary Instrument Conn's to Piping Temperature Conn's 1-1/2" Fl'dg Pressure Conn's 1/2" Threaded Orifice Tap Conn's 1/2" Threaded										
			-----GASKETS----- Grafoil Flange Gasket, Flat Ring, 1/16" thick, John Crane or Approved Equal										
			-----BOLTING----- Alloy Stud Bolt, ASTM A193 Grade B7 with 2 Heavy Hex Nuts, ASTM A194 Grade 2H										
		2" and smaller	-----Y-STRAINER----- 600#, Carbon Steel Body, ASTM A216, Grade WCB, Threaded Ends, 304 Stainless Steel Screen with 0.45 Diameter Perforations Acceptable Model Armstrong Fig. No. B15C										
		3" and larger	-----Y-STRAINER----- 150# ANSI, Raised Face Flanged Ends, Carbon Steel Body, ASTM A216 Grade WCB, 304 Stainless Steel Screen with 0.045" Diameter Perforations Acceptable Model: Armstrong Fig. No. B1FL

THE RALPH M. PARSONS COMPANY

Page 36 of 50

JOB NUMBER

6154-3

DOCUMENT NO

C-2

REV

SERVICE				CLASS	N	
				PAGE 3	OF 4	
CODE NUMBER	ENCODER	SIZE FROM TO	DESCRIPTION	NOTES	REV	
		1/2" - 3/4"	<p>-----STEAM TRAPS-----</p> <p>Steam Trap, Screwed Ends, Impulse Type, 1-1/4 Cr-1/2 Moly Body, Stainless Steel Bonnet, Seat and Disc, Integral Strainer and Blow-off Acceptable Model: Yarway Fig. No. 720</p> <p>-----THREAD COMPOUND-----</p> <p>Use "Liquid O Ring" for Pipe Threads</p>			
		2" and smaller	<p>-----GATE VALVES-----</p> <p>800# Threaded Ends, OS&Y Seal Welded Bonnet, Body and Bonnet, Carbon Steel, Forgings - ASTM A105, Trim F6 Acceptable Model Vogt Fig. No. 2801 thru 2808</p>			
		3" and larger	<p>-----GATE VALVES-----</p> <p>150# ANSI Flanged Ends, Raised Face OS&Y Bolted Bonnet, Body and Bonnet Carbon Steel, Castings - ASTM A216, Grade WCB, Forgings ASTM A105, Trim No. 4 Acceptable Model Pacific Fig. No. 150-4</p>			
		2" and smaller	<p>-----GLOBE VALVES-----</p> <p>800# Threaded Ends, OS&Y Seal Welded Bonnet, Body and Bonnet, Carbon Steel, Forgings - ASTM A105, Trim F6 Acceptable Model Vogt Fig. No. 2821 thru 2828</p>			
		3" and larger	<p>-----GLOBE VALVES-----</p> <p>150# ANSI Flanged Ends, Raised Face OS&Y Bolted Bonnet, Body and Bonnet Carbon Steel, Castings - ASTM A216, Grade WCB, Forgings ASTM A105, Trim No. 4 Acceptable Model Pacific Fig. No. 160-4</p>			
		2" and smaller	<p>-----CHECK VALVES-----</p> <p>800# Threaded Ends, Bolted Bonnet Horizontal Piston Type, Body and Bonnet, Carbon Steel, Forgings - ASTM A105, Trim F6 Acceptable Model Vogt Fig. No. 701 thru 708</p>
THE RALPH M. PARSONS COMPANY				page 37 of 50	JOB NUMBER 6154-3	DOCUMENT NO C-2
ENG-PM-1B				REV.		

SERVICE				CLASS	
				PAGE 4	N OF 4
CODE NUMBER	ENCODER	SIZE FROM TO	DESCRIPTION	NOTES	REV
		3" and larger	<p>-----CHECK VALVES CONT'D-----</p> <p>150# ANSI Flanged Ends, Raised Face Bolted Bonnet, Swing Type, Body and Bonnet Carbon Steel, Castings - ASTM A216, Grade WCB, Forgings ASTM A105, Trim No. 4 Acceptable Model Pacific Fig. No. 180-4</p>		
		2" and smaller	<p>-----BALL VALVES-----</p> <p>150# ANSI, Threaded Ends, Handle Operated, Body and Ends, Carbon Steel, Castings, ASTM A216, Grade WCB, SEats and Seals, Reinforced TFE, Trim 316 Stainless Steel Acceptable Model Worcester Controls Fig. No. W5944RSE</p>		
		2" and smaller	<p>-----PLUG VALVES-----</p> <p>300# Threaded Ends Carbon Steel Body, Cover, Plug, and Cover Bolts, Castings ASTM A216, Grade WCB, Teflon or Approved Equal Sleeve and Diaphragm, Wrench Operated, Extra Strong Bore Acceptable Model Tufline Fig. No. 0366SE Nom. Lubricated</p>

THE RALPH M. PARSONS COMPANY		Page 38 of 50	JOB NUMBER 6154-3	DOCUMENT NO C-2	REV
---	--	---------------	----------------------	--------------------	-----

SERVICE: Low Pressure Air				CLASS PAGE 1 OF 3	
RATING: 125# FACING: Flat Face MATERIAL: Carbon Steel				CORROSION ALLOWANCE — Per B16.1 PRESSURE LIMIT — 2000F TEMPERATURE LIMIT —	

CODE NUMBER	EN-CODER	SIZE FROM TO	DESCRIPTION	NOTES	REV
			-----PIPE----- Carbon Steel, ASTM A53, Grade B, Schedule 40 Bore, Threaded Ends		
		2" and smaller			
		3" and larger	Carbon Steel, ASTM A53, Grade B, Standard Weight, Beveled Ends		
			-----FITTINGS-----		
		2" and smaller	150# Malleable Iron, ASTM A47, Threaded Ends		
		3" and larger	Seamless Carbon Steel ASTM A234, Grade WPB Standard Weight, Beveled Ends		
			-----THREADOLET-----		
		2" and smaller	3000# Carbon Steel, ASTM A105, Conforming to Bonnet Forge		
			-----SWAGE NIPPLES-----		
		2" and smaller	Carbon Steel, Thread Both Ends, ASTM A53, Grade B, Schedule 40 Bore		
			-----UNIONS-----		
		2" and smaller	150# Malleable Iron, ASTM A197, Ground Joint Type with Integral Seats, Threaded Ends		
			-----PLUGS-----		
		2" and smaller	Carbon Steel, ATM A105 Round Head Type, Threaded		
			-----CAPS-----		
		2" and smaller	3000# Forged Carbon Steel, ASTM A105, Schedule 40 Bore, Threaded		
			-----THREAD COMPOUND-----		
			Use "Liquid O Ring" for Pipe Threads		
			-----PIPE BENDS-----		
			Bend (Minimum 5 times the normal diameter) may be used in place of Threaded Fittings		
			-----FLANGES-----		
		2" and smaller	150# ANSI, Flat Face, Threaded Ends, Carbon Steel, ASTM A105 Schedule 40 Bore		

THE RALPH M. PARSONS COMPANY	JOB NUMBER 6154-3	DOCUMENT NO. C-2	REV.
-------------------------------------	-----------------------------	----------------------------	-------------

Page 39 of 50

ENG-PM-1B

SERVICE				CLASS	
				PAGE 2	P OF 3
CODE NUMBER	ENCODER	SIZE FROM TO	DESCRIPTION	NOTES	REV
		3" and larger	150# ANSI, Flat Face, Slip-On Type, Carbon Steel, ASTM A105, Schedule 40 Bore		
		1/2" and larger	150# ANSI, Flat Face Blind Flange Carbon Steel ASTM A105		
		1" and larger	-----ORIFICE FLANGES----- 300# ANSI, Raised Face, Weld-Neck Type, Carbon Steel, ASTM A105, Schedule 40 Bore with 1/2 Scrd Taps		
		2" and smaller	-----BRANCH CONNECTIONS----- Branch Full or Reduced Size		
		3" and larger	Use Full or Reducing Tee Full size Full size tee 2" and smaller Threadolet		
			-----PIPING INSTRUMENT CONNECTIONS----- Primary Instr. Conn's to Piping Temperature Conn's 1" Scrd Pressure Conn's 1/2" Scrd		
			-----GASKETS----- Grafoil Flange Gasket, Flat Ring, 1/16" thick, John Crane or Approved Equal		
			-----BOLTING----- Hex Head Machine Bolt with Hex Nut, ASTM A307 Grade B		
		2" and smaller	-----Y-STRAINER----- 300" - Bronze Body ASTM B-62 Threaded Ends, 304 or 55 Screen with 0.045 Perforations Acceptable Model Armstrong Fig. No. F7SC-300		
		3" and larger	150# ANSI, Flanged, Raised Face, Carbon Steel Body, ASTM A216, Grade WCB, 304 S.S. Screen with 0.045 Diameter Perforations Acceptable Model Armstrong Fig. No. BIFL		
			-----THREAD COMPOUND----- Thread Compound use "Liquid O Ring" for Pipe Threads

SERVICE				CLASS		P OF 3	
CODE NUMBER		ENCODER	SIZE FROM TO	DESCRIPTION		NOTES	REV
			2" and smaller	-----GATE VALVES----- 150# Threaded Ends, Rising Stem, Integral Seat, Body and Bonnet - Bronze ASTM B62, Trim Manufacturer's Standard Acceptable Model Crane Fig. No. 431			
			3" and larger	-----GATE VALVES----- 125# ANSI Flanged Ends, Flat Face, OS&Y, Bolted Bonnet Body and Bonnet Cast Iron, ASTM A126, Class B, Trim Bronze Acceptable Model Crane Fig. No. 465 1/2			
			2" and smaller	-----GLOBE VALVES----- 200# Threaded Ends, Rising Stem, Union Bonnet, Integral Seat, Body and Bonnet - Bronze ASTM B61 - Trim Bronze Acceptable Model Crane Fig. No. 70			
			3" and larger	-----GLOBE VALVES----- 125# ANSI Flanged Ends, Flat Face, OS&Y, Bolted Bonnet Body and Bonnet Cast Iron, ASTM A126, Class B, Trim Bronze Acceptable Model Crane Fig. No. 351			
			2" and smaller	-----CHECK VALVES----- 200# Threaded Ends, Swing Type, Screwed Bonnet, Body and Bonnet Bronze ASTM B61, Trim Bronze Acceptable Model Crane Fig. No. 36			
			3" and larger	-----CHECK VALVES----- 125# ANSI, Flanged, Flat Face, Swing Type, Bolted Bonnet, Body and Bonnet Cast Iron - ASTM A126, Class B, Trim Bronze Acceptable Model Crane Fig. No. 373			
			2" and smaller	-----BALL VALVES----- 300# - Threaded Ends, Handle Operated Body Bronze ASTM B61, Ball Stem and Ex- ternal Parts - Bronze, Seat and Body Seal TFE Acceptable Model Jamesbury Fig. No. A11TT
THE RALPH M. PARSONS COMPANY				JOB NUMBER 6154-3	DOCUMENT NO C-2	REV.	

SERVICE: Cooling Water Supply and Return				CLASS PAGE 1 of 3	
RATING: 125# FACING: Flat Face MATERIAL: Carbon Steel				CORROSION ALLOWANCE — PRESSURE LIMIT — TEMPERATURE LIMIT — Per B16.1 200°F	
CODE NUMBER	EN- CODER	SIZE FROM TO	DESCRIPTION	NOTES	REV.
		2" and smaller	-----PIPE----- Carbon Steel, Galvanized, ASTM A120, Extra Strong, Threaded and Coupled Ends		
		3" and larger	Carbon Steel, ASTM A53, Grade B, Standard Weight, Beveled Ends		
		2" and smaller	-----FITTINGS----- 300# Galvanized Malleable Iron, Threaded Ends, ASTM A197		
		3" and larger	Black, Seamless or Welded Carbon Steel, Butt Weld Ends, Standard Weight, ASTM A284, Grade WPB		
		2" and smaller	-----SWAGE NIPPLES----- 300# Galvanized Malleable Iron ASTM A197, Threaded Ends		
		2" and smaller	-----UNIONS----- 300# Galvanized Malleable Iron ASTM A197, Ground Joint Type with Bronze to Iron Seat, Threaded Ends		
		2" and smaller	-----PLUGS----- 300# Galvanized Malleable Iron ASTM A197, Solid Square Head Type, Threaded End		
		2" and smaller	-----FLANGES----- 150# ANSI, Flat Face Screwed Flange, Galvanized Steel, ASTM A105 150# ANSI, Flat Face Blind Flange, Galvanized Steel, ASTM A105		
		3" and larger	150# ANSI, Flat Face Slip-on Type, Carbon Steel, ASTM A105 150# ANSI, Flat Face Blind Flanges, Carbon Steel ASTM A105		
THE RALPH M. PARSONS COMPANY			JOB NUMBER 6154-3	DOCUMENT NO. C-2	REV.

SERVICE				CLASS	
				Q	
				PAGE 2 OF 3	
CODE NUMBER	ENCODER	SIZE FROM TO	DESCRIPTION	NOTES	REV
			<p>-----ORIFICE FLANGES-----</p> <p>300# ANSI, Raised Face Weld-Neck Type, Forged Carbon Steel, ASTM A105, with 1/2" Scrd Taps</p> <p>2" and smaller Extra Strong Bore 3" and larger Standard Weight Bore</p> <p>-----BRANCH CONNECTIONS-----</p> <p>Branch Use</p> <p>2" and smaller Full or Reduced Size Full or Reducing Tee 3" and larger Full Size Full size tee 2" and smaller Threadolet</p> <p>-----PIPING INSTRUMENT CONNECTIONS---</p> <p>Primary Instr. Conn's to Piping Temperature Conn's 1" Scrd Pressure Conn's 1/2" Scrd Secondary Piping Use this class</p> <p>-----GASKETS-----</p> <p>Grafoil Flange Gasket, Flat Ring, 1/16" thick, John Crane or Approved Equal.</p> <p>-----BOLTING-----</p> <p>Hex Head Machine Bolt with Hex Nut, ASTM A307 Grade B</p> <p>-----THREAD COMPOUND-----</p> <p>Use "Liquid O Ring" for Pipe Threads</p> <p>-----GATE VALVES-----</p> <p>2" and smaller 150# Threaded Ends, Rising Stem, Integral Seat, Body and Bonnet - Bronze ASTM B62, Trim Manufactures Standard Acceptable Model Crane Fig. No. 431</p> <p>-----GATE VALVES-----</p> <p>3" and larger 125# ANSI - Flanged Ends, Flat Face, OS&Y Bolted Bonnet, Body and Bonnet Cast Iron ASTM A126, Class B, Trim Bronze Acceptable Model Crane Fig. No. 465 1/2</p>		

SERVICE				CLASS	
				PAGE 3	Q OF 3
CODE NUMBER	ENCODER	SIZE FROM TO	DESCRIPTION	NOTES	REV
		2" and smaller	<p>-----GLOBE VALVE-----</p> <p>200# Threaded Ends, Rising Stem, Union Bonnet, Integral Seat, Body and Bonnet - Bronze ASTM B61 - Trim Bronze Acceptable Model Crane Fig. No. 70</p>		
		3" and larger	<p>125# ANSI - Flanged Ends, Flat Face, OS&Y Bolted Bonnet, Body and Bonnet Cast Iron ASTM A126, Class B, Trim Bronze Acceptable Model Crane Fig. No. 351</p>		
		2" and smaller	<p>-----CHECK VALVES-----</p> <p>200# Threaded Ends, Swing Type, Screwed Bonnet, Body and Bonnet Bronze, ASTM B61, Trim Bronze Acceptable Model Crane Fig. No. 36</p>		
		3" and larger	<p>-----CHECK VALVES-----</p> <p>125# ANSI, Flanged, Flat Face, Swing Type, Bolted Bonnet, Body and Bonnet Cast Iron, ASTM A126, Class B, Trim Bronze Acceptable Model Crane Fig. No. 373</p>		
		2" and smaller	<p>-----BALL VALVES-----</p> <p>300# Threaded Ends, Handle Operated, Body Bronze, ASTM B61, Ball, Stem and External Parts - Bronze, Seat and Body Seal TFE Acceptable Model Jamesbury Fig. No. A11TT</p>

SERVICE: High Pressure Gas				CLASS PAGE 1 OF 2	
RATING: 15,000# FACING: Coned and Threaded MATERIAL: 316L Stainless Steel				CORROSION ALLOWANCE — PRESSURE LIMIT — TEMPERATURE LIMIT — 300°F	
CODE NUMBER	EN- CODER	SIZE FROM TO	DESCRIPTION	NO. ES	REV
		9/16"	-----TUBING----- Stainless Steel, ASTM A312 Grade TP 316L .125 Wall		
		9/16"	-----FITTINGS----- Stainless Steel, ASTM A312 Grade TP316L		
		9/16"	-----UNION TEES----- Acceptable Part No. SNO-TRIK SS-940-3		
		9/16"	-----UNIONS----- Acceptable Part No. SNO-TRIK SS-940-6		
		9/16"	-----BULKHEAD UNIONS----- Acceptable Part No. SNO-TRIK SS-940-61		
		9/16"	-----UNION ELBOWS----- Acceptable Part No. SNO-TRIK SS-940-9		
		9/16"	-----CONED TUBE STUB ADAPTER----- Acceptable Part No. SNO-TRIK SS-94M-A-941		
		9/16"	-----CAPS----- Acceptable Part No. SNO-TRIK SS-940-C		
		9/16"	-----PLUG----- Acceptable Part No. SNO-TRIK SS-940-P		
		9/16"	-----FEMALE THREAD CONNECTOR----- Acceptable Part No. SNO-TRIK SS-940-7-94F		
		9/16"	-----CONED TUBE STUB REDUCER----- Acceptable Part No. SNO-TRIK SS-940-R-641		
THE RALPH M. PARSONS COMPANY			JOB NUMBER 6154-3	DOCUMENT NO C-2	REV.

SERVICE				CLASS	
				U	
				PAGE 2 OF 2	
CODE NUMBER	ENCODER	SIZE FROM TO	DESCRIPTION	NOTES	REV
		9/16"	<p>-----PRE-CONED TUBING-----</p> <p>Stainless Steel, ASTM A312 Grade TP316L .125 Wall Acceptable Part No. SNO-TRIK SS-912-4, "SS-912-8, & SS-912-12"</p>		
		9/16"	<p>-----VALVES-----</p> <p>FP Series (Straight Pattern) 45,000#, Threaded Body 316 Stainless Steel, Stem 400 Series Stainless Steel, Packing, TFE Acceptable Part No. SNO-TRIK SS-945-FP</p>		
		9/16"	<p>FPAR Series (Angle Pattern) Acceptable Part No. SNOP-TRIK SS-945-FPAR</p>

SERVICE: Pressurized Feed Gas				CLASS PAGE 1 OF 2	
RATING: 300# FACING: Raised Face MATERIAL: Stainless Steel				CORROSION ALLOWANCE — Per B16.5 PRESSURE LIMIT — 2000F TEMPERATURE LIMIT —	
CODE NUMBER	EN- CODER	SIZE FROM TO	DESCRIPTION	NOTES	REV.
		1/2" - 10"	-----PIPE----- Stainless Steel, ASTM A312 Grade TP316L, Schedule 40S, Beveled Ends		
		1/2" - 10"	-----FITTINGS----- Seamless Stainless Steel, ASTM A403 Grade WP316L, Buttwelding Ends Schedule 40S		
		1/2" - 10"	-----FLANGES----- 300# ANSI, Raised Face Weld-Neck Type, Forged Stainless Steel ASTM A182 Grade F316, Schedule 40S Bore		
		2" - 10"	-----ORIFICE FLANGES----- 300# ANSI, Raised Face Weld-Neck Type, Forged Stainless Steel ASTM A182 Grade F316, Schedule 40S Bore, with 1/2" Socketweld Taps		
		Header 1/2" - 10"	-----BRANCH CONNECTIONS----- <div style="display: flex; justify-content: space-between;"> Branch Use </div> Full or Reducing Full or Reducing Tees		
			-----PIPING INSTRUMENT CONNECTIONS----- Primary Instrument Connections to Piping Temperature Conn's 1-1/2" Flgd Pressure Conn's 1/2" BW Orifice Tap Connections 1/2" SW		
		1/2" - 10"	-----GASKETS----- Grafoil Flange Gasket, Flat Ring, 1/16" Thick, John Crane or Approved Equal		
			-----BOLTS----- Alloy Stud Bolts, ASTM A193 Grade B7, with 2 Heavy Hex Nuts, ASTM A194, Grade 2H		

THE RALPH M. PARSONS COMPANY

Page 47 of 50

JOB NUMBER
6154-3

DOCUMENT NO.
C-2

REV.

SERVICE				CLASS V	
				PAGE 2	OF 2
CODE NUMBER	ENCODER	SIZE FROM TO	DESCRIPTION	NOTES	REV
		1/2" - 6"	<p>-----GLOBE VALVES-----</p> <p>300# ANSI, Buttweld Ends, OS&Y, Bolted Bonnet, 316 Stainless Steel Body, 316 Stainless Steel Trim, Grafoil Packing, Sch 40S Bore</p> <p>Acceptable Model: Aloyco Fig. No. 2316A or 2316</p>		
		1/2" - 6"	<p>300# ANSI, Raised Face Flanged Ends, OS&Y Bolted Bonnet, 316 Stainless Steel Body and Trim, Grafoil Packing</p> <p>Acceptable Model Aloyco Fig. No. 2317A or 2317</p>		
		1/2" - 4" 6" only	<p>-----BALL VALVES-----</p> <p>300 ANSI, Buttweld Ends, 316 S.S. Body, Ball, Stem, and External Parts, Polyfill or Approved Equal Seat, Metal "S" Gasket or Approved Equal Body Seal, Lever Operated</p> <p>Schedule 40S Bore</p> <p>Acceptable Model: Worcester Controls Fig. No. W5966PMBWS7 (1/2" - 4") Fig. No. W4566PMBWS7 (6" only)</p>		
		1/2" - 3"	<p>-----PLUG VALVE-----</p> <p>300# ANSI, Butt-Weld Ends, 316 Stainless Steel Body, Cover, and Plug, Stainless Steel Cover Bolts, UHMW Polyethylene or Approved Equal Sleeve and Diaphragm, Wrench Operated, Sch 40S Bore</p>		
		4" - 10"	<p>Ditto, except Enclosed Gear Operated</p> <p>Acceptable Model: Tuflin Fig. No. 1366BW, Non-lubricated</p>		
		1/2" - 10"	<p>-----CHECK VALVES-----</p> <p>300# ANSI, Buttweld Ends, Swing Type, Bolted Cover, 316 Stainless Steel Body, 316 Stainless Steel Trim, Sch 40S Bore</p> <p>Acceptable Model: Aloyco Fig. No. 2376</p>

9.0 COATING AND WRAPPING

9.1 SCOPE OF WORK

The Contractor shall provide all material, labor, equipment, and tools necessary for the preparation and application of corrosion resistant coatings for exterior surfaces of carbon and stainless steel pipe, flanges, valves, and fittings in direct buried service.

9.2 MATERIALS OF CONSTRUCTION

The following materials or Approved Equal are acceptable:

<u>MATERIALS</u>	<u>MANUFACTURER</u>	<u>MFR's CODE</u>	<u>SERVICE TEMPERATURE</u>
Tape Primer	Polyken Div	No. 927	-30°F to 200°F
Primary Tape	of the	No. 980	-30°F to 200°F
Filler Tap	Kendall Co.,	No. 931	-30°F to 200°F
Joint Tape	Boston, Mass.	No. 930	-30°F to 200°F

9.3 EQUIPMENT

The pipe wrapping shall be electrically inspected with a Tinker & Rasor Model AP or APW or Approved Equal holiday detector set at a minimum dc voltage of 150 times the mil thickness of the coating to detect any wrapping flaws.

10.0 FIRE PROTECTION

10.1 SCOPE OF WORK

This Specification establishes the requirements for the design, fabrication, and installation including furnishing labor, materials, tools, and equipment, and performing operations necessary for engineering, detailing, inspection, testing, documentation, delivery to jobsite and installing Underwriters Laboratories (UL) and/or Factory Mutual (FM) approved automatic fire sprinkler systems, fire hose cabinets, and fire hose racks.

10.2 MATERIALS OF CONSTRUCTION

Sprinkler heads for offices and other finished areas shall be UL and/or FM approved, pendant type with ceiling plate, a temperature rating of 212 deg F, and a standard 1/2-inch orifice size. Sprinkler heads for all other areas shall be UL and/or FM approved brass upright type, with a standard 1/2-inch orifice size and a temperature rating of 212 deg F except near heat sources where the temperature rating shall be in accordance with NFPA Standard No. 13, Table 3-16.6.4.

Water flow detectors shall be provided and installed according to NFPA Standard No. 72A. Wiring and conduits shall be provided and installed by the Contractor.

Piping shall comply with the ANSI and ASTM standards. Pipe hangers shall be in accordance with requirements of the Underwriters' Laboratories, Inc., for use in sprinkler systems.

Pipe:	Carbon Steel, ASTM A 53, Grade B, Standard Weight
Screwed Fittings:	Cast Iron ASTM A 126 conforming to ANSI B16.4 & B16.1 or Malleable Iron, ASTM A 197 conforming to ANSI B16.3
Flanges:	Cast Iron ASTM A 126 conforming to ANSI B16.1
Couplings and Unions:	As per NFPA Standard No. 13
Valves:	(1) Class 175 WWP Iron Body, Bronze Mounted, OS&Y Gate Valves for all sizes larger than 2 inches (2) Class 175 WWP Iron Body Swing Alarm Check Valve (3) Class 175 WWP Iron Body Dry Pipe Valve

10.3 EQUIPMENT

10.3.1 Alarm Check Valves

The alarm check valves shall be Viking Model F-1 Alarm Check Valve with retarding chambers and complete trim packages, or Approved Equal. A water motor gong local alarm shall be included with each wet pipe system.

10.3.2 Fire Hose Racks, Fire Hose and Extinguisher Cabinets

Fire hose racks and fire hose cabinets shall be of the surface mounted type and shall be provided and installed at the approximate locations shown on the drawings. All fire hose racks and cabinets shall be installed in compliance with NFPA Standard No. 14 for Class II service and NFPA Standard No. 13 for combined systems. All fire hose cabinets shall be sized to house a 2-1/2 gallon water-type fire extinguisher in addition to the hose and appurtenances.

APPENDIX D
CALCULATIONS

GENERAL

- D-1 Krypton-85 Radiolytic Heat Generation
- D-2 Rubidium Oxidation
- D-3 Lag Feed Storage

ION IMPLANTATION/SPUTTERING

- D-4 Equipment Sizing
- D-5 One-Year Product Storage
- D-6 Electric Power Costs

ZEOLITE ENCAPSULATION

- D-7 Equipment Sizing
- D-8 One-Year Product Storage
- D-9 Substrate Costs
- D-10 Vessel Rupture

R&P
TITLE KRYPTON 85 ENCAPSULATION

SHEET NO. 1 OF 4

JOB NO. 65A-3

DEPARTMENT

AUTHOR

DATE _____

415/81

[illegible]

RADIOLYTIC HEAT GENERATION

$$^{85}\text{Kr} (Z=36) \beta^- \text{ decays to } ^{85}\text{Rb} (Z=37)$$

Reference: NCRP Report No. 44,

Krypton - 05 In The Atmosphere -

Accumulation, Biological Significance,

and Control Technology July 1, 1975 pg 3

mean energy $\left. \begin{array}{ll} \beta_1^- & 0.0475 \text{ MeV} \\ \gamma_1 & 0.514 \text{ MeV} \end{array} \right\} 0.0043 \text{ fraction decays}$

mean energy $\bar{E}_2$ 0.251 MeV 0.9957 fraction decays

TITLE KRYPTON 85 ENCAPSULATIONSHEET NO. 2 OF 4JOB NO. 6154-3

DEPARTMENT

AUTHOR

DATE

4/15/81

REV	CHECKER	DATE	REV	CHECKER	DATE	REV	CHECKER	DATE

$$(0.0043)(0.0475 \frac{\text{MeV}}{\text{dis}})(1.6021 \times 10^{-19} \frac{\text{J}}{\text{eV}})(10^6 \frac{\text{eV}}{\text{MeV}})$$

$$= (3.70 \times 10^{10} \frac{\text{dis/s}}{\text{Ci}})(1 \frac{\text{W s}}{\text{J}}) = 0.0012 \times 10^{-3} \frac{\text{W}}{\text{Ci 85Kr}}$$

$$(0.0043)(0.514 \frac{\text{MeV}}{\text{dis}})(1.6021 \times 10^{-19} \frac{\text{J}}{\text{eV}})(10^6 \frac{\text{eV}}{\text{MeV}})$$

$$= (3.70 \times 10^{10} \frac{\text{dis/s}}{\text{Ci}})(1 \frac{\text{W s}}{\text{J}}) = 0.0131 \times 10^{-3} \frac{\text{W}}{\text{Ci 85Kr}}$$

$$(0.9957)(0.251 \frac{\text{MeV}}{\text{dis}})(1.6021 \times 10^{-19} \frac{\text{J}}{\text{eV}})(10^6 \frac{\text{eV}}{\text{MeV}})$$

$$= (3.70 \times 10^{10} \frac{\text{dis/s}}{\text{Ci}})(1 \frac{\text{W s}}{\text{J}}) = 1.4815 \times 10^{-3} \frac{\text{W}}{\text{Ci 85Kr}}$$

$$1.496 \times 10^{-3} \frac{\text{W}}{\text{Ci 85Kr}}$$

$$(1.496 \times 10^{-3} \frac{\text{W}}{\text{Ci 85Kr}})(392 \frac{\text{Ci}}{\text{g 85Kr}}) = 0.586 \frac{\text{W}}{\text{g 85Kr}}$$

Reference: Merrill Eisenbud, Environmental Radioactivity 2nd Ed 1973 pg. 485
Effective Energy (MeV): 0.24

$$(0.24 \frac{\text{MeV}}{\text{dis}})(1.6021 \times 10^{-19} \frac{\text{J}}{\text{eV}})(10^6 \frac{\text{eV}}{\text{MeV}})$$

$$= (3.70 \times 10^{10} \frac{\text{dis/s}}{\text{Ci}})(1 \frac{\text{W s}}{\text{J}}) = 1.423 \times 10^{-3} \frac{\text{W}}{\text{Ci 85Kr}}$$

$$(1.423 \times 10^{-3} \frac{\text{W}}{\text{Ci 85Kr}})(392 \frac{\text{Ci}}{\text{g 85Kr}}) = 0.558 \frac{\text{W}}{\text{g 85Kr}}$$

TITLE KRYPTON 85 ENCAPSULATION

SHEET NO. 3 OF 4
DATE 4/15/81

JOB NO. 6154-3 DEPARTMENT _____

AUTHOR Paul F. Davis

REV	CHECKER	DATE	REV	CHECKER	DATE	REV	CHECKER	DATE

Reference: A.B. Christensen, Physical Properties and Heat Transfer Characteristics

of Materials for Krypton-85 Storage,

ICP-1128, Sept 1977, pg 3

average decay energy 0.246 MeV

$$\frac{(0.246 \frac{\text{MeV}}{\text{dis}})(1.6021 \times 10^{-19} \frac{\text{J}}{\text{eV}})(10^6 \frac{\text{eV}}{\text{MeV}})}{(3.70 \times 10^{10} \frac{\text{dis}}{\text{Ci}})(1 \frac{\text{W}}{\text{J}})} = 1.458 \times 10^{-3} \frac{\text{W}}{\text{Ci } 85\text{Kr}}$$

$$(1.458 \times 10^{-3} \frac{\text{W}}{\text{Ci } 85\text{Kr}})(392 \frac{\text{Ci}}{\text{g } 85\text{Kr}}) = 0.572 \frac{\text{W}}{\text{g } 85\text{Kr}}$$

Reference: SE Nunn & WA Reardon,
The Formation and Decay of Selected
Isotopes, BNWL-487, January 1967.
ADPG

$$\sim 0.53 \frac{\text{W}}{\text{g } 85\text{Kr}}$$

D-1

CALCULATION SHEET

RMP

THE RALPH M. PARSONS COMPANY

TITLE KRYPTON 85 ENCAPSULATION

JOB NO. 6154-3

DEPARTMENT

AUTHOR

SHEET NO.

4 OF

4

DATE 4/15/81

REV	CHECKER	DATE	REV	CHECKER	DATE	REV	CHECKER	DATE

FOR THESE CALCULATIONS

WILL USE:

$$\underline{1.458 \times 10^{-3} \frac{W}{Ci \cdot 85 Kr}}$$

$$\frac{(1.458 \times 10^{-3} \frac{W}{Ci \cdot 85 Kr}) (18.7 \frac{MCi}{y}) (10^6 \frac{Ci}{MCi})}{(232.5 \frac{m^3}{y})}$$

$$\underline{= 117.3 \frac{W}{m^3} \leftarrow}$$

($m^3 @ 0^\circ C, 1 atm$) THIS IS
 RADIOLYTIC DECAY HEAT PER
 CUBIC METER FEED GAS

TITLE KRYPTON 85 ENCAPSULATION

JOB NO. 6154-3

DEPARTMENT

AUTHOR

SHEET NO.

1 OF 1
DATE 5/5/81

REV	CHECKER	DATE	REV	CHECKER	DATE	REV	CHECKER	DATE

RUBIDIUM OXIDATION

85.47 8.00

$$(617 \frac{\text{g Rb}}{\text{g}}) \frac{8.00 \frac{\text{g O}_2}{\text{g mole}}}{85.47 \frac{\text{g Rb}}{\text{g mole}}} = 57.8 \frac{\text{g O}_2}{\text{g}}$$

for oxidation of
Rb accumulation
in 60 day lag
storage

$$\frac{(232.5 \frac{\text{m}^3}{\text{g}}) (\frac{200}{10^6}) (10^3 \frac{\text{ft}^3}{\text{m}^3}) (32.0 \frac{\text{g O}_2}{\text{g mole O}_2})}{22.4 \frac{\text{ft}^3}{\text{g mole O}_2}} = 66.4 \frac{\text{g O}_2}{\text{g}}$$

200 ppm O₂ in feed gas would
provide enough O₂ to oxidize Rb
accumulation in lag storage

TITLE KRYPTON 85 ENCAPSULATIONSHEET NO. 1 OF 5JOB NO. 6154-3DEPARTMENT ProcessAUTHOR PerrettDATE 4/29/8

REV	CHECKER	DATE	REV	CHECKER	DATE	REV	CHECKER	DATE

Calculations for Lag Feed Storage.

Basis: provide 60 days of storage (out of a 300 day/year operation or) $1/5$ th of the annual production.

Previous calculations gave a rate of 232.5 $m^3/yr.$ with a heat generation of 117.3 W/m^3 .

$$\frac{60 d}{300 d/yr} \times 232.5 \frac{m^3}{yr} \div .028317 m^3/ft^3 = 1642. ft^3 (1 atm, 0^\circ C)$$

$$\frac{60}{300} \times 232.5 \times 117.3 \frac{W}{m^3} = 5454. \text{ WATTS}$$

$$5454 W \times 3.413 \frac{BTU/HR}{W} = 18615. \text{ BTU/HR HEAT RELEASE}$$

Preliminary considerations suggested use of 12" (A.W.P.) Sch 80 O.S. pipe with allowable working pressures of 720 psig up to 650°F for use as storage vessels. We use a design pressure of 500 psig, $2/3$ of A.W.P. The wall thickness is 0.688 in. and the contained volume is 0.7056 ft^3/ft .

At 0°C and 514.7 psia the contained gas volume is:

TITLE Krypton 85 Encapsulation SHEET NO. 2 OF 5
 JOB NO. 6154-3 DEPARTMENT Process AUTHOR Perrett DATE 4/29/61

REV	CHECKER	DATE	REV	CHECKER	DATE	REV	CHECKER	DATE

$$0.7056 \times \frac{514.7}{14.7} = 24.7 \text{ ft}^3/\text{ft of gas @ } 0^\circ\text{C}$$

$$\text{for } \frac{1642 \text{ ft}^3 \text{ of gas to be contained}}{24.7 \text{ ft}^3/\text{ft of gas (0}^\circ\text{C)}} = 66.48 \text{ ft of pipe}$$

Assuming 80 feet of pipe as 8-10 ft. sections stacked 2 wide and 4 high, have a space envelope of ~30" wide x 60" high x 1.2' long.

Since 80 ft. of pipe = 1976. ft³, we can calculate what the temperature could be before exceeding 500 psig.

$$\frac{1976 \text{ ft}^3}{(1 \text{ atm, } T)} = \left(\frac{T + 460}{492} \right) \times \frac{1642 \text{ ft}^3}{(1 \text{ atm, } 0^\circ\text{C})}$$

$$T^\circ\text{F} = 492 \left(\frac{1976}{1642} \right) - 460 = 132^\circ\text{F} \quad \left(\begin{array}{l} \text{1st est.,} \\ \text{see below} \end{array} \right)$$

But have to remove 18615 BTU/hr through a natural convection surface film on

$$80 \text{ ft} \times 3.338 \text{ ft}^2/\text{ft} = 267.04 \text{ ft}^2$$

$$\therefore h_c \Delta T = \frac{\dot{Q}}{A} = 18615 / 267.04 = 69.71 \frac{\text{BTU}}{\text{ft}^2 \cdot \text{hr.}}$$

since, $h_c \approx 0.8$ need a $\Delta T \approx 87^\circ\text{F}$. $\frac{Q}{A}$ air conv. (actually calculated later, this is an est. to get 1st est. of L)

TITLE Krusten 85 Encasulation SHEET NO. 3 OF 5
 JOB NO. 6/54-3 DEPARTMENT Process AUTHOR Parret DATE 4/29/81

REV	CHECKER	DATE	REV	CHECKER	DATE	REV	CHECKER	DATE

in @ 90°F (max) and exits @ 110°F max. (20°F ΔT rise)

$$\bar{T}(\text{air}) = 100^\circ\text{F} \quad T_s = 187^\circ\text{F} \quad T_{\text{gas}} \approx 200^\circ\text{F}$$

We increase the design pressure to

$$514.7 \text{ psia} \times \frac{(200 + 460)}{(132 + 460)} = 573.8 \text{ psia}$$

$$\text{or } 573.8 - 14.7 = 560 \text{ psig}$$

For $T_s = 187^\circ\text{F}$, $\bar{T}_\infty = 100^\circ\text{F}$ $Pr < 10^9 \therefore \text{LAMINAR}$

$$Nu = 0.47 (Pr Gr)^{1/4}$$

$$Pr(\text{air}) = 0.7$$

$$Gr = \frac{g (T_s - T_\infty) L^3}{\nu^2}$$

$$\nu = \mu / \rho$$

$$Gr = \frac{g \left(\frac{T_s - T_\infty}{T_\infty} \right) L^3 \rho^2}{\mu^2}$$

$$g = 32.2 \text{ ft/sec}^2$$

$$\mu = \left(\frac{0.0183 \text{ cP}}{14.88} \right) \frac{\text{lb}}{\text{ft} \cdot \text{sec}}$$

$$Gr = \frac{(32.2) \left(\frac{87^\circ\text{R}}{560^\circ\text{R}} \right) \left(\frac{12.75}{12} \right)^3 (0.0808)^2}{(0.0183/14.88)^2}$$

$$\rho = 0.0808 \text{ lb/ft}^3$$

$$Gr = 0.259 \times 10^9$$

$$k = 0.019 \frac{\text{BTU}}{\text{ft} \cdot \text{H}^\circ\text{F}}$$

$$Nu = \frac{h D}{k} = 0.47 \left(0.7 (0.259 \times 10^9) \right)^{1/4} = 54.54$$

$$h_c = \frac{(0.019)(54.54)}{\frac{12.75}{12}} = 0.975 \text{ BTU/ft}^2 \cdot \text{H}^\circ\text{F}$$

$$\therefore \Delta T(2) = 69.71 / 0.975 = 71.48 \quad \text{vs } \Delta T(1) \approx 87$$

$$\text{assume } \Delta T(2) = 75; h_c(2) \left(\frac{75}{87} \right)^{1/4} \times 0.975 = 0.94 \quad \Delta T(2) = 74.2^\circ\text{F} \quad \checkmark$$

TITLE Krypton 85 Encapsulation SHEET NO. 4 OF 5
 JOB NO. 6154-3 DEPARTMENT Process AUTHOR Direct DATE 4/29/81

REV	CHECKER	DATE	REV	CHECKER	DATE	REV	CHECKER	DATE

Then $\bar{T}_{s_{k,u}} = 100 + 75 = 175^\circ\text{F}$ $\bar{T}_{gas} = 250^\circ\text{F}$

based on $h_c(i) \approx h_c(o)$

and design pressure is then:

$$\left[514.7 \times \left(\frac{250 + 460}{132 + 460} \right) \right] - 14.7 = 600 \text{ psig.}$$

Increasing length from 10' to 12' gives 500 psig design.

Air Flow:

For 20°F rise $\dot{W} = \frac{\dot{Q}}{C_p \Delta T}$

$C_p = 0.25 \text{ BTU/lb}$
 $\rho = .0808 \text{ lb/ft}^3$

$\dot{W} = \frac{18615}{(0.25)(20)} = 3723 \text{ lb/hr}$
 $= 62.05 \text{ lb/min}$
 or 768 cfm.

REQUIRED

considering a "frental" area

of $30'' \times 10'$ up the stack = 25 ft^2 $\vec{V} = 30.7 \text{ ft/min}$
 $= 0.5 \text{ ft/sec}$

$\therefore$ some assist to natural convection, but not much

$$\frac{DkP}{\mu} = \frac{12.75}{12.0} \times \frac{0.5 \times 0.0808}{.0183/1488} = 3490$$

$$Nu = \frac{hD}{k} = 0.023 Re^{.8} Pr^{.4} = 13.94$$

$$h = \frac{k}{D} \times 13.94 = \frac{(.019)(13.94)}{12.75/12.0} = 0.25$$

also $h(\text{natural conv.})$ & $h(\text{forced conv.})$ are not simply

TITLE Kristan 85 Encapsulation SHEET NO. 5 OF 5
 JOB NO. 6154-3 DEPARTMENT Process AUTHOR Pierret DATE 4/29/8

REV	CHECKER	DATE	REV	CHECKER	DATE	REV	CHECKER	DATE

additive, $h(\text{Total}) < h(\text{n.c.}) + h(\text{f.c.})$ and the inside
 h , $h_c(i)$ does not change, so use 250°F as T_{gas}
 and 175°F as T_{wall} .

 

TITLE ION IMPLANTATIONSHEET NO. 1 OF 3JOB NO. 6154-3 DEPARTMENT _____AUTHOR R. WILKINSON DATE 6-13-81

REV	CHECKER	DATE	REV	CHECKER	DATE	REV	CHECKER	DATE

ION IMPLANTATION / SPUTTERING EQUIPMENT SIZINGDESIGN PARAMETERS

1. USE 10-INCH PIPE, COMPATIBLE WITH SURF STORAGE
2. 3000 cm² INITIAL SUBSTRATE AREA
3. 1 CM THICK DEPOSIT
4. 79% NI, 21% LA BY WEIGHT
5. 12.7% KRYPTON IN DEPOSIT BY WEIGHT
6. SPUTTERING RATE: 7.95 g/A-HR. × 0.009 A/cm²
= 0.07155 g/cm²-HR BASED ON INITIAL TARGET SURFACE AREA.
7. DESIGN THROUGHPUT: 232.5 m³ GAS AT STP
8. DEPOSIT DENSITY: 8.0 g/cm³

A. SUBSTRATE SIZE

10-INCH STD. WT. PIPE (10.02 IN. I.D.) W/ CAP

$$\text{CAP SURFACE AREA} = 1.084 D^2 = 1.084 (10.02 \times 2.54)^2 = 702.15 \text{ cm}^2$$

STRAIGHT LENGTH

$$L = \frac{(3000 - 702.15)}{\pi \times 10.02 \times 2.54} = 28.74 \text{ cm} = 11.315", \text{ USE } 12"$$

$$\text{ACTUAL SUBSTRATE AREA} = 3139 \text{ cm}^2$$

B. DEPOSIT VOLUME

$$\text{DEPOSIT O.D.} = 10.02 \times 2.54 = 25.45 \text{ cm}$$

$$\text{DEPOSIT I.D.} = 23.45 \text{ cm}$$

$$V = \frac{\pi (25.45^2 - 23.45^2)}{4} \times 12 \times 2.54 + \frac{\pi (25.45^3 - 23.45^3)}{24} = 2811 \text{ cm}^3$$

TITLE ION IMPLANTATION SHEET NO. 2 OF 3
 JOB NO. 6154-3 DEPARTMENT _____ AUTHOR R. WILKINSON DATE 6-13-81

REV	CHECKER	DATE	REV	CHECKER	DATE	REV	CHECKER	DATE

C. DEPOSIT CONSTITUENTS

$$\begin{aligned} \text{DEPOSIT WEIGHT} &= 2811 \times 8.0 = 22488 \text{ g} \quad (10.22 \text{ LB}) \\ \text{ENTRAPPED GAS} &= 22488 \times 0.127 = 2856 \text{ g} \\ \text{NICKEL } (22488 - 2856) \times 0.79 &= 15509 \text{ g} \\ \text{LANTHANUM } (22488 - 2856) \times 0.21 &= 4123 \text{ g} \end{aligned}$$

D. TARGET VOLUME

$$\begin{aligned} \text{NICKEL DENSITY} &= 8.9 \text{ g/cm}^3 \\ \text{LANTHANUM DENSITY} &= 6.15 \text{ g/cm}^3 \end{aligned}$$

$$\text{VOLUME} = \frac{15509}{8.9} + \frac{4123}{6.15} = 2413 \text{ cm}^3$$

E. TARGET SIZE

6 INCH STD. WT. PIPE (6.625" O.D.) W/ GAP
 USE L = 11.125" TO MAINTAIN TARGET TO SUBSTRATE GAP

$$2413 = \frac{\pi (D_o^2 - 16.8275^2)}{4} 28.2575 + \frac{\pi (D_o^3 - 16.8275^3)}{24}$$

BY TRIAL AND ERROR, USE $D_o = 19.4275 \text{ cm}$, OR A
 TARGET THICKNESS OF 1.30 cm.

$$\text{ACTUAL TARGET VOLUME} = 2428 \text{ cm}^3$$

F. PROCESSING TIME : INITIAL TARGET AREA = 2134 cm²

$$T = \frac{22488 - 2856}{0.07155 \times 2134} \approx 129 \text{ HRS}$$

TITLE ION IMPLANTATION SHEET NO. 3 OF 3
 JOB NO. 6154-3 DEPARTMENT _____ AUTHOR R. WILKINSON DATE 6-13-81

REV	CHECKER	DATE	REV	CHECKER	DATE	REV	CHECKER	DATE

G. ENTRAPPED GAS

$$\frac{2856 \text{ g}}{83.8 \text{ g/mole-Kr}} \times 22.4 \text{ l/mole} = 763 \text{ l/deposit}$$

H. UNITS REQUIRED

$$\frac{232,500 \text{ l/year}}{763 \text{ l/deposit}} = 305 \text{ DEPOSITS/YEAR}$$

$$\frac{305 \times 129}{300 \times 24} = 5.57 \text{ UNITS MINIMUM, 24 HRS./DAY, 300 DAYS/YEAR}$$

USE 8 UNITS

$$\text{AVE. UTILIZATION} = \frac{5.57}{8} \approx 70\%$$

TITLE Krypton 85 Ion Implantation SHEET NO. 1 OF 2
 JOB NO. 6154-3 DEPARTMENT Process AUTHOR Perret DATE 5/1/81

REV	CHECKER	DATE	REV	CHECKER	DATE	REV	CHECKER	DATE

Calculations for 1-year Product Storage

Information used is per E. L. Tenigey, sketch and pages 56, 57, 58 undated. 3/19/81

435 of these units used to hold the annual production, which has a heat release of $5 \times 18615 = 93075 \frac{\text{BTU}}{\text{HR}}$. (See prior calcs. for lag storage.)

Heat release per unit is $93075/435 = 214 \frac{\text{BTU}}{\text{HR}}$

Because of the deposit geometry, assume only 10" of length are used for heat transfer. $A(\text{heat tr.}) = 10" \times 11\frac{1}{2}" \times \pi = 2.5 \text{ ft}^2$

$$\frac{\dot{Q}}{A} = \frac{214 \text{ BTU/HR}}{2.5 \text{ FT}^2} = 85.6 \frac{\text{BTU/HR}}{\text{FT}^2} = h_c \Delta T_f$$

Again from calcs. for lag storage, know $h_c \approx 0.98$

TITLE Krypton 85 Ion Implantation SHEET NO. 2 OF 2
 JOB NO. 6154-3 DEPARTMENT Process AUTHOR Perret DATE 5/1/81

REV	CHECKER	DATE	REV	CHECKER	DATE	REV	CHECKER	DATE

so 1st est. of $\Delta T_f (1) \approx 87^\circ\text{F}$. Raising prior results

(for same ΔT)

$$h_c \approx 0.975 \left\{ \frac{11.5''}{12.75''} \right\}^{1/4} = 0.950 \frac{\text{BTU/hr}}{\text{ft}^2 \cdot ^\circ\text{F}}$$

$$\Delta T_f (2) = \frac{85.6 \frac{\text{BTU/hr}}{\text{ft}^2}}{h_c} = 90.1^\circ\text{F}$$

$$h_c (2) = 0.975 \left\{ \frac{11.5}{12.75} \times \frac{90.1}{87} \right\}^{1/4} = .9585$$

$$\Delta T_f (3) = 89.3^\circ\text{F} \approx \Delta T_f (2) \quad \checkmark$$

Surface ΔT less than 90°F rise.

Assume the units can be stacked 15" on centers and spaced 24" face to face. A $6 \times 6 \times 13$ array will require $90'' \times 90''$ on the face $\times 26'$ deep.

Alternate arrangements can be used and the best fit to overall bldg. geometry will be determined. Same air loading is required as determined for zeolite encapsulation, 1920 scfm.

Floor space for standing these units singly on 15" centers is about $30' \times 30'$ vs. about $12' \times 26'$ for above.

TITLE KRYPTON 85 ENCAPSULATIONSHEET NO. 1 OF 4JOB NO. 6154-3

DEPARTMENT _____

AUTHOR Smith DavisDATE 5/18/81

REV	CHECKER	DATE	REV	CHECKER	DATE	REV	CHECKER	DATE

ION/IMPLANTATION ELECTRIC POWER COST

DEMAND — During each 156 hour deposit batch run:

$$\text{TARGET } (2500\text{v})(20\text{a}) = 50,000 \text{ va} = 50.0 \text{ Kw DC}$$

$$\text{ANODE } (60\text{v})(50\text{a}) = 3000 \text{ va} = 3.0 \text{ Kw DC}$$

$$\text{FILAMENT } (10\text{v})(56\text{a}) \frac{1}{\sqrt{2}} = 400 \text{ va} = 0.4 \text{ Kw AC}$$

$$\text{SUBSTRATE } (250\text{v})(30\text{a}) = 7500 \text{ va} = 7.5 \text{ Kw DC}$$

60.9 Kw

Power demand from E.D. McClanahan,
personal communication 4/6/81

(included in MINUTES OF APRIL 6, 1981
MEETING E.E. Fisher to R.J. Secondo
4/17/81.)

$$(60.9 \text{ Kw}) \left(156 \frac{\text{hr}}{\text{batch}}\right) \left(435 \frac{\text{batch}}{\text{yr}}\right) = 4.13 \times 10^6 \text{ Kwh/yr}$$

ASSUMING demand at sputtering chamber
is 50% of power supplied to electrical
equipment

TITLE KRYPTON 85 ENCAPSULATION (ION/IMP'N) SHEET NO. 2 OF 4
 JOB NO. 654-3 DEPARTMENT _____ AUTH. Daniel Davis DATE 5/18/81

REV	CHECKER	DATE	REV	CHECKER	DATE	REV	CHECKER	DATE

$$\frac{4.13 \times 10^6 \text{ Kwh/y}}{0.50} = \underline{8.2 \times 10^6 \text{ Kwh/y}}$$

Load Factor $\geq 85\%$

$$\frac{60.9 \text{ Kw}}{0.50} = 121 \text{ Kw peak demand}$$

For Encapsulation Facility

$$(121 \text{ Kw})(730 \frac{\text{hr}}{\text{mo}}) = 88,300 \text{ Kwh/mo usage}$$

(TVA uses $730 \frac{\text{hr}}{\text{mo}}$ for rate schedules)

Cost of electricity will depend upon demand & usage for conceptual Nuclear Fuels Reprocessing Plant site

ASSUME $0.035 \frac{\$}{\text{Kwh}}$ conceptual NFRP site
 Oak Ridge, TN industrial
 (BACKUP DATA FOLLOWS)

$$(8.2 \times 10^6 \frac{\text{Kwh}}{\text{y}})(0.035 \frac{\$}{\text{Kwh}}) = \underline{\$287,000}$$

ELECTRIC
 POWER COST
 ION/IMPLANTATION

TITLE KRYPTON 85 ENGAPSULATIONSHEET NO. 3 OF 4JOB NO. 6154-3

DEPARTMENT _____

AUTHOR Smith DavisDATE 5/20/81

REV	CHECKER	DATE	REV	CHECKER	DATE	REV	CHECKER	DATE

ELECTRIC POWER COST

Oak Ridge, Tennessee industrial
from TVA, Chattanooga, TN

Charlie Henry (615) 755 6781

TVA uses monthly peak demand Kw and
usage Kwh/mo for determining rate
of this type — 730 hr/mo used.

1000 Kw peak demand } for conceptual
730,000 Kwh/mo usage } NFRP site

load factor

100%

$$3.274 \times 10^{-2} \frac{\$}{\text{Kwh}}$$

90%

$$3.374 \times 10^{-2} \frac{\$}{\text{Kwh}}$$

80%

$$3.500 \times 10^{-2} \frac{\$}{\text{Kwh}}$$

40%

$$4.60 \times 10^{-2} \frac{\$}{\text{Kwh}}$$

THE RALPH M. PARSONS COMPANY

D-6

CALCULATION SHEET

TITLE KRYPTON 85 ENCAPSULATIONSHEET NO. 4 OF 4JOB NO. 6154-3

DEPARTMENT _____

AUTHOR David F. DavisDATE 5/20/81

REV	CHECKER	DATE	REV	CHECKER	DATE	REV	CHECKER	DATE

(E POWER CONT.)

400 Kw peak demand } site
292,000 Kwh/mo usage }

low cost
in Chattanooga
District, TVA

Oak Ridge
TVA

high cost
in Chattanooga
District, TVA

$$3.253 \times 10^{-2} \frac{\$}{\text{Kwh}}$$

$$3.271 \times 10^{-2} \frac{\$}{\text{Kwh}}$$

$$3.458 \times 10^{-2} \frac{\$}{\text{Kwh}}$$

all at 100% load factor

TITLE **KRYPTON 85 ENCAPSULATION**

SHEET NO. **1** OF **14**

JOB NO. **6154-3**

DEPARTMENT

AUTHOR *Smith Davis*

DATE

4/20/01

REV	CHECKER	DATE	REV	CHECKER	DATE	REV	CHECKER	DATE

HOT ISOSTATIC PRESS

PHYSICAL DIMENSIONS

TOTAL VOLUME INSIDE PRESSURE VESSEL

WORK ZONE VOLUME

TITLE KRYPTON 85 ENCAPSULATIONSHEET NO. 2 OF 14JOB NO. 6154-3

DEPARTMENT _____

AUTHOR S. F. DavisDATE 4/24/8

REV	CHECKER	DATE	REV	CHECKER	DATE	REV	CHECKER	DATE

HIGH PRESSURE - C185KR/BATCH

$$\frac{(18.7 \text{ MCi/y})(10^6 \text{ Ci/MCi})}{600 \text{ batches}} = 3.12 \times 10^4 \frac{\text{Ci 85Kr}}{\text{batch}}$$

$$\frac{(18.7 \text{ MCi/y})(10^6 \text{ Ci/MCi})}{300 \text{ batches}} = 6.23 \times 10^4 \frac{\text{Ci 85Kr}}{\text{batch}}$$

HEAT GENERATION PER BATCH

$$\frac{(18.7 \text{ MCi/y})(10^6 \text{ Ci/MCi})(1.458 \times 10^{-3} \frac{\text{W}}{\text{Ci}})}{600 \text{ batches}} = 45.4 \frac{\text{W}}{\text{batch}}$$

$$\frac{(18.7 \text{ MCi/y})(10^6 \text{ Ci/MCi})(1.458 \times 10^{-3} \frac{\text{W}}{\text{Ci}})}{300 \text{ batches}} = 90.9 \frac{\text{W}}{\text{batch}}$$

TITLE KRYPTON 85 ENCAPSULATIONSHEET NO. 3 OF 14JOB NO. 6154-3

DEPARTMENT

AUTHOR

DATE

4/24/81

REV	CHECKER	DATE	REV	CHECKER	DATE	REV	CHECKER	DATE

HIGH PRESSUREVOLUME ENCAPSULATED PER BATCH

$$\frac{232.5 \frac{\text{m}^3}{\text{yr}}}{600 \text{ batches}} (10^3 \frac{\text{l}}{\text{m}^3}) = 387.5 \frac{\text{l}}{\text{batch}} \quad (0^\circ\text{C}, 1 \text{ atm condition})$$

$$\frac{232.5 \frac{\text{m}^3}{\text{yr}}}{300 \text{ batches}} (10^3 \frac{\text{l}}{\text{m}^3}) = 775 \frac{\text{l}}{\text{batch}} \quad (0^\circ\text{C}, 1 \text{ atm condition})$$

VOLUME GAS SUPPLIED PER ENCAPSULATION BATCH

600 cycles/yr 1000 atm, 700°C

0.30 fraction supplied is encapsulated

ATTACHMENT 4, MINUTES OF MEETING
KRYPTON 85 ENCAPSULATION PRECONCEPTUAL
DESIGN JOB NO 6154-3, APRIL 6, 1981

$$0.30 S = 387.5 \frac{\text{l}}{\text{batch}}$$

$$S = 1291.7 \frac{\text{l}}{\text{batch}}$$

THE RALPH M. PARSONS COMPANY

D-7
CALCULATION SHEET

TITLE KRYPTON 85 ENCAPSULATION

SHEET NO. 4 OF 14

JOB NO. 6154-3

DEPARTMENT

AUTHOR

DATE 4/24/81

REV	CHECKER	DATE	REV	CHECKER	DATE	REV	CHECKER	DATE

300 cycles/y 500 atm, 900°C

0.55 fraction supplied is encapsulated

(APRIL 6, 1981 MEETING MINUTES)

$$0.55 S = 775 \frac{\text{l}}{\text{batch}}$$

$$S = 1409.1 \frac{\text{l}}{\text{batch}}$$

VOLUME GAS PUMPED BACK PER BATCH

600 cycles

$$\begin{array}{r} 1291.7 \frac{\text{l}}{\text{batch}} \\ - 387.5 \text{ " } \\ \hline 904.2 \frac{\text{l}}{\text{batch}} \end{array}$$

(0°C, 1 atm condition)

300 cycles

$$\begin{array}{r} 1409.1 \frac{\text{l}}{\text{batch}} \\ - 775 \text{ " } \\ \hline 634.1 \frac{\text{l}}{\text{batch}} \end{array}$$

TITLE KRYPTON 85 ENCAPSULATIONSHEET NO. 5 OF 14JOB NO. 6154-3

DEPARTMENT

AUTHOR [Signature]DATE 5/6/01

REV	CHECKER	DATE	REV	CHECKER	DATE	REV	CHECKER	DATE

HIGH PRESSURE - VOLUME GAS IN
WORK ZONE

600 cycles/y

1292 l gas in work zone
(0°C, 1 atm condition) which
could under incredible
occurrence release into
building

300 cycles/y

1410 l gas in work zone
(0°C, 1 atm) which could
under incredible occurrence
release into building

GAS VOLUMES PROVIDED BY
AB CHRISTENSEN 5/5/01

TITLE **KRYPTON 85 ENCAPSULATION**SHEET NO. **6** OF **14**JOB NO. **6154-3**

DEPARTMENT

AUTHOR **W. F. Dick**DATE **5/6/81**

REV	CHECKER	DATE	REV	CHECKER	DATE	REV	CHECKER	DATE

HIGH PRESSURE - VOLUME GAS INVOID VOLUME

This is gas which provides isostatic pressure

600 cycles/y 5848 l gas in void volume (0°C, 1 atm condition) which could under incredible occurrence release into building

300 cycles/y 7700 l gas in void volume (0°C, 1 atm condition) which could under incredible occurrence release into building

GAS VOLUMES PROVIDED BY
AB CHRISTENSEN 5/5/81

THE RALPH M. PARSONS COMPANY

D-7
CALCULATION SHEETTITLE KRYPTON 85 ENCAPSULATIONSHEET NO. 7 OF 14JOB NO. 6154-3

DEPARTMENT _____

AUTHOR [Signature]DATE 5/6/8

REV	CHECKER	DATE	REV	CHECKER	DATE	REV	CHECKER	DATE

HIGH PRESSURE - VOLUME GASTOTAL POTENTIAL RELEASE

600 cycles/y

$$\begin{array}{r} 1292\text{ l} \\ + 5848\text{ l} \\ \hline 7140\text{ l} \end{array}$$

300 cycles/y

$$\begin{array}{r} 1410\text{ l} \\ + 7700\text{ l} \\ \hline 9110\text{ l} \end{array}$$

TITLE KRYPTON 85 ENCAPSULATIONSHEET NO. 8 OF 14JOB NO. 6154-3

DEPARTMENT _____

AUTHOR [Signature]DATE 4/24/8

REV	CHECKER	DATE	REV	CHECKER	DATE	REV	CHECKER	DATE

HIGH PRESSURE

BUILDING OVERPRESSURE WHICH
WOULD RESULT FROM INCREDIBLE
OCCURRENCE OF GAS RELEASE
FROM HIP

ASSUMING IDEAL GAS BEHAVIOR

$$PV = nRT$$

$$P = \frac{nRT}{V}$$

before pressure
increase

$$P + \Delta P = \frac{(n + \Delta n)RT}{V}$$

after release of
 Δn moles gas

$$n = \frac{PV}{RT}$$

$$P + \Delta P = \frac{\left(\frac{PV}{RT} + \Delta n\right)RT}{V} = P + \frac{\Delta n RT}{V}$$

$$\Delta P = \frac{\Delta n RT}{V}$$

$$V = \frac{\Delta n RT}{\Delta P}$$

TITLE KRYPTON 85 ENCAPSULATIONSHEET NO. 9 OF 14JOB NO. 6154-3

DEPARTMENT _____

AUTHOR W. J. SmithDATE 5/6/8

REV	CHECKER	DATE	REV	CHECKER	DATE	REV	CHECKER	DATE

600 cycles/y

7140 l (0°C, 1 atm) gas
which could release

$$\Delta n = \frac{7140 \text{ l}}{22.41 \frac{\text{l}}{\text{gmole}}} = 319 \text{ gmoles}$$

$$R = 0.08205 \frac{\text{atm l}}{\text{gmole K}^\circ}$$

ASSUME before pressure increase T_n n moles at 298°K (25°C) T_{on} on moles at 973°K (700°C) $C_p = \text{constant}$

$$nC_p(T - 298) = \Delta n C_p(973 - T)$$

$$T = \frac{298n + 973\Delta n}{n + \Delta n}$$

NOTE: THIS
ASSUMES GAS IN
WORK ZONE
EXPANDED FROM1000 ATM TO 15.7 PSIA
AT 700°C

$$n = \frac{PV}{RT_n} = \frac{(1)V}{(0.08205)(298)} = 0.0409V \quad (V \text{ in liters})$$

$$T = \frac{12.19V + 973\Delta n}{0.0409V + \Delta n}$$

$$\text{FOR } \Delta P = 1 \text{ psi} = \frac{1}{14.7} \text{ atm}$$

THE RALPH M. PARSONS COMPANY

D-7
CALCULATION SHEET

TITLE KRYPTON 85 ENCAPSULATION

SHEET NO. 10 OF 14

JOB NO. 6154-3

DEPARTMENT

AUTHOR

DATE

REV	CHECKER	DATE	REV	CHECKER	DATE	REV	CHECKER	DATE

$$V = \frac{(319)(0.08205)}{\frac{1}{14.7}} \left\{ \frac{12.19V + 973(319)}{0.0409V + (319)} \right\}$$

$$V = \frac{4690V + 1.194 \times 10^8}{0.0409V + 319}$$

$$0.0409V^2 + 319V = 4690V + 1.194 \times 10^8$$

$$0.0409V^2 - 4371V - 1.194 \times 10^8 = 0$$

$$V = \frac{4371 \pm \sqrt{1.911 \times 10^7 + 1.953 \times 10^7}}{0.0818}$$

$$V = \frac{4371 \pm 6216}{0.0818}$$

$$V = 129,000 \text{ l}$$

$$129 \text{ m}^3 \text{ round to } \underline{130 \text{ m}^3}$$

$$(130 \text{ m}^3) \left(35.31 \frac{\text{g}}{\text{m}^3} \right) = 4590 \text{ g}^3$$

round to 4600 g^3

TITLE KRYPTON 85 ENCAPSULATIONJOB NO. 6154-3

DEPARTMENT _____

AUTHOR [Signature]SHEET NO. 11 OF 14DATE 5/6/8

REV	CHECKER	DATE	REV	CHECKER	DATE	REV	CHECKER	DATE

300 cycles/y

9110 l (0°C, 1 atm) gas
which could release

$$\Delta n = \frac{9110 \text{ l}}{22.41 \frac{\text{l}}{\text{gmole}}} = 407 \text{ gmole}$$

$$V = \frac{(407)(0.08205)}{14.7} \left\{ \frac{12.19V + 973(407)}{0.0409V + 407} \right\}$$

$$V = \frac{5984V + 7.22 \times 10^7}{0.0409V + 407}$$

$$0.0409V^2 + 407V = 5984V + 1.944 \times 10^8$$

$$0.0409V^2 - 5577V - 1.944 \times 10^8 = 0$$

$$V = \frac{5577 \pm \sqrt{3.11 \times 10^7 + 3.18 \times 10^7}}{0.0818}$$

$$V = \frac{5577 \pm 7930}{0.0818}$$

$$V = 166,000 \text{ l}$$

$$166 \text{ m}^3$$

$$(166 \text{ m}^3) \left(35.31 \frac{\text{g}}{\text{m}^3} \right) = 5900 \text{ g}^3$$

TITLE KRYPTON 85 ENCAPSULATIONSHEET NO. 12 OF 14JOB NO. 6154-3

DEPARTMENT _____

AUTHOR _____

DATE 4/20/81

REV	CHECKER	DATE	REV	CHECKER	DATE	REV	CHECKER	DATE

MASS SUBSTRATE REQUIRED PER BATCH LOADING

$$600 \text{ cycles/y} \quad 0.050 \text{ cm}^3/\text{g-atm}$$

$$(0.050 \text{ cm}^3/\text{g-atm})(1000 \text{ atm})(10^{-3} \frac{\text{l}}{\text{cm}^3}) = 0.050 \frac{\text{l gas mix}}{\text{g Zeolite}}$$

$$\frac{387.5 \text{ l gas mix/batch}}{0.050 \frac{\text{l gas mix}}{\text{g Zeolite}}} = 7,750 \frac{\text{g Zeolite}}{\text{batch}}$$

$$300 \text{ cycles/y} \quad 0.027 \text{ cm}^3/\text{g-atm}$$

$$(0.027 \text{ cm}^3/\text{g-atm})(500 \text{ atm})(10^{-3} \frac{\text{l}}{\text{cm}^3}) = 0.0135 \frac{\text{l gas mix}}{\text{g Vycor}}$$

$$\frac{775 \text{ l gas mix/batch}}{0.0135 \frac{\text{l gas mix}}{\text{g Vycor}}} = 57,407 \frac{\text{g Vycor}}{\text{batch}}$$

TITLE KRYPTON 85 ENCAPSULATIONSHEET NO. 13 OF 14JOB NO. 654-3

DEPARTMENT

AUTHOR

DATE 4/28/81

REV	CHECKER	DATE	REV	CHECKER	DATE	REV	CHECKER	DATE

VOLUME SUBSTRATE REQUIRED PER BATCH LOADING

600 cycles/y

$$\frac{7,750 \frac{\text{g Zeolite}}{\text{batch}}}{1.0 \frac{\text{g Zeolite}}{\text{cm}^3 \text{Zeolite}}} = 7,750 \frac{\text{cm}^3 \text{Zeolite}}{\text{batch}}$$

$$\frac{7,750 \frac{\text{g Zeolite}}{\text{batch}}}{0.95 \frac{\text{g Zeolite}}{\text{cm}^3 \text{Zeolite}}} = 8,158 \frac{\text{cm}^3 \text{Zeolite}}{\text{batch}}$$

Free poured

300 cycles/y

$$\frac{57,407 \frac{\text{g Vycor}}{\text{batch}}}{1.3 \frac{\text{g Vycor}}{\text{cm}^3}} = 44,160 \frac{\text{cm}^3 \text{Vycor}}{\text{batch}}$$

SUBSTRATE	NOMINAL WORK SOAK (SUBSTRATE CONTAINER) VOLUME	ENCAP- SULATION PRESSURE	ENCAP- SULATION SOAK TEMPER- ATURE	NUMBER CYCLES PER YEAR	YOKE HEIGHT	YOKE WIDTH
ZEOLITE 5A	8l	1000ATM	700°C	600	12FT (3658)	5FT (1524)
"THIRSTY" VYCOR	45l	500ATM	900°C	300	14FT (4267)	5.8FT (1778)

² PRESSURE VESSEL INSIDE DIMENS
CAPSULE, FURNACE, HEAT SHIELD
SUCH THAT NOMINAL TOTAL VOLUME
FILLED WITH GAS

YOKE WIDTH	YOKE TRAVEL	WORK ZONE DIMENSIONS	VOLUME ENCAP-SULATED PER BATCH (0°C, 1ATM CONDITION)	FRACTION SUPPLIED ENCAP-SULATED	VOLUME PUMPED-BACK PER BATCH (0°C, 1ATM CONDITION)	VOLUME GAS IN WORK ZONE ¹ (0°C, 1ATM CONDITION)	PRESSURE VESSEL INSIDE DIMENSIONS ²	VOLUME GAS MAXIMUM POTENTIAL ISOSTATIC PRESSURE (0°C, 1ATM CONDITION)
5FT (1524)	8.3FT (2540)	7 IN DIA x 14 IN HI (178 DIA x 356 HI) 8.0 l	387.5 l	0.30	904.2 l	1292 l	11.5 IN DIA x 17.5 IN HI (295 DIA x 439 HI) 30 l	5848 l
5.8FT (1778)	10FT (3048)	12 IN DIA 24 IN HI (305 DIA x 610 HI) 44.5 l	775 l	0.55	634.1 l	1410 l	16.5 IN DIA x 28.5 IN HI (420 DIA x 722 HI) 100 l	7700 l

DIMENSIONS ARE OCCUPIED BY
SHIELD & INTERNAL FEATURES
VOLUME IS ONLY PARTIALLY

- ¹ VOLUME GAS WITHIN HIP WHICH POT
³ VOLUME GAS WITHIN HIP WHICH IS
⁴ WORK ZONE PLUS VOID VOLUME GAS
⁵ VOLUME OF BUILDING WHICH WOULD
14.7 PSIA TO 15.7 PSIA IN EVE
⁶ CM³ FEED EXPRESSED AT 0°C, 1

ESSURE SEL SIDE MEN- ONS ²	VOLUME GAS MAX- IMUM FOR ISOSTATIC PRESSURE ³ (0°C, 1ATM CONDITION)	VOLUME GAS TOTAL POTENTIAL RELEASE ⁴ (0°C, 1ATM CONDITION)	BUILDING VOLUME 1 PSI ΔP OVER PRESSURE ⁵	SUBSTRATE BULK DENSITY	SUBSTRATE VOID FRACTION	SUBSTRATE FEED GAS LOADING ⁶	CI 85 KR PER BATCH	HEAT GENER- ATION PER BATCH
5 IN DIA 5 IN HI 5 DIA 9 HI) 0 l	5848 l	7140 l	130 M ³ (4600 FT ³)	1.0 G/CM ³ VIBRAT- IONAL COMPACTED (0.95 G/CM ³ FREE POURED)	0.5	0.050 CM ³ /G-ATM @ 700°C	3.12 × 10 ⁴ CI/BATCH	45.4 W/BATCH
5 IN DIA 25 IN HI 20 DIA 22 HI) 0 l	7700 l	9110 l	166 M ³ (5900 FT ³)	1.3 G/CM ³	0.13	0.027 CM ³ /G-ATM @ 900°C	6.23 × 10 ⁴ CI/BATCH	90.9 W/BATCH

HIP WHICH POTENTIALLY COULD RELEASE FROM WORK ZONE
HIP WHICH IS PROVIDING ISOSTATIC PRESSURE
ID VOLUME GAS WHICH POTENTIALLY COULD RELEASE
WHICH WOULD INCREASE IN STATIC PRESSURE FROM
7 PSIA IN EVENT OF HIP TOTAL POTENTIAL RELEASE
SED AT 0°C, 1ATM CONDITION

DESIGN PARAMETERS
PRECONCEPTUAL DESIGN
85 KRYPTON ENCAPSULA
HIGH PRESSURE

6154-3

22

5/6/8

5/6/81

AMETERS
DESIGN
INSULATION
SURE

HEAT	GENERATION	PER BATCH	VOLUME	SUBSTRATE	MASS	SOAK TIME	MAXIMUM	TOTAL	GAS CON-	PRESSIVE	ENERGY
45.4	W/BATCH	8.158 CM ³ (FOR FREE POURED)	44.160 CM ³	57.407 G	2 HR	1.55 MJ	2.48 MJ				
90.9	W/BATCH										

D-7
14 of 14

TITLE Krypton 85 Encapsulation SHEET NO. 1 OF 7
 JOB NO. 6154-3 DEPARTMENT Process AUTHOR Perret DATE 4/30/8

REV	CHECKER	DATE	REV	CHECKER	DATE	REV	CHECKER	DATE

Calculations for 1 year Product Storage

For 600 units per year case of HP (high pressure) encapsulation in zeolite, the working volume is given as 7"φ x 14" high. Assume a 1/16" gap between canned substrate and vol. walls, and 1/16" walls for can.

$$\begin{aligned} \therefore \text{O.D. of can} &= 7.000 - 2(.0625) = 6.875" \\ \text{I.D. of can} &= 6.875 - 2(.0625) = 6.750" \end{aligned}$$

$$\text{contained Vol.} = \frac{6.75^2 \pi}{4} \times 13.75" = 492 \text{ in}^3 = 8.063 \text{ L}$$

to contain 7.750 L of zeolite.

For a 1/16" wall of 304ss., 6.875" O.D. @ 400°F, A.W.P. = 173^P, Choose a standard pipe size and a minimum gap for an "overpack". Std pipe minimizes cost, minimum gap minimized ΔT across the gas gap. Using an 8" sch 120 overpack 8.625" O.D. x 7.187" I.D.,

60.7 lbs/ft of length, have

$$\frac{\text{I.D.} \quad \text{O.D.}}{7.187 - 6.875}{2} = 0.156" \text{ gap}$$

TITLE Krypton 85 Encapsulation SHEET NO. 2 OF 7
 JOB NO. 6154-3 DEPARTMENT Process AUTHOR Parrot DATE 4/30/81

REV	CHECKER	DATE	REV	CHECKER	DATE	REV	CHECKER	DATE

For pure conduction: $\frac{k}{L} \Delta T = \frac{\dot{Q}}{A}$

air @ 300°F $k = 0.019 \text{ BTU/hr-H-}^\circ\text{F}$

$$\text{then } \frac{k}{L} = 0.019 \times \frac{12}{0.156} = 1.46 \frac{\text{BTU/hr}}{\text{H-}^\circ\text{F}}$$

For 600 cans per year:

$$\frac{232.5 \frac{\text{m}^3}{\text{yr}} \times 117.3 \frac{\text{W}}{\text{m}^2} \times 3.413 \frac{\text{BTU/hr}}{\text{W}}}{600 \text{ cans/yr}} = 155.1 \frac{\text{BTU/hr}}{\text{can}}$$

Using the curved surface only:

$$\bar{A} = \pi \bar{D} L = \frac{\pi \times 6.93'' \times 13.875''}{144} = 2.10 \text{ H}^2$$

$$\Delta T_{\text{gap}} = \frac{155.1 \text{ BTU/hr}}{2.10 \text{ H}^2 \times 1.46 \frac{\text{BTU/hr}}{\text{H-}^\circ\text{F}}} = 50.64^\circ\text{F}$$

$$\Delta T_{\text{wall}} = \frac{155.1 \text{ BTU/hr}}{2.387 \text{ H}^2 \times \frac{10 \times 12}{.72} \frac{\text{BTU/hr}}{\text{H-}^\circ\text{F}}} = 0.4^\circ\text{F}$$

$$\bar{D} = 7.884$$

$$t = 0.72''$$

$$\Delta T_0 = \frac{\dot{Q}}{A k_c} \approx \frac{155.1}{2.61 \times 0.9} = 66.0^\circ\text{F}$$

for given T_{max} center line of 300°C = 572°F
 and air @ 120°F, total max $\Delta T = 452^\circ\text{F}$; the total
 from above = 117°F = 26% of allowable which
 appears reasonable for conceptual design pending

TITLE <i>Krypton 85 Encapsulation</i>		SHEET NO. <i>3</i> OF <i>7</i>	
JOB NO. <i>16154-3</i>		DEPARTMENT <i>Process</i>	
AUTHOR <i>Derrett</i>		DATE <i>4/30/81</i>	
REV	CHECKER	DATE	REV

further definition of DT through zeolite matrix.

To minimize storage space consider an array

$$4 \times 6 \times 25 = 600$$

where the overpacks are pushed into the face and discharged from the rear much as the old "X"-file.

Alternately for more compact volume:

$$7 \times 7 \times 13 = 637 \text{ Units}$$

A sch 120 - 8" pipe of 304 ss @ 200°F has A.W.P. = 3700psi

check on assumption $h_c \approx 0.9$:

From calcs. for lag storage $Gr = \frac{g \left(\frac{T_s - T_{\infty}}{T_{\infty}} \right) L^3 \rho^2}{H^2}$

TITLE <u>Krypton 85 Encapsulation</u>			SHEET NO. <u>4</u> OF <u>7</u>		
JOB NO. <u>6154-3</u>		DEPARTMENT <u>Process</u>		AUTHOR <u>Perret</u>	
DATE <u>4/30/</u>					
REV	CHECKER	DATE	REV	CHECKER	DATE

only T_s and T_{∞} and $L = D$ change.

Because of large total heat load assume 40°F rise in air, 100°F to 140°F for $T_{\infty} = 120^\circ\text{F}$

$$Gr = \frac{32.2 \left(\frac{66}{560} \right) \left(\frac{8.625}{12.0} \right)^3 (0.0808)^2}{(.0183/1488)^2} = .061 \times 10^9$$

$$Nu = 0.47 (80.78) = 37.96$$

$$h_c = \frac{.019 \times 37.96}{8.625/12} = 1.0036$$

Since $h > h(\text{assumed})$, correct $T_s - T_{\infty} = 66$, $h \propto \Delta T^{1/4}$

$$h_c \approx 0.97 \quad \Delta T \approx 61 \quad \left(\frac{61}{66} \right)^{1/4} \times 1.0036 = 0.985$$

$$\Delta T = 60.3^\circ\text{F}$$

In any event the over factor added only 51°F ΔT to the base causes the surface ΔT exists in any case.

from data provided: h with $He \approx 1.5 \times 10^{-3} \text{ W/cm}^2 \cdot \text{K}$
 $\approx 0.087 \frac{\text{BTU/hr}}{\text{ft}^2 \cdot \text{F}} = 1.04 \frac{\text{BTU/hr}}{\text{ft}^2 \cdot \text{F}}$

$\frac{Q}{A} @ 3.375$	$= 155.1 / 2.025 = 76.6$	$\frac{\text{BTU/hr}}{\text{ft}^2 \cdot \text{F}}$	
$@ 2.375$	$= 55.3$		} 128°F
$@ 1.375$	$= 31.2$		
$@ 0.375$	$= 8.51$		

128°F ΔT estimated based on He back of fill.

RMP

THE RALPH M. PARSONS COMPANY

D-8
CALCULATION SHEET

TITLE <i>Krypton 85 Encapsulation</i>		SHEET NO. <i>5</i> OF <i>7</i>	
JOB NO. <i>6154-3</i>		DEPARTMENT <i>Process</i>	
AUTHOR <i>Derrek</i>		DATE <i>4/30/8</i>	
REV	CHECKER	DATE	REV

For ~300 units per year of "thirsty" vycor encapsulation under 500 atm. of pressure, the working volume is given as 12" ϕ x 24" deep.

If we assume a $\frac{1}{16}$ " gap for easy fit and a $\frac{1}{8}$ " wall for 100 psi differential, the

interior volume is $12.00 - \frac{2}{16} - \frac{2}{8} = 11 \frac{5}{8}" \phi$
 $24.00 - \frac{2}{16} - \frac{2}{8} = 23 \frac{5}{8}"$ Long.

$$Vol = \frac{(11 \frac{5}{8})^2 \pi}{4} \times 23 \frac{5}{8} = 2507.5 \text{ in}^3 = 41.091 \text{ L}$$

since need 300 x 44.16 L of vycor substrate, would need about 330 vessels.

Use 12.5" ϕ as work vol. interior = $12.50 - \frac{3}{8} = 12.125"$

$$Vol = 2727.9 \text{ in}^3 = 44.701 \text{ L. just about big enough}$$

for 44.16 L vycor & 300 units.

For over pack use 14" sch 80 pipe (12.50" I.D.) for

TITLE Krypton 85 Encapsulation

SHEET NO. 6 OF 7

JOB NO. 6154-3 DEPARTMENT Process

AUTHOR Perret

DATE 4/30/81

REV	CHECKER	DATE	REV	CHECKER	DATE	REV	CHECKER	DATE

Assume 18" on centers, 5x5 array x 12 deep

For 300 units have $2(155.1) = 310.2 \text{ BTU/hr}$

$$A_s = \pi D L = \pi (12.375)(13.875) / 144 = 6.446 \text{ ft}^2; \dot{Q}/A = 48.1 \frac{\text{BTU}}{\text{hr-ft}^2}$$

This compares to $155.1 / 2.10 = 73.8 \frac{\text{BTU/hr}}{\text{ft}^2}$ of case 1

$\therefore$ all ΔT 's are proportionately reduced for the internal gas gap and the surface film.

For the temp. rise in the matrix:

$\dot{Q}/A$	Q_{flow}	A	Q/A	$\bar{Q}/A$	$\sim \Delta T_{\text{rise}}$
6.0625	310.2	6.446	48.1	44.14	$\frac{1}{2} \sim 10$
5.0625			40.125		
4.0625			32.25	36.22	
3.0625			24.31		
2.0625			16.37	20.34	
1.0625			8.43		
.0625			0.496	4.465	

$$\Sigma = 156^\circ\text{F}$$

$\therefore$ Both alternatives look feasible from thermal point of view and little difference in required storage volumes; thus the only difference

TITLE Krypton 85 Encapsulation SHEET NO. 7 OF 7
JOB NO. 61543 DEPARTMENT Process AUTHOR Perret DATE 4/30/8

REV	CHECKER	DATE	REV	CHECKER	DATE	REV	CHECKER	DATE

appears to lie in the no. of units handled and the weights. Based on the preliminary design given above, the small unit weights about 165 lbs while the larger is about 400 lbs. The effect on required handling equipment needs to be evaluated.

In either case, for a 40°F temperature rise

$$\dot{W} = \frac{\dot{Q}}{C_p \Delta T} = \frac{5 \times 18615}{(0.25)(40)} = 2.5 \times 3723 \text{ lb/hr}$$
$$= 1920 \text{ cfm}$$

to be supplied to the storage area.

J.

TITLE KRYPTON 85 ENCAPSULATION

SHEET NO. 1 OF 4

JOB NO. 6154-3

DEPARTMENT

AUTHOR

DATE

5/18/81

REV	CHECKER	DATE	REV	CHECKER	DATE	REV	CHECKER	DATE

HIGH PRESSURE SUBSTRATE COSTS

600 batches/y

$$(7,750 \frac{\text{cm}^3}{\text{batch}})(1.0 \frac{\text{g}}{\text{cm}^3})(10^{-3} \frac{\text{kg}}{\text{g}})(600 \frac{\text{batches}}{\text{y}}) = 4650 \frac{\text{kg}}{\text{y}}$$

$$(3.35 \frac{\text{\$}}{\text{lb}})(2.2 \frac{\text{lb}}{\text{kg}})(4650 \frac{\text{kg}}{\text{y}}) = \underline{34,300 \frac{\text{\$}}{\text{y}}}$$

Zeolite 5A
SUBSTRATE 600¢/y

$$7.37 \frac{\text{\$}}{\text{kg}}$$

300 batches/y

$$(44,160 \frac{\text{cm}^3}{\text{batch}})(1.3 \frac{\text{g}}{\text{cm}^3})(10^{-3} \frac{\text{kg}}{\text{g}})(300 \frac{\text{batches}}{\text{y}}) = 17,222 \frac{\text{kg}}{\text{y}}$$

 $\frac{1}{4}$ -inch dia x 36-inch long Vycor glass rod

$$1.5 \frac{\text{g}}{\text{cm}^3}$$

$$5.0 \frac{\text{\$}}{\text{rod}}$$

$$\frac{\frac{\pi}{4} (\frac{1}{4} \text{ in})^2 (36 \text{ in}) (16.39 \frac{\text{cm}^3}{\text{in}^3}) (1.5 \frac{\text{g}}{\text{cm}^3})}{1000 \frac{\text{g}}{\text{kg}}} = 0.0434 \frac{\text{kg}}{\text{rod}}$$

RMP

THE RALPH M. PARSONS COMPANY

D-9
CALCULATION SHEETTITLE **KRYPTON OS ENCAPSULATION (HIP)**SHEET NO. **2** OF **4**JOB NO. **6154-3**

DEPARTMENT

AUTHOR

DATE

5/8/81

REV	CHECKER	DATE	REV	CHECKER	DATE	REV	CHECKER	DATE

$$\frac{5 \frac{\#}{\text{rod}}}{0.0434 \frac{\text{Kg}}{\text{y}}} = 115.2 \frac{\#}{\text{Kg}}$$

$$(17,222 \frac{\text{Kg}}{\text{y}})(115.2 \frac{\#}{\text{Kg}}) = 1,984,000 \frac{\#}{\text{y}}$$

Vycor glass 300¢/y
(Dow-Corning)

3.35 $\frac{\#}{\text{lb}}$ Zeolite 5A

5 $\frac{\#}{\text{rod}}$ Vycor glass rod

Substrate costs provided by
personal communication AB Christensen,
5/15/81

TITLE KRYPTON ENCAPSULATION (H1 P)

SHEET NO. 3 OF 4
DATE 5/20/01

JOB NO. 6154-3

DEPARTMENT

AUTHOR

REV	CHECKER	DATE	REV	CHECKER	DATE	REV	CHECKER	DATE

COST OF OVERPACK CONTAINERS600 batches/y

14-inch length sch 120 8-inch dia pipe

carbon steel $32 \frac{\$}{ft}$ 316 sst $250 \frac{\$}{ft}$

Figure 17 units cut from 20 ft pipe length.

$$(20 ft)(32 \frac{\$}{ft}) \frac{600 \text{ units}}{17 \text{ units}} = \$22,600 \text{ PIPE}$$

2,400 ENDCAPS

$$\underline{\$25,000 \text{ C.S.}} \\ 600 \phi/y$$

$$(20 ft)(250 \frac{\$}{ft}) \frac{600 \text{ units}}{17 \text{ units}} = \$176,000 \text{ PIPE}$$

9,000 ENDCAPS

$$\underline{\$185,000 \text{ 316 SST}} \\ 600 \phi/y$$

TITLE KRYPTON ENDCAPSULATION (HI P)SHEET NO. 4 OF 4JOB NO. 6154-3

DEPARTMENT

AUTHOR SmithDATE 5/20/81

REV	CHECKER	DATE	REV	CHECKER	DATE	REV	CHECKER	DATE

300 batches/y

24-inch length sch 80 14-inch dia pipe
carbon steel 55 $\frac{\$}{ft}$
stainless steel 316 300 $\frac{\$}{ft}$

Figure 10 units cut from 20 ft pipe
length.

$$(20 ft)(55 \frac{\$}{ft}) \frac{300 \text{ units}}{10 \text{ units}} = \$33,000 \text{ PIPE}$$
$$\begin{array}{r} 5,000 \text{ ENDCAPS} \\ \$38,000 \text{ C.S.} \\ \hline 300 \phi/y \end{array}$$

$$(20 ft)(300 \frac{\$}{ft}) \frac{300 \text{ units}}{10 \text{ units}} = \$180,000 \text{ PIPE}$$
$$\begin{array}{r} 10,000 \text{ ENDCAPS} \\ \$190,000 \text{ 316 SST} \\ \hline 300 \phi/y \end{array}$$

PIPE COSTS FROM DICK DORSCH, RMPCO PIPING
ESTIMATOR, COST ENGINEERING &
SCHEDULING

TITLE VESSEL RUPTURE SHEET NO. 1 OF 1
JOB NO. 6154-3 DEPARTMENT AUTHOR R. WILKINSON DATE 6-30-81

REV	CHECKER	DATE	REV	CHECKER	DATE	REV	CHECKER	DATE

BASED ON PRELIMINARY ASSESSMENTS, AND ON THE CONFIGURATION USED FOR THE PRECONCEPTUAL DESIGN, THE MOST SERIOUS CREDIBLE ACCIDENT FOR THE HOT ISOSTATIC PRESS WOULD BE BRITTLE FAILURE OF THE YOKE UNDER PRESSURE, AND LAUNCHING OF THE TOP PLUG AS A MISSILE. THIS CALCULATION WILL DETERMINE THE MAXIMUM VELOCITY OF THE TOP PLUG, AND THE REQUIRED THICKNESS OF CONCRETE TO CONTAIN THE MISSILE.

CALCULATIONS ARE BASED ON THE PROCEDURES USED IN ENICO 1055, "PRELIMINARY SAFETY EVALUATION OF A COMMERCIAL-SCALE KRYPTON-85 ENCAPSULATION FACILITY", SEPTEMBER, 1980. FOR WORST CASE CALCULATION, ENERGY VALUES ARE BASED ON ARGON GAS PROPERTIES.

P_1 = PRESSURE PRIOR TO RUPTURE = 1000 ATM.

T_1 = TEMPERATURE PRIOR TO RUPTURE = 700°C = 973°K

V = GAS VOLUME = 7140 L (0°C, 1 ATM)

V_1 = SPECIFIC INITIAL VOLUME (PER REDLICH-KWONG EQUATION)
= 103 cm³/MOLE

V_2 = 162.5 m³

P_2 (ESTIMATED) = 1.055 ATM.

T_2 (ESTIMATED) = 80°K

V_2 = 6250 cm³/MOLE

TITLE VESSEL RUPTURE SHEET NO. 2 OF 2
JOB NO. 6154-3 DEPARTMENT _____ AUTHOR E. WILKINSON DATE 6-30-81

REV	CHECKER	DATE	REV	CHECKER	DATE	REV	CHECKER	DATE

$$\Delta U = 121.92 \text{ J/L}$$

$$\text{TOTAL ENERGY} = 870,540 \text{ J}$$

THE ESTIMATED PLUG DIMENSIONS ARE 11.5 IN. DIAMETER BY 10 IN. THK., ESTIMATED WEIGHT = 300 LB = 136 Kg

$$K.E = 0.6 \Delta U = 0.6 \times 870,540 = 522,300 \text{ J}$$

$$V_p = (2K.E / W_p)^{1/2} = 87.64 \text{ m/s}$$

THE THICKNESS OF CONCRETE REQUIRED TO STOP THE PLUG IS

$$t = \frac{6 \times 10^{-4} W_p}{A_p} \log_{10} (1 + 5 \times 10^{-5} V_p^2)$$

$$W_p = 136 \text{ Kg}$$

$$A_p = 0.067 \text{ m}^2$$

$$t = 0.172 \text{ m} = 6.8 \text{ IN.}$$

THEREFORE, THE 18 IN. THICK CONCRETE CELL CEILING IS MORE THAN ADEQUATE.

THE EQUIVALENT EXPLOSIVE ENERGY IS

$$0.193 \text{ Kg TNT}$$

$$0.426 \text{ LB TNT}$$

APPENDIX E
COST ESTIMATES

- E-1 ION IMPLANTATION/SPUTTERING
- E-2 ZEOLITE ENCAPSULATION

THE RALPH M. PARSONS COMPANY

E-1

PROJECT NAME: KRYPTON ENCAPSULATION PRECONCEPTUAL DESIGN
ION IMPLANTATION / SPUTTERING FACILITY DATE JULY, 1981

ESTIMATE OF COST _____ PAGE _____ OF _____

PROJECT NO. 6154-3 SUMMARY BY _____

ACCT. NO.	DESCRIPTION	LABOR COST \$	MATERIAL COST \$	TOTAL COST \$
	DIRECT COST			
400	IMPROVEMENTS TO LAND	23,000	2,000	25,000
500	BUILDING & OTHER STRUCTURES	1,620,000	1,525,000	3,145,000
600	UTILITIES (NOT INCLUDED)	—	—	—
700	EQUIPMENT	215,000	1,480,000	1,695,000
800	DEMOLITION & REMOVALS (NONE)	—	—	—
	TOTAL DIRECT COST	1,858,000	3,007,000	4,865,000
	CONTRACTOR INDIRECTS @ 10%			487,000
	TOTAL CONSTRUCTION COST			5,352,000
	TITLE I @ 6%			321,000
	TITLE II @ 14%			750,000
	TITLE III @ 8%			428,000
	A - FIELD INSPECTION			
	B - SHOP INSPECTION			
	PROJECT ADMINISTRATION @ 10%			535,000
	SUB-TOTAL ENGINEERING			2,034,000
	SUB-TOTAL			7,386,000
	ESCALATION (NOT INCLUDED)			
	SUB-TOTAL			7,386,000
	CONTINGENCY @ 40%			2,954,000
	TOTAL JOB COST			10,340,000

THE RALPH M. PARSONS COMPANY

ESTIMATE WORKSHEET

M.T.O. BY <u>RW</u>		PRICED BY <u>RW</u>		DATE <u>JULY, 1981</u>		SHEET <u> </u> OF <u> </u>						
JOB NO.: <u>0154-3</u>		CLIENT: <u>U.S. DOE</u>		TYPE OF ESTIMATE:		CKD BY:						
UNIT/AREA	DESCRIPTION	QUANTITY	UNIT	COST OR M/HR PER UNIT			MATERIAL EXPENSE	SUBCONTRACT		LABOR		TOTAL DOLLARS
CAPACITY				MATL	M/H	LAB \$		M/HR	DOLLARS	M/HR	DOLLARS	
ACCNT												
400	IMPROVEMENTS TO LAND											
	SITE CLEARING	6000	SY	-	.014					84		
	EXCAVATION	640	CY	-	.15					96		
	COMPACTED BACKFILL	200	CY	2 ⁰⁰	.16		400			32		
	GRADING	5200	SF	-	.012					62		
	DISPOSAL	440	CY	-	.10					44		
	CONCRETE WALKS (EST) 6" THK.	400	SF	1 ⁰⁰	.10		640			40		
	SUB-TOTAL						1040			358		
	PRODUCTIVITY (1.80 x 358)	644	MH			19 ⁰⁰				644	12560	
	SUB-TOTAL						1040				12560	13600
	SUBCONTRACTOR MARK-UP		%	35	80		360				10040	10400
	TOTAL 400						1400				22600	24000

THE RALPH M. PARSONS COMPANY

ESTIMATE WORKSHEET

M.T.O. BY <u>RW</u>		PRICED BY <u>RW</u>		DATE <u>JULY, 1981</u>		SHEET <u> </u> OF <u> </u>						
JOB NO.: <u>6154-3</u>		CLIENT: <u>U.S. DOE</u>		TYPE OF ESTIMATE:		CKD BY:						
UNIT/AREA	DESCRIPTION	QUANTITY	UNIT	COST OR M/HR PER UNIT			MATERIAL EXPENSE	SUBCONTRACT		LABOR		TOTAL DOLLARS
CAPACITY				MATL	M/H	LAB \$		M/HR	DOLLARS	M/HR	DOLLARS	
ACCNT												
	<u>500 BUILDINGS & STRUCTURES</u>											
	CONCRETE						307730			10185	339160	646890
	MASONRY						2890			524	18310	21200
	STRUCTURAL STEEL & MISC. METALS						48340			752	28160	76500
	FINISHES						50150			4001	138950	189100
	PAINTING & SPECIAL COATING						5000			2005	70400	75400
	DOORS & WINDOWS						14400			302	10600	30000
	SPECIALTIES						7210			166	5890	13100
	PIPING						66890			3744	146210	213100
	INSTRUMENTATION						99710			1550	58290	158000
	ELECTRICAL						284120			9158	343880	628000
	HVAC						289350			3578	124950	414300
	FIRE PROTECTION						35100			936	32700	67800
	PLUMBING						31050			1890	73850	104900
	SPECIAL BLDG. COMPONENTS						275120			6165	225280	500400
	<u>TOTAL 500</u>						1522060				1616630	3138690
	<u>USE</u>						1525000				1620000	3145000

THE RALPH M. PARSONS COMPANY

ESTIMATE WORKSHEET

M.T.O. BY <u>SV</u>		PRICED BY <u>RW</u>		DATE <u>JULY, 1981</u>		SHEET <u> </u> OF <u> </u>						
JOB NO.: <u>6154-3</u>		CLIENT: <u>US DOE</u>		TYPE OF ESTIMATE:		CKD BY:						
UNIT/AREA	DESCRIPTION	QUANTITY	UNIT	COST OR M/HR PER UNIT			MATERIAL EXPENSE	SUBCONTRACT		LABOR		TOTAL DOLLARS
CAPACITY				MATL	M/H	LAB \$		M/HR	DOLLARS	M/HR	DOLLARS	
ACCENT												
500	BUILDINGS											
	<u>CONCRETE</u>											
	FOUNDATION	230	CY				55410			1254		
	WALLS	338	CY				112250			2893		
	SUSPENDED SLABS	263	CY				60290			1511		
	SUB-TOTAL						227950			5658		
	PRODUCTIVITY (1.80 x 5658)	10185				1850				10185	188420	
	SUB-TOTAL						227950				188420	
	SUBCONTRACTOR MARK-UP		%	35	80		79780				150740	
							307730				339160	646890

THE RALPH M. PARSONS COMPANY

ESTIMATE WORKSHEET

M.T.O. BY <u>SV</u>		PRICED BY <u>RW</u>		DATE <u>JULY, 1981</u>		SHEET <u> </u> OF <u> </u>						
JOB NO.: <u>6154-3</u>		CLIENT: <u>US DOE</u>		TYPE OF ESTIMATE:		CKD BY:						
UNIT/AREA	DESCRIPTION	QUANTITY	UNIT	COST OR M/HR PER UNIT			MATERIAL EXPENSE	SUBCONTRACT		LABOR		TOTAL DOLLARS
CAPACITY				MATL	M/H	LAB \$		M/HR	DOLLARS	M/HR	DOLLARS	
ACCT												
	<u>500 BUILDINGS</u>											
	<u>CONCRETE</u>											
	<u>FOUNDATION</u>											
	<u>VAPOR BARRIER</u>	<u>4800</u>	<u>SF</u>	<u>.20</u>	<u>.005</u>		<u>960</u>			<u>24</u>		
	<u>CONCRETE FOOTINGS</u>	<u>170</u>	<u>CY</u>	<u>60</u>	<u>.40</u>		<u>10200</u>			<u>68</u>		
	<u>SLAB ON GRADE (4800 SF)</u>	<u>60</u>	<u>CY</u>	<u>60</u>	<u>.30</u>		<u>3600</u>			<u>18</u>		
	<u>FORMWORK</u>	<u>3600</u>	<u>SF</u>	<u>.71</u>	<u>.01</u>		<u>2560</u>			<u>360</u>		
	<u>REBAR (190#/CY)</u>	<u>22</u>	<u>TON</u>	<u>700</u>	<u>16</u>		<u>15400</u>			<u>352</u>		
	<u>EMBEDS (C.S., 75#/CY)</u>	<u>9</u>	<u>TON</u>	<u>2500</u>	<u>40</u>		<u>22500</u>			<u>300</u>		
	<u>FINISH</u>	<u>4800</u>	<u>SF</u>	<u>.04</u>	<u>.015</u>		<u>190</u>			<u>72</u>		
	<u>SUB-TOTAL</u>						<u>55410</u>			<u>1254</u>		
	<u>WALLS</u>											
	<u>CONCRETE WALLS (12" THK)</u>	<u>320</u>	<u>CY</u>	<u>60</u>	<u>.70</u>		<u>19200</u>			<u>224</u>		
	<u>PARAPET (8" THK)</u>	<u>16</u>	<u>CY</u>	<u>60</u>	<u>.70</u>		<u>960</u>			<u>11</u>		
	<u>COLUMNS (12" x 12")</u>	<u>1.5</u>	<u>CY</u>	<u>60</u>	<u>.70</u>		<u>90</u>			<u>1</u>		
	<u>FORMWORK</u>	<u>18,200</u>	<u>SF</u>	<u>.71</u>	<u>.02</u>		<u>12920</u>			<u>364</u>		
	<u>REBAR (240#/CY)</u>	<u>40.5</u>	<u>TON</u>	<u>700</u>	<u>18</u>		<u>28350</u>			<u>729</u>		
	<u>EMBEDS (120#/CY)</u>	<u>20</u>	<u>TON</u>	<u>2500</u>	<u>60</u>		<u>50000</u>			<u>1200</u>		
	<u>FINISH</u>	<u>18,200</u>	<u>SF</u>	<u>.04</u>	<u>.02</u>		<u>730</u>			<u>364</u>		
	<u>SUB-TOTAL</u>						<u>112250</u>			<u>2893</u>		
	<u>SUSPENDED SLAB</u>											
	<u>CONCRETE (12" THK)</u>	<u>263</u>	<u>CY</u>	<u>60</u>	<u>.40</u>		<u>15780</u>			<u>105</u>		
	<u>FORMWORK</u>	<u>7100</u>	<u>SF</u>	<u>1.30</u>	<u>.04</u>		<u>9230</u>			<u>284</u>		
	<u>REBAR (190#/CY)</u>	<u>25</u>	<u>TON</u>	<u>700</u>	<u>20</u>		<u>17500</u>			<u>500</u>		
	<u>EMBEDS (60#/CY)</u>	<u>8</u>	<u>TON</u>	<u>2500</u>	<u>60</u>		<u>17500</u>			<u>480</u>		
	<u>FINISH</u>	<u>7100</u>	<u>SF</u>	<u>.04</u>	<u>.02</u>		<u>280</u>			<u>142</u>		
	<u>SUB-TOTAL</u>						<u>60270</u>			<u>1511</u>		

THE RALPH M. PARSONS COMPANY

ESTIMATE WORKSHEET

M.T.O. BY <i>RW</i>		PRICED BY <i>RW</i>		DATE <i>July, 1981</i>		SHEET <i> </i> OF <i> </i>						
JOB NO.: <i>6154-3</i>		CLIENT:		TYPE OF ESTIMATE:		CKD BY:						
UNIT/AREA	DESCRIPTION	QUANTITY	UNIT	COST OR M/HR PER UNIT			MATERIAL EXPENSE	SUBCONTRACT		LABOR		TOTAL DOLLARS
CAPACITY				MATL	M/H	LAB \$		M/HR	DOLLARS	M/HR	DOLLARS	
ACCNT												
<i>500</i>	<i>BUILDINGS</i>											
	<i>MASONRY</i>											
	<i>8" CONCRETE BLOCK</i>	<i>1860</i>	<i>SF</i>	<i>1.1</i>	<i>0.15</i>		<i>2050</i>			<i>279</i>		
	<i>12" CONCRETE BLOCK</i>	<i>60</i>	<i>SF</i>	<i>1.5</i>	<i>0.20</i>		<i>90</i>			<i>12</i>		
	<i>SUB-TOTAL</i>						<i>2140</i>			<i>291</i>		
	<i>PRODUCTIVITY (1.80 x 291)</i>	<i>524</i>	<i>MH</i>			<i>1940</i>				<i>524</i>	<i>10170</i>	
	<i>SUB-TOTAL</i>						<i>2140</i>				<i>10170</i>	<i>12310</i>
	<i>SUBCONTRACTOR MARK-UP</i>		<i>%</i>	<i>35</i>	<i>80</i>		<i>750</i>				<i>8140</i>	<i>8890</i>
	<i>TOTAL</i>						<i>2890</i>				<i>18310</i>	<i>21200</i>

THE RALPH M. PARSONS COMPANY

ESTIMATE WORKSHEET

M.T.O. BY <u>SV</u>		PRICED BY <u>EW</u>		DATE <u>JULY, 1981</u>				SHEET <u> </u> OF <u> </u>				
JOB NO.: <u>6154-3</u>		CLIENT: <u>US DOE</u>		TYPE OF ESTIMATE:				CKD BY:				
UNIT/AREA	DESCRIPTION	QUANTITY	UNIT	COST OR M/HR PER UNIT			MATERIAL EXPENSE	SUBCONTRACT		LABOR		TOTAL DOLLARS
CAPACITY				MATL	M/H	LAB \$		M/HR	DOLLARS	M/HR	DOLLARS	
ACCNT												
500	BUILDINGS											
	<u>STRUCTURAL STEEL & MISC. METALS</u>											
	OPEN WEB STEEL JOISTS (13 @ 1200)	7.8	TN	600	8		4680			62		
	METAL DECKING	1790	SF	3 ²⁸	.02		5730			36		
	PIPES, PLATES, & RODS (EST)	2	TN	1360	10		2720			20		
	MISCELLANEOUS SUPPORTS (EST)	12	TN	1390	20		16680			240		
	MISC. (EST)	5	TN	1200	12		6000			60		
	SUB-TOTAL						35810			418		
	PRODUCTIVITY (1.80 x 418)	752	MH			20 ⁸⁰				752	15640	
	SUB-TOTAL						35810				15640	51450
	SUBCONTRACTOR MARK-UP		%	35	80		12530				12530	25050
	TOTAL						48340				28160	76500

THE RALPH M. PARSONS COMPANY

ESTIMATE WORKSHEET

M.T.O. BY <u>RW</u>		PRICED BY <u>RW</u>		DATE <u>JULY, 1981</u>		SHEET <u> </u> OF <u> </u>							
JOB NO.: <u>6154-3</u>		CLIENT: <u>US DOE</u>		TYPE OF ESTIMATE:		CKD BY:							
UNIT/AREA	DESCRIPTION	QUANTITY	UNIT	COST OR M/HR PER UNIT			MATERIAL EXPENSE	SUBCONTRACT		LABOR		TOTAL DOLLARS	
CAPACITY				MATL	M/H	LAB \$		M/HR	DOLLARS	M/HR	DOLLARS		
ACCNT													
500	BUILDINGS												
	<u>FINISHES</u>												
	INSULATED METAL SIDING	8190	SF	2 ⁸⁰	.08		22930			655			
	INVERTED ROOFING SYSTEM	4930	SF	1 ⁸⁰	.25		8870			1233			
	FLASHING & SHEET METAL	750	LF	1 ⁰⁰	.15		750			113			
	4" METAL STUDS x 9'-6" (16" c/c)	210	LF	5 ⁸⁰	.19		1220			40			
	5/8" THK GYPSUM BOARD (TYPE X)	1650	SF	0 ³⁰	.015		500			25			
	5/8" THK GYPSUM BOARD	2280	SF	0 ²⁰	.015		460			34			
	SUSPENDED PLASTER CEILING	600	SF	1 ¹⁵	.05		690			30			
	SUSPENDED ACOUSTICAL CEILING	860	SF	0 ⁸⁰	.02		700			17			
	CERAMIC TILE WALLS	130	SF	1 ⁴⁵	.10		190			13			
	CERAMIC TILE FLOORING	250	SF	1 ⁴⁵	.10		360			25			
	VINYL ASBESTOS TILE FLOORING	950	SF	0 ⁹⁰	.04		480			38			
	SUB-TOTAL						37150			2223			
	PRODUCTIVITY (1.80 x 2223)	4001	MH			19 ³⁰				4001	77220		
	SUB-TOTAL						37150			77220			
	SUBCONTRACTOR MARK-UP		%	35	80		13000			61730			
	TOTAL						50150			138950	189100		

THE RALPH M. PARSONS COMPANY

ESTIMATE WORKSHEET

M.T.O. BY <u>RLW</u>		PRICED BY <u>RLW</u>		DATE <u>JULY, 1981</u>		SHEET <u> </u> OF <u> </u>						
JOB NO.: <u>6154-3</u>		CLIENT: <u>US DOE</u>		TYPE OF ESTIMATE:		CKD BY:						
UNIT/AREA	DESCRIPTION	QUANTITY	UNIT	COST OR M/HR PER UNIT			MATERIAL EXPENSE	SUBCONTRACT		LABOR		TOTAL DOLLARS
CAPACITY				MATL	M/H	LAB \$		M/HR	DOLLARS	M/HR	DOLLARS	
ACCNT												
500	BUILDINGS											
	<u>PAINTING & SPECIAL COATING</u>											
	PAINTING											
	GYPSUM BOARD	3930	SF	.12	.03		470			118		
	MASONRY BLOCK	1920	SF	.12	.05		230			96		
	PIPING (EST)	1000	SF	.12	.05		120			50		
	DUCTWORK (EST)	3000	SF	.12	.04		360			120		
	SPECIAL COATING											
	PLASTER CEILING	600	SF	.20	.05		120			30		
	CONCRETE WALLS	5100	SF	.20	.06		1020			306		
	CONCRETE FLOORS	3900	SF	.20	.06		780			234		
	PIPING (EST)	1000	SF	.20	.06		200			60		
	DUCTWORK (EST)	2000	SF	.20	.05		400			100		
	SUB-TOTAL						3700			1114		
	PRODUCTIVITY (1.80 x 1114)	2005	1/H			19 ⁵⁰				2005	39100	
	SUB-TOTAL						3700				39100	
	SUB-CONTRACTOR 11% MK-UP		%	35	80		1300				31300	
	TOTAL						5000				70400	75400

ESTIMATE WORKSHEET

M.T.O. BY <u>AW</u>		PRICED BY <u>AW</u>		DATE <u>JULY, 1981</u>		SHEET <u>OF</u>		CKD BY:	
JOB NO: <u>6154-3</u>		CLIENT: <u>US DOE</u>		TYPE OF ESTIMATE:					
UNIT/AREA	KEYWAY CALCULATION	QUANTITY	COST OR M/HRS	MATL	M/H	LABS	MATERIAL	SUBCONTRACT	LABOR
DESCRIPTION	KEYWAY CALCULATION / SPUTTERING		PER UNIT				EXPENSE		
CAPACITY									
500 BUILDINGS									
DOORS & WINDOWS									
FORWARD HAZOP DOORS 8'x8' METAL OVERHEAD 3'-0" x 7'-0" METAL CLAD Hollow METAL DOORS 3'-0" x 7'-0" Hollow CORE WOOD 3'-0" x 7'-0" METAL DOOR, SHIPPING 3'-0" x 7'-0" OFFICE (LUMINOUS) 11'-0" x 9'-0" WIRE GLASS 12" x 24"									
SUB-TOTAL 302 PRODUCTIVITY (1.80 x 168) 302 SUB-TOTAL 14380 168 302 5890 20270 9730 30000									
SUBCONTRACTOR / MAKE-UP % 35.80 5020 19400 19400									
TOTAL									

THE RALPH M. PARSONS COMPANY

ESTIMATE WORKSHEET

M.T.O. BY <u>RW</u>		PRICED BY <u>RW</u>		DATE <u>July, 1981</u>		SHEET <u> </u> OF <u> </u>						
JOB NO.: <u>6154-3</u>		CLIENT: <u>US DOE</u>		TYPE OF ESTIMATE:		CKD BY:						
UNIT/AREA	DESCRIPTION	QUANTITY	UNIT	COST OR M/HR PER UNIT			MATERIAL EXPENSE	SUBCONTRACT		LABOR		TOTAL DOLLARS
CAPACITY				MATL	M/H	LAB \$		M/HR	DOLLARS	M/HR	DOLLARS	
ACCENT												
500	BUILDINGS											
	<u>SPECIALTIES</u>											
	BATH ACCESSORIES											
	TOILET PARTITION	2	EA	250	6		500			12		
	URINAL SCREEN	1	EA	60	2		60			2		
	MIRROR W/ SS FRAME & SHELF	2	EA	30	2		60			4		
	COMB. TOWEL DISP. & RECEPT.	2	EA	200	4		400			8		
	FEMININE NAPKIN DISP	1	EA	170	2		170			2		
	TOILET PAPER DISP	2	EA	20	1		40			2		
	SOAP DISPENSER	2	EA	25	1		50			2		
	TOILET SEAT DISP.	2	EA	30	1		60			2		
	CABINET WORK											
	24" x 72" x 36" W/ LAM. TOP & SS SINK	1	EA	1650	20		1650			20		
	12" x 72" x 24" WALL HUNG	1	EA	300	4		300			4		
	36" x 168" x 36" W/ LAM. TOP	1	EA	1450	24		1450			24		
	15' x 18' x 60' LOCKERS	10	EA	60	1		600			10		
	SUB-TOTAL						5340			92		
	PRODUCTIVITY (1.80 x 92)	166	MH			1920				166	3240	
	SUB-TOTAL						5340				3240	8580
	SUBCONTRACTOR MARK-UP		%	35	80		1870				2650	
	TOTAL						7210				5890	13100

THE RALPH M. PARSONS COMPANY

ESTIMATE WORKSHEET

M.T.O. BY <u>L. Brooks</u>		PRICED BY <u>RW</u>		DATE <u>JULY, 1981</u>		SHEET <u>1</u> OF <u>12</u>						
JOB NO.: <u>6154-3</u>		CLIENT: <u>US DOE</u>		TYPE OF ESTIMATE:		CKD BY:						
UNIT/AREA	DESCRIPTION	QUANTITY	UNIT	COST OR M/HR PER UNIT			MATERIAL EXPENSE	SUBCONTRACT		LABOR		TOTAL DOLLARS
CAPACITY				MATL	M/H	LABS		M/HR	DOLLARS	M/HR	DOLLARS	
ACCENT												
500	BUILDINGS											
	<u>PIPING SUMMARY</u>											
	FROM SHT. 2						1830			28		
	" " 3						11890			277		
	" " 4						1427			114		
	" " 5						2110			229		
	" " 6						1215			91		
	" " 7						2895			99		
	" " 8						1214			65		
	" " 9						2832			252		
	" " 10						3118			256		
	" " 11						5241			334		
	" " 12						3975			75		
	SUB-TOTAL						37747			1820		
	FIELD WELD & TEST (ALLOW)						800			80		
	UTILITY SUPPORTS (ALLOW)						6000			60		
	CLEAN & TEST (ALLOW)						5000			120		
	SUB-TOTAL						49550			2080		
	PRODUCTIVITY (1.80 x 2080)	3744	MH			21 ⁷⁰				3744	81240	
	SUB-TOTAL						49550				81240	
	SUBCONTRACTOR MARKUP		%	35	80		17340				64970	
							66890				146210	213100

[illegible]

THE RALPH M. PARSONS COMPANY

ESTIMATE WORKSHEET

M.T.O. BY <u>L. BROOKS</u>		PRICED BY <u>EW</u>		DATE <u>JULY, 1981</u>		SHEET <u>3</u> OF <u>12</u>						
JOB NO.: <u>0154-3</u>		CLIENT: <u>US DOE</u>		TYPE OF ESTIMATE:		CKD BY:						
UNIT/AREA	DESCRIPTION	QUANTITY	UNIT	COST OR M/HR PER UNIT			MATERIAL EXPENSE	SUBCONTRACT		LABOR		TOTAL DOLLARS
CAPACITY				MATL	M/H	LAB \$		M/HR	DOLLARS	M/HR	DOLLARS	
ACCNT	LOW PRESSURE STEAM											
	SPEC N, CARBON STEEL											
	PIPE											
	2" XS THREADED ENDS	50	LF	2 ⁹⁰	.35		145			18		
	1 1/2" XS THREADED ENDS	100	LF	1 ⁹⁰	.30		190			30		
	1" XS THREADED ENDS	100	LF	1 ²⁰	.25		130			25		
	FITTINGS TEES 2x2x2	3		14-			42			7		
	1x1x1	4		8 ²⁰			33			6		
	ELLS 2" LR	10		10-			100			23		
	1 1/2" LR	10		8 ²⁰			85			17		
	1" LR	20		6 ²⁵			124			30		
	VALVES											
	GATE 2"	6		280	4		1680			24		
	1 1/2"	2		220	3		440			6		
	1"	8		190	3		1520			24		
	3/4"	5		160	2		800			10		
	GLOBE 1"	8		210	3		1680			24		
	PCV 2"	1		620	4		620			4		
	TCV 2"	2		620	4		1240			8		
	1 1/2"	1		480	3		480			3		
	1"	4		370	2		1480			8		
	TRAP, 3/4"	5		220	2		1100			10		
							11890			277		

ESTIMATE WORKSHEET

[illegible]

[illegible]

THE RALPH M. PARSONS COMPANY

ESTIMATE WORKSHEET

[illegible]

THE RALPH M. PARSONS COMPANY

ESTIMATE WORKSHEET

[illegible]

ESTIMATE WORKSHEET

M.T.O. BY	L.A.BROOKS	PRICED BY	RW	DATE	JULY, 1981	SHEET	9 OF 12	
JOB NO.	6154-3	CLIENT:		TYPE OF ESTIMATE:		CKD BY:		
UNIT/AREA	KRYPTON ENCAPSULATION	QUANTITY	UNIT	COST OR M/HRS PER UNIT	MATERIAL EXPENSE	SUBCONTRACT	LABOR	TOTAL DOLLARS
DESCRIPTION	ION IMPLANTATION / SPUTTERING			MATL M/H LAB \$		M/HRS DOLLARS	M/HRS DOLLARS	
CAPACITY								
ACCOUNT	CLOSED LOOP COOLING WATER RETURN							
	SPEC Q, CARBON STEEL							
	PIPE 2" SCH XS THREADED	100	LF	2 ⁹⁰ .35	290		35	
	1" SCH XS THREADED	80	LF	1 ³⁰ .25	104		20	
	FITTINGS							
	ELBOWS							
	90° 2" LR	8		10 ⁻ 2.3	80		18	
	90° 1" LR	44		6 ²⁰ 1.5	273		66	
	TEES 2"x2"x2"	4		14 ⁻ 2.3	56		9	
	2"x2"x1"	10		14 ⁻ 2.3	140		23	
	1"x1"x1"	6		8 ²⁰ 1.5	49		9	
	VALVES							
	GATE 2"	2		280 ⁻ 4	560		8	
	SOLENOID VALVES 1"	8		140 ⁻ 6	1120		48	
	FLEX HOSE w/ BUTT WELD END CONNECTIONS x 9" LG, 1"	8		20 ⁻ 2	160		16	
					2832		252	

ESTIMATE WORKSHEET

[illegible]

ESTIMATE WORKSHEET

M.T.O. BY LA. BROOKS		PRICED BY		DATE		SHEET 11 OF 12						
JOB NO.: 6154-3		CLIENT:		TYPE OF ESTIMATE:				CKD BY:				
UNIT/AREA	DESCRIPTION	QUANTITY	UNIT	COST OR M/MRS PER UNIT		MATERIAL EXPENSE		SUBCONTRACT		LABOR		TOTAL DOLLARS
CAPACITY				MATL	M/H	LAB \$		M/MRS	DOLLARS	M/MRS	DOLLARS	
	PRESSURIZED FIELD GAS											
	WV. SYSTEM											
	300 PSIG											
	SPEC V, T316L55											
	PIPE	150	LF	130	.25		195			30		
	FITTINGS											
	FLANGES 1" 300" W.D. RF	20		85	1.5		170			30		
	ELBOWS 1" 90° LR	45		620	1.5		279			68		
	ELBOWS 1" 45°	5		620	1.5		31			8		
	TEES 1" 1" x 1"	22		820	1.5		180			35		
	1" x 1" x 1"	4		820	1.5		33			6		
	1 1/2" x 1 1/2" x 1 1/2"	4		1040	1.7		42			7		
	REDUCERS											
	1 1/2" x 1"	8		640	1.5		51			12		
	VALVES 1" 300" GATE	5		240	4		1200			20		
	VALVES 1" 300" SOLENOIDS	18		160	6		2880			109		
	FLOW ELEMENTS	2		90	2		180			4		
							5241			334		

ESTIMATE WORKSHEET

[illegible]

THE RALPH M. PARSONS COMPANY

ESTIMATE WORKSHEET

M.T.O. BY <u>RW</u>		PRICED BY <u>RW</u>		DATE <u>JULY, 1981</u>		SHEET <u> </u> OF <u> </u>						
JOB NO.: <u>0154-3</u>		CLIENT: <u>US DOE</u>		TYPE OF ESTIMATE:		CKD BY:						
UNIT/AREA	DESCRIPTION	QUANTITY	UNIT	COST OR M/HR PER UNIT			MATERIAL EXPENSE	SUBCONTRACT		LABOR		TOTAL DOLLARS
CAPACITY				MATL	M/H	LABS		M/HR	DOLLARS	M/HR	DOLLARS	
ACCNT												
500	BUILDINGS											
	<u>INSTRUMENTATION</u>											
	CONTROL INSTRUMENTATION (15% OF PIPING)						7430			312		
	HVAC (10% OF HVAC)						21430			199		
	RADIATION MONITORING (ALLOW)						10000			100		
	PROCESS CONTROLS (ALLOW)						15000			150		
	DATA PROCESSING (ALLOW)						20000			100		
	SUB-TOTAL						73860			861		
	PRODUCTIVITY (1.80 x 861)	1550	MH			20%				1550	32400	
	SUB-TOTAL						73860				32400	
	SUBCONTRACTOR MARK-UP			%	35	80	25850				25850	
	TOTAL						99710				58250	158000

THE RALPH M. PARSONS COMPANY

ESTIMATE WORKSHEET

M.T.O. BY SHR		PRICED BY RV		DATE July, 1981		SHEET OF	
JOB NO.: 6154-3		CLIENT: US DOE		TYPE OF ESTIMATE:		CKD BY:	
UNIT/AREA	DESCRIPTION	QUANTITY	UNIT	COST OR M/HRS PER UNIT	MATERIAL	SUBCONTRACT	LABOR
	ION IMPLANTATION/SPUTTERING				EXPENSE		
	CAPACITY				M/HRS	DOLLARS	DOLLARS
ACCT							
500 BUILDING							
ELECTRICAL SUMMARY							
PRODUCTIVITY (1.80 * 5088)		9158	MH	20%	210460	5088	191040
SUB-TOTAL					210460		191040
SUBCONTRACTOR MARK-UP		%	35.80		73660		152840
TOTAL					284120		243880
							628000

THE RALPH M. PARSONS COMPANY

ESTIMATE WORKSHEET

M.T.O. BY <u>S. H. Rowe</u>		PRICED BY		DATE <u>6/12/81</u>		SHEET <u>1</u> OF <u>2</u>					
JOB NO.: <u>6154-3</u>		CLIENT: <u>DOE</u>		TYPE OF ESTIMATE:		CKD BY:					
UNIT/AREA	QUANTITY	UNIT	COST OR M/HR PER UNIT			MATERIAL EXPENSE	SUBCONTRACT		LABOR		TOTAL DOLLARS
DESCRIPTION CAPACITY			MATL	M/H	LAB \$		M/HR	DOLLARS	M/HR	DOLLARS	
ACCNT											
	1000 KVA Unit Substation US1	1	EA			50400			60		
	MCC 1 480/277V C/D Type B	1	EA			22000			80		
	MCC 2 480/277V C/D Type B	1	EA			14000			64		
	45 KVA Xfrm 480-208Y/120V	1	EA								
	9 KVA Xfrm 480-208Y/120V	1	EA			470			9		
	Panel/board ELA 8 CKT	1	EA			200			8		
	Panel/board ELB 4 CKT	1	EA			170			6		
	Panel/board LPA 42 CKT	1	EA			800			28		
	Panel/board ELPB 12 CKT	1	EA			244			10		
	60A Wlding Recp & SW	1	EA			400			4		
	30A Disc SW	1	EA			35			2		
	480V Motor & Load Conn < 10 HP	13	EA	1.20	2	110			26		
	15 HP	2	EA	1.30	2.1	3			6		
	Area Ltg, Wire & Conduit	7100	SF	2.40	.08	17040			568		
	Special Cell Lts	8	EA	1000	5	8000			40		
	Recp, Wire & Conduit	7100	SF	1.80	.06	12780			426		
	Multiplexer & Terminal Bd.	1	EA			5000			60		

[illegible]

THE RALPH M. PARSONS COMPANY

ESTIMATE WORKSHEET

M.T.O. BY <u>E. Hom</u>		PRICED BY <u>E. Hom / RW</u>		DATE <u>JULY, 1981</u>		SHEET <u>1</u> OF <u>5</u>						
JOB NO.: <u>6154-3</u>		CLIENT: <u>US DOE</u>		TYPE OF ESTIMATE:		CKD BY:						
UNIT/AREA	DESCRIPTION	QUANTITY	UNIT	COST OR M/HR PER UNIT			MATERIAL EXPENSE	SUBCONTRACT		LABOR		TOTAL DOLLARS
CAPACITY				MATL	M/H	LAB \$		M/HR	DOLLARS	M/HR	DOLLARS	
ACCNT												
500	BUILDINGS											
	<u>HVAC SUMMARY</u>											
	FROM SHT. 2						11950			198		
	" " 3						161550			351		
	" " 4						14220			189		
	" " 5						26610			1250		
	" "											
	SUB-TOTAL						214330			1988		
	PRODUCTIVITY (1.80 x 1988)	3578	MH			1988				3578	69410	
	SUB-TOTAL						214330				69410	283740
	SUBCONTRACTOR MARK-UP		%	35	80		75020				55540	130560
	TOTAL						289350				124950	414300

ESTIMATE WORKSHEET

[illegible]

THE RALPH M. PARSONS COMPANY

ESTIMATE WORKSHEET

M.T.O. BY <u>E. HOM</u>		PRICED BY		DATE <u>6-9-81</u>				SHEET <u>3</u> OF <u>5</u>				
JOB NO.: <u>6154-3</u>		CLIENT: <u>DOE</u>		TYPE OF ESTIMATE:				CKD BY:				
UNIT/AREA		QUANTITY	UNIT	COST OR M/HR PER UNIT			MATERIAL EXPENSE	SUBCONTRACT		LABOR		TOTAL DOLLARS
DESCRIPTION <u>KRYPTON ENCAPSULATION</u>				MATL	M/H	LABS		M/HR	DOLLARS	M/HR	DOLLARS	
CAPACITY <u>SPUTTERING CONCEPT</u>												
ACCNT												
	<u>HVAC</u>											
	<u>STEAM HEATING COIL</u>	<u>1</u>	<u>EA</u>	<u>250</u>	<u>7</u>		<u>250</u>			<u>7</u>		
	<u>1170 CFM & 53,000 BTU/HR</u>											
	<u>2-FT² FACE AREA, 1-ROW</u>											
	<u>+ 40°F ENT. & + 90°F LV. AIR</u>											
	<u>15 PSIG STEAM</u>											
	<u>SPRAY COOLING CHAMBER</u>	<u>2</u>	<u>EA</u>	<u>5000</u>	<u>40</u>		<u>10000</u>			<u>80</u>		
	<u>FILTER FIRE PROTECTION</u>											
	<u>5000 CFM & 10 FT² FACE AREA</u>											
	<u>1-BANK SPRAY NOZZLES,</u>											
	<u>MOISTURE SEPARATOR, DRAIN PAN</u>											
	<u>EXHAUST AIR HEPA FILTER</u>	<u>2</u>	<u>EA</u>	<u>75000</u>	<u>120</u>		<u>150000</u>			<u>240</u>		
	<u>PLENUM, 6000 CFM RATING</u>											
	<u>FLANDERS FILTERS CO.</u>											
	<u>2-STAGES OF HEPA FILTERS</u>											
	<u>24"X24"X11 1/2" FLUID SEAL TYPE</u>											
	<u>ARRANGED 2-WIDE BY 3-HIGH</u>											
	<u>BAG-OUT TYPE E-4 FILTER</u>											
	<u>HOUSINGS WITH IN-PLACE</u>											
	<u>REMOTE DDP TEST SECTIONS</u>											
	<u>T-I, T-C, & T-O.</u>											
	<u>SUPPLY AIR FILTER BOX</u>	<u>2</u>	<u>EA</u>	<u>650</u>	<u>12</u>		<u>1300</u>			<u>24</u>		
	<u>CAP. 5,000 CFM</u>											
	<u>FARR CO. SIDE LOADING</u>											
	<u>MODEL 3P UNIVERSAL GLIDE PACK</u>											
	<u>WITH 4-24"X24"X4" TYPE 30/30</u>											
	<u>30% EFF PREFILTERS &</u>											
	<u>4-24"X24"X12"-90% EFF.</u>											
	<u>TYPE HP-200 HIGH EFF. FILTERS</u>											
							<u>161550</u>			<u>351</u>		

THE RALPH M. PARSONS COMPANY

ESTIMATE WORKSHEET

M.T.O. BY <u>E. HOM</u>		PRICED BY		DATE <u>6-9-81</u>				SHEET <u>4</u> OF <u>5</u>						
JOB NO.: <u>6154-3</u>		CLIENT: <u>DOE</u>		TYPE OF ESTIMATE:				CKD BY:						
UNIT/AREA		QUANTITY	UNIT	COST OR M/HR\$ PER UNIT			MATERIAL EXPENSE	SUBCONTRACT			LABOR			TOTAL DOLLARS
DESCRIPTION				MATL	M/H	LAB \$		M/HR\$	DOLLARS	M/HR\$	DOLLARS			
CAPACITY		SPUTTERING CONCEPT												
ACCNT	HVAC													
	REFRIGERANT COOLING COIL													
	CAP. 1170 CFM @ 30,000 BTU/HR													
	2.5 FT ² FACE AREA, 3-ROW DX													
	VENT FAN													
	CAP. 18,000 CFM AT 1.0"SP, 15HP													
	NEW YORK BLOWER CO.													
	TUBULAR ACOUSTAFOL TYPE													
	SIZE T-309, IN-LINE													
	CENTRIFUGAL TYPE													
	VENT FAN													
	CAP. 18,000 CFM AT 1.0"SP, 15HP													
	NEW YORK BLDWER CO.													
	TUBULAR ACOUSTAFOL TYPE													
	SIZE T-309, IN-LINE													
	CENTRIFUGAL TYPE PROVIDED													
	WITH INLET VORTEX DAMPERS													
	STEAM UNIT HEATER													
	CAP. 50,000 BTU/HR, 15PSIG													
	STEAM, HORIZ. SUSPENDED TYPE													
	TRANE CO. MODEL 60-S													
	POWER ROOF VENTILATOR													
	150 CFM AT 3/8" SP.													
	SPUN ALUMINUM LOW SILHOUETTE													
	TYPE													
							14220				187			

THE RALPH M. PARSONS COMPANY

ESTIMATE WORKSHEET

M.T.O. BY E.HOM			PRICED BY		DATE 6-9-81		SHEET 5 OF 5					
JOB NO.: 6154-3			CLIENT: DOE		CKD BY:							
UNIT/AREA			TYPE OF ESTIMATE:									
ACCNT	DESCRIPTION	QUANTITY	UNIT	COST OR M/HR PER UNIT			MATERIAL EXPENSE	SUBCONTRACT		LABOR		TOTAL DOLLARS
				MATL	M/H	LAB \$		M/HR	DOLLARS	M/HR	DOLLARS	
	HVAC											
	AIR COOLED REFRIGERANT	1	EA	400	40		400				40	
	CONDENSING UNIT											
	CAP. 30,000 BTU/HR, 95°F ENT AIR											
	CARRIER 38 GS 042, 4 KW											
	GRAVITY ROOF VENTILATOR	4	EA	600	25		2400				100	
	36 FT² THROAT AREA											
	ALL ALUM. CONSTRUCTION											
	DUCTWORK, GALV. STEEL	4000	LB	1.50	0.08		6000				320	
	DUCTWORK, STAINLESS STEEL	1600	LB	3.90	0.10		6240				160	
	GRILLES & REGISTERS	1	LS				2000				60	
	MANUAL, BALANCING, BACKDRAFT DAMPERS	1	LS				2500				50	
	REFRIG. TUBING, COPPER TYPE "L"											
	20' - 1 1/2" OD	1	LS				120				20	
	20' - 5/8" OD	1	LS				150				20	
	INSULATION	1	LS				600				40	
	AUTOMATIC CONTROLS - HONEYWELL	1	LS				2200				220	
	PRESS. DIFFERENTIAL CONTROL -											
	AIR MONITOR	1	LS				3000				120	
	TEST & BALANCE	1	LS				1000				100	
							26610				1250	

THE RALPH M. PARSONS COMPANY

ESTIMATE WORKSHEET

M.T.O. BY <i>RW</i>		PRICED BY <i>EW</i>		DATE <i>JULY, 1981</i>				SHEET <i> </i> OF <i> </i>				
JOB NO.: <i>6154-3</i>		CLIENT: <i>US DOE</i>		TYPE OF ESTIMATE:				CKD BY:				
UNIT/AREA	DESCRIPTION	QUANTITY	UNIT	COST OR M/HR PER UNIT			MATERIAL EXPENSE	SUBCONTRACT		LABOR		TOTAL DOLLARS
CAPACITY				MATL	M/H	LAB \$		M/HR	DOLLARS	M/HR	DOLLARS	
ACCNT												
<i>500</i>	<i>BUILDINGS</i>											
	<i>FIRE PROTECTION, EST</i>	<i>5200</i>	<i>SF</i>	<i>5⁰⁰</i>	<i>.10</i>		<i>26000</i>			<i>520</i>		
	<i>PRODUCTIVITY (1.8 x 520)</i>	<i>936</i>	<i>MH</i>			<i>19⁴⁰</i>				<i>936</i>	<i>18160</i>	
	<i>SUB-TOTAL</i>						<i>26000</i>				<i>18160</i>	<i>44160</i>
	<i>SUBCONTRACTOR MARK-UP</i>			<i>%</i>	<i>35</i>	<i>80</i>	<i>9100</i>				<i>14540</i>	<i>23640</i>
	<i>TOTAL</i>						<i>35100</i>				<i>32700</i>	<i>67800</i>

THE RALPH M. PARSONS COMPANY

ESTIMATE WORKSHEET

M.T.O. BY <u>RW</u>		PRICED BY <u>RW</u>		DATE <u>JULY, 1981</u>				SHEET <u> </u> OF <u> </u>				
JOB NO.: <u>6154-3</u>		CLIENT: <u>US DOE</u>		TYPE OF ESTIMATE:				CKD BY:				
UNIT/AREA	DESCRIPTION	QUANTITY	UNIT	COST OR M/HR PER UNIT			MATERIAL EXPENSE	SUBCONTRACT		LABOR		TOTAL DOLLARS
CAPACITY				MATL	M/H	LAB \$		M/HR	DOLLARS	M/HR	DOLLARS	
ACCNT												
500	BUILDINGS											
	<u>PLUMBING</u>											
	ROOF DRAINS, EST.						5000			250		
	LAVATORY FIXTURES, EST.						5000			100		
	DRAINS & VENTS, EST.						10000			500		
	WATER SERVICES, EST.						3000			200		
	SUB-TOTAL						23000			1050		
	PRODUCTIVITY (1.80 x 1050)	1890	MH			21 ¹⁰				1890	41010	
	SUB-TOTAL						23000				41010	64010
	SUBCONTRACTOR MARK-UP			%	35	80	8050				32810	40890
	TOTAL						31050				73850	104900

THE RALPH M. PARSONS COMPANY

ESTIMATE WORKSHEET

M.T.O. BY <u>AW</u>		PRICED BY <u>AW</u>		DATE <u>JULY, 1981</u>		SHEET <u> </u> OF <u> </u>				
JOB NO.: <u>6154-3</u>		CLIENT: <u>US DOE</u>		CKD BY:						
UNIT/AREA	DESCRIPTION	QUANTITY	UNIT	TYPE OF ESTIMATE:		SUBCONTRACT		LABOR		TOTAL DOLLARS
CAPACITY				COST OR M/HR PER UNIT		M/HR	DOLLARS	M/HR	DOLLARS	
				MATL	M/H	LAB \$				
500	BUILDINGS									
	<u>SPECIAL Bldg. COMPONENTS</u>									
	PRODUCT STORAGE									
	7'-6" x 7'-6" x 26' STORAGE ASSEMBLY	2285	LB	8.22	.20				457	
	CONSTRUCTED OF 304LSS ANGLE	1260	LB	4.22	.05				65	
	1/2" PLATE W/ NITRONIC 60 ROLLERS,	12760	LB	3.22	.10				1276	
	2 PAIR ON 6" C/C, TYP. OF 36	25520	LB	3.22	.02				510	
	POSITIONS, TOTAL OF 468	7160	LB	3.22	.02				143	
	STORAGE SPACES	716	LB	3.22	1.0				716	
	7488 1" O.D. x 9/16" I.D. BOLLS									
	7488 1/2" Ø STAY BOLTS									
	14976 1/2" PLATE BRACKETS									
	72-4 x 4 x 1/2" x 26' ANGLES									
	35-4 x 4 x 1/2" x 7'-6" COLUMNS									
	35-6" x 6" x 1" BASE PL.									
	SUB-TOTAL	49700	LB				161790		3165	
	SHIELDING WINDOWS									
	3-30" x 30" WINDOWS (CELL									
	OPERATING, INSPECTION, AND									
	SEALING)									
	1-18" x 16" (PRODUCT	1	LOT				42000		360	
	LOAD-IN)									
	SUB-TOTAL	6165	NH			20.15	203790		3425	125150
	PRODUCTIVITY (180 x 3425)									
	SUB-TOTAL									
	SUBCONTRACTOR MARK-UP		%	35	80					
	TOTAL									
	</									

ESTIMATE WORKSHEET

M.T.O. BY <u>BU</u>		JOB NO.: <u>6154-3</u>		CLIENT: <u>US DOE</u>		PRICED BY <u>BU</u>		DATE <u>JULY, 1981</u>		SHEET <u>OF</u>		CKD BY:	
DESCRIPTION		QUANTITY	COST OR M/HRS PER UNIT	MATL	M/H	LAB \$	MATERIAL EXPENSE	SUBCONTRACT	LABOR	TOTAL DOLLARS			
700 EQUIPMENT													
Summary													
VESSELS & TANKS													
PUMPS													
AGITATORS													
HEAT EXCHANGERS													
COMPRESSORS													
SPUTTERING CHAMBERS													
PROCESS SPECIALTIES													
OTHER MAJOR EQUIPMENT													
SUB-TOTAL													
SEISMIC QUALIFICATION (20% OF MAT'L)													
PRODUCTIVITY (1.80 x 3170)													
5706 M/H													
2035													
182520													
912580													
554000													
1650													
52000													
29000													
98000													
4400													
20800													
152730													
350													
220													
40													
280													
160													
160													
20													
1940													
3170													
5706													
115830													
SUB-TOTAL													
1095100													
383290													
1478390													
1480000													
USE													
TOTAL													
214290													
1692680													
98460													
481750													
115830													
1210930													
215000													
1695000													

Downloaded from <http://ajph.org/> on November 10, 2014

THE RALPH M. PARSONS COMPANY

ESTIMATE WORKSHEET

[illegible]

THE RALPH M. PARSONS COMPANY

ESTIMATE WORKSHEET

M.T.O. BY <i>RW</i>		PRICED BY <i>RW</i>		DATE <i>JULY, 1981</i>		SHEET <i> </i> OF <i> </i>						
JOB NO.: <i>6154-3</i>		CLIENT: <i>US DOE</i>		TYPE OF ESTIMATE:		CKD BY:						
UNIT/AREA	DESCRIPTION	QUANTITY	UNIT	COST OR M/HR PER UNIT			MATERIAL EXPENSE	SUBCONTRACT		LABOR		TOTAL DOLLARS
CAPACITY				MATL	M/H	LAB \$		M/HR	DOLLARS	M/HR	DOLLARS	
ACCNT												
	<i>700 EQUIPMENT</i>											
	<u><i>HEAT EXCHANGERS</i></u>											
	<i>KEF-II-HE1, FEED GAS COOLER, 20,000 BTU/HR, 316 SS SHELL & TUBES, C.S. CHANNEL, 600 PSIG DESIGN</i>	<i>1</i>	<i>EA</i>	<i>18000</i>	<i>LOT</i>		<i>18000</i>			<i>80</i>		
	<i>KEF-II-HE2, COOLING WATER HEAT EXCHANGER, 2,000,000 BTU/HR, C.S. SHELL & BONNET, ADMIRALTY TUBES</i>	<i>1</i>	<i>EA</i>	<i>80000</i>	<i>LOT</i>		<i>80000</i>			<i>200</i>		
	<i>SUB-TOTAL</i>						<i>98000</i>			<i>280</i>		
	<u><i>COMPRESSORS</i></u>											
	<i>KEF-II-COM1 & 2, FEED GAS MIXTURE COMPRESSORS, TRIPLE DIAPHRAGM, 200 PSIG INLET, 500 PSIG OUTLET, 1CFM, 400 RPM, 316 SS</i>	<i>2</i>	<i>EA</i>	<i>14500</i>	<i>LOT</i>		<i>29000</i>			<i>160</i>		

THE RALPH M. PARSONS COMPANY

ESTIMATE WORKSHEET

M.T.O. BY <u>RW</u>		PRICED BY <u>RW</u>		DATE <u>JULY, 1981</u>		SHEET <u> </u> OF <u> </u>		
JOB NO.: <u>0154-3</u>		CLIENT: <u>US DOE</u>		CKD BY: <u> </u>				
UNIT/AREA DESCRIPTION (on implantation) <u>SPUTTERING CAPACITY</u>		TYPE OF ESTIMATE:		SUBCONTRACT		LABOR		TOTAL DOLLARS
ACCNT		QUANTITY	UNIT	COST OR M/HR PER UNIT	MATERIAL EXPENSE	M/HR	DOLLARS	
		MATL	M/H	LAB \$				
<u>700 Equipment</u>								
<u>SPUTTERING CHAMBER</u>								
<u>SPUTTERING HEADS, PEDASTAL SUPPORTED CONNECTOR ASSEMBLY, EST, T316SS</u>		8	EA	4000	2.0		32000	160
<u>SHIELDED COOLING JACKETS, LEAD & T-316 SS, EST</u>		8	EA	2500	—		20000	—
<u>SUB-TOTAL</u>							52000	160
<u>PROCESS SPECIALTIES</u>								
<u>KEF-II-F1, FEED GAS FILTER, IN-LINE, 2 1/4", 750 PSIG DESIGN, 316 SS</u>		1	EA	450	0		450	8
<u>SUMP SAMPLER, SUMP CATCH TANK SAMPLER, PLUNGER TYPE, AIR OPERATED, SOLENOID ACTIVATED, MANUAL INITIATED</u>		2	EA	600	6		1200	12
<u>SUB-TOTAL</u>							1650	20

THE RALPH M. PARSONS COMPANY

ESTIMATE WORKSHEET

M.T.O. BY <u>A. Smith</u>		PRICED BY <u>A. Smith/RW</u>		DATE <u>July, 1981</u>		SHEET <u> </u> OF <u> </u>	
JOB NO.: <u>6154-3</u>		CLIENT: <u>US DOE</u>		TYPE OF ESTIMATE: <u> </u>		CKD BY: <u> </u>	
UNIT/AREA	DESCRIPTION	QUANTITY	COST OR M/HRS PER UNIT	MATERIAL	SUBCONTRACT	LABOR	TOTAL DOLLARS
CAPACITY	1000 IMPERIAL/SPUTTERERS						
700 Equipment							
Other Major Equipment							
	MULTIPLIER Robo Carree	2 EA	100.000	50	200.000	100	
	AUTOMATIC WELDER	1 EA	80.000	200	80.000	200	
	LEAK DETECTOR	1 EA	20.000	150	20.000	150	
	MASTER SUTURE MANIPULATOR, Model "F"	4 EA	21.000	60	84.000	240	
	SPECIAL TOOLS & FIXTURES	1 LOT	10.000	10	10.000	10	
	BRIDGE CRANE, 5 TON/2-1/2 T	1 EA	150.000	1200	150.000	1200	
	2 TON MONORAIL HOIST	1 EA	10.000	40	10.000	40	
SUB-TOTAL					554.000	1940

THE RALPH M. PARSONS COMPANY

E-2

PROJECT NAME: KRYPTON ENCAPSULATION PRECONCEPTUAL DESIGN
ZEOLITE ENCAPSULATION FACILITY DATE JULY, 1981

ESTIMATE OF COST _____ PAGE _____ OF _____

PROJECT NO. 6154-3 SUMMARY BY _____

ACCT. NO.	DESCRIPTION	LABOR COST \$	MATERIAL COST \$	TOTAL COST \$
	DIRECT COST			
400	IMPROVEMENTS TO LAND	22,000	2,000	24,000
500	BUILDING & OTHER STRUCTURES	1,325,000	1,290,000	2,615,000
600	UTILITIES (NOT INCLUDED)	_____	_____	_____
700	EQUIPMENT	230,000	1,895,000	2,125,000
800	DEMOLITION & REMOVALS (NONE)	_____	_____	_____
	TOTAL DIRECT COST	1,577,000	3,187,000	4,764,000
	CONTRACTOR INDIRECTS @ 10%			476,000
	TOTAL CONSTRUCTION COST			5,240,000
	TITLE I @ 6%			315,000
	TITLE II @ 14%			734,000
	TITLE III @ 8%			421,000
	A - FIELD INSPECTION			
	B - SHOP INSPECTION			
	PROJECT ADMINISTRATION @ 10%			525,000
	SUB-TOTAL ENGINEERING			1,995,000
	SUB-TOTAL			7,235,000
	ESCALATION (NOT INCLUDED)			
	SUB-TOTAL			7,235,000
	CONTINGENCY @ 40%			2,895,000
	TOTAL JOB COST			10,130,000

THE RALPH M. PARSONS COMPANY

ESTIMATE WORKSHEET

M.T.O. BY <i>RW</i>		PRICED BY <i>RW</i>		DATE <i>JULY, 1981</i>				SHEET <i> </i> OF <i> </i>				
JOB NO.: <i>6154-3</i>		CLIENT: <i>U.S. DOE</i>		TYPE OF ESTIMATE:				CKD BY:				
UNIT/AREA	DESCRIPTION	QUANTITY	UNIT	COST OR M/HR PER UNIT			MATERIAL EXPENSE	SUBCONTRACT		LABOR		TOTAL DOLLARS
CAPACITY				MATL	M/H	LAB \$		M/HR	DOLLARS	M/HR	DOLLARS	
ACCNT												
400	IMPROVEMENTS TO LAND											
	SITE CLEARING	6000	SY	-	.014					84		
	EXCAVATION	610	CY	-	.15					92		
	COMPACTED BACKFILL	200	CY	2 nd	.16		400			32		
	GRADING	4700	SF	-	.012					56		
	DISPOSAL	410	CY	-	.10					41		
	CONCRETE WALKS (EST) 6" THK	400	SF	1 st	.10		640			40		
	SUB-TOTAL						1040			345		
	PRODUCTIVITY (1.80 x 345)	621	MH			1950				621	12110	
	SUB-TOTAL						1040				12110	13150
	SUBCONTRACTOR MARK-UP		%	35	80		360				9690	
	TOTAL 400						1400				21800	23200
	USE						2000				22000	24000

THE RALPH M. PARSONS COMPANY

ESTIMATE WORKSHEET

M.T.O. BY <u>RW</u>		PRICED BY <u>RW</u>		DATE <u>JULY, 1981</u>		SHEET <u> </u> OF <u> </u>						
JOB NO.: <u>6154-3</u>		CLIENT: <u>U.S. DOE</u>		TYPE OF ESTIMATE:		CKD BY:						
UNIT/AREA	DESCRIPTION	QUANTITY	UNIT	COST OR M/HR PER UNIT			MATERIAL EXPENSE	SUBCONTRACT		LABOR		TOTAL DOLLARS
CAPACITY				MATL	M/H	LAB \$		M/HR	DOLLARS	M/HR	DOLLARS	
ACCNT												
500	BUILDINGS & STRUCTURES											
	CONCRETE						170 460			4646	154 740	325 200
	MASONRY						2620			616	21 480	24 100
	STRUCTURAL STEEL & MISC. METALS						52 840			835	31 260	84 100
	FINISHES						33 510			3130	108 790	142 300
	PAINTING & SPECIAL COATING						3860			1546	54 340	58 200
	DOORS & WINDOWS						23 750			378	13 250	37 200
	SPECIALTIES						7 210			166	5 890	13 100
	PIPING						84 210			3991	155 890	240 100
	INSTRUMENTATION						92 460			1492	31 180	148 600
	ELECTRICAL						221 810			7151	275 990	497 800
	HVAC						190 200			2621	91 500	281 700
	FIRE PROTECTION						29 700			792	30 900	60 600
	PLUMBING						27 000			1620	54 300	91 300
	SPECIAL BLDG. COMPONENTS						344 770			8048	294 010	668 800
	TOTAL 500						1 284 620				1 323 520	2 608 140
	USE						1 290 000				1 325 000	2 615 000

THE RALPH M. PARSONS COMPANY

ESTIMATE WORKSHEET

M.T.O. BY <u>RW</u>		PRICED BY <u>RW</u>		DATE <u>JULY, 1981</u>				SHEET <u> </u> OF <u> </u>							
JOB NO.: <u>6154-3</u>		CLIENT: <u>U.S. DOE</u>		TYPE OF ESTIMATE:				CKD BY:							
UNIT/AREA	DESCRIPTION	QUANTITY	UNIT	COST OR M/HR PER UNIT			MATERIAL EXPENSE		SUBCONTRACT		LABOR		TOTAL DOLLARS		
CAPACITY				MATL	M/H	LAB \$			M/HR	DOLLARS	M/HR	DOLLARS			
ACCNT															
	<u>500 BUILDINGS</u>														
	<u>CONCRETE</u>														
	<u>FOUNDATION</u>	<u>207</u>	<u>CY</u>				<u>37970</u>				<u>845</u>				
	<u>WALLS</u>	<u>188</u>	<u>CY</u>				<u>65380</u>				<u>1182</u>				
	<u>SUSPENDED SLABS</u>	<u>94</u>	<u>CY</u>				<u>22920</u>				<u>554</u>				
	<u>SUB-TOTAL</u>	<u>489</u>	<u>CY</u>				<u>126270</u>				<u>2581</u>				
	<u>PRODUCTIVITY (1.80x2581)</u>	<u>4646</u>	<u>MH</u>			<u>1850</u>					<u>4646</u>		<u>85950</u>		
	<u>SUB-TOTAL</u>						<u>126270</u>						<u>85950</u>		
	<u>SUB-CONTRACTOR MARK-UP</u>		<u>%</u>	<u>35</u>	<u>80</u>		<u>44190</u>						<u>68790</u>		
	<u>TOTAL</u>						<u>170460</u>						<u>154740</u>	<u>325200</u>	

THE RALPH M. PARSONS COMPANY

ESTIMATE WORKSHEET

M.T.O. BY <i>RW</i>		PRICED BY <i>RW</i>		DATE <i>JULY, 1981</i>		SHEET ____ OF ____						
JOB NO.: <i>6154-3</i>		CLIENT: <i>U.S. DOE</i>		TYPE OF ESTIMATE:		CKD BY:						
UNIT/AREA	DESCRIPTION	QUANTITY	UNIT	COST OR M/HR PER UNIT			MATERIAL EXPENSE	SUBCONTRACT		LABOR		TOTAL DOLLARS
CAPACITY				MATL	M/H	LAB \$		M/HR	DOLLARS	M/HR	DOLLARS	
ACCNT												
500	BUILDINGS & STRUCTURES											
	CONCRETE											
	FOUNDATION											
	VAPOR BARRIER	4700	SF	.20	.005		940			24		
	CONCRETE FOOTINGS	159	CY	.60	.40		9540			64		
	SLAB ON GRADE (3900 SF)	48	CY	.60	.30		2880			14		
	FORMWORK	3400	SF	.71	.01		2410			34		
	REBAR (190 #/CY)	20	Ton	700	16		14000			320		
	EMBEDS (C.S., 75 #/CY)	8	Ton	2500	40		20000			320		
	FINISH	4600	SF	.04	.015		180			69		
	SUB-TOTAL						37970			845		
	WALLS											
	CONCRETE WALLS (12" THK)	179	CY	.60	.70		10740			125		
	PARAPET (8" THK)	7	CY	.60	.70		420			5		
	COLUMNS (12" x 12")	1.5	CY	.60	.70		90			1		
	FORMWORK	14500	SF	.71	.02		10300			290		
	REBAR (240 #/CY)	22.5	Ton	700	18		15750			405		
	EMBEDS (120 #/CY)	11	Ton	2500	60		27500			66		
	FINISH	14500	SF	.04	.02		580			290		
	SUB-TOTAL						65380			1182		
	SUSPENDED SLAB											
	CONCRETE (12" THK)	94	CY	.60	.40		5640			38		
	FORMWORK	2600	SF	1.30	.04		3380			104		
	REBAR (190 #/CY)	9	Ton	700	20		6300			180		
	EMBEDS (60 #/CY)	3	Ton	2500	60		7500			180		
	FINISH	2400	SF	.04	.02		100			52		
	SUB-TOTAL						22920			554		

THE RALPH M. PARSONS COMPANY

ESTIMATE WORKSHEET

M.T.O. BY <u>RW</u>		PRICED BY <u>RW</u>		DATE <u>JULY, 1981</u>				SHEET <u> </u> OF <u> </u>				
JOB NO.: <u>6154-3</u>		CLIENT: <u>U.S. DOE</u>		TYPE OF ESTIMATE:				CKD BY:				
UNIT/AREA	DESCRIPTION	QUANTITY	UNIT	COST OR M/HR PER UNIT			MATERIAL EXPENSE	SUBCONTRACT		LABOR		TOTAL DOLLARS
CAPACITY				MATL	M/H	LAB \$		M/HR	DOLLARS	M/HR	DOLLARS	
ACCNT												
ECO	BUILDINGS & STRUCTURES											
	MASONRY											
	8" CONCRETE BLOCK	1680	SF	1.10	0.15		1850			252		
	12" CONCRETE BLOCK	60	SF	1.50	0.20		90			90		
	SUB-TOTAL						1940			342		
	PRODUCTIVITY (1.80 x 342)	616	MH			1940				616	11950	
	SUB-TOTAL						1940				11950	13890
	SUB-CONTRACTOR MARK-UP		%	35	80		680				9530	10210
	TOTAL						2620				21480	24100

THE RALPH M. PARSONS COMPANY

ESTIMATE WORKSHEET

M.T.O. BY <u>RW</u>		PRICED BY <u>RW</u>		DATE		SHEET ____ OF ____						
JOB NO.: <u>6154-3</u>		CLIENT: <u>U.S. DOE</u>		TYPE OF ESTIMATE:		CKD BY:						
UNIT/AREA	DESCRIPTION	QUANTITY	UNIT	COST OR M/HR PER UNIT			MATERIAL EXPENSE	SUBCONTRACT		LABOR		TOTAL DOLLARS
CAPACITY				MATL	M/H	LAB \$		M/HR	DOLLARS	M/HR	DOLLARS	
ACCNT												
500	BUILDINGS											
	<u>STRUCTURAL STEEL & Misc. METALS</u>											
	OPEN WEB STEEL JOISTS (12 @ 1200)	7.2	Ton	600	8		4320			58		
	METAL DECKING	1700	SF	3 ¹⁰	.02		5440			34		
	PIPES, PLATES & ROOS (EST)	2	Ton	1360	10		2720			20		
	MISCELLANEOUS SUPPORTS (EST)	14	Ton	1390	20		19460			280		
	MISC. (EST)	6	Ton	1200	12		7200			72		
	SUB-TOTAL						39140			464		
	PRODUCTIVITY (1.80 x 464)	835	MH			20 ⁰⁰				835	17370	
	SUB-TOTAL						39140				17370	56510
	SUBCONTRACTORS MARK-UP		%	35	80		13700				13890	27590
	TOTAL						52840				31260	84100

THE RALPH M. PARSONS COMPANY

ESTIMATE WORKSHEET

M.T.O. BY <i>RD</i>		PRICED BY <i>RD</i>		DATE <i>JULY, 1981</i>				SHEET <i> </i> OF <i> </i>				
JOB NO.: <i>6154-3</i>		CLIENT: <i>U.S. DOE</i>		TYPE OF ESTIMATE:				CKD BY:				
UNIT/AREA <i>KRYPTON ENCAPSULATION</i>		QUANTITY	UNIT	COST OR M/HR PER UNIT			MATERIAL EXPENSE	SUBCONTRACT		LABOR		TOTAL DOLLARS
DESCRIPTION <i>ZEOLITE ENCAPSULATION</i>				MATL	M/H	LAB \$		M/HR	DOLLARS	M/HR	DOLLARS	
CAPACITY												
ACCENT												
500	BUILDINGS											
	<u>FINISHES</u>											
	INSULATED METAL SIDING	4250	SF	2 ⁸⁰	.08		11700			340		
	INVERTED ROOFING SYSTEM	4400	SF	1 ⁸⁰	.25		7720			1100		
	FLASHING & SHEET METAL	550	LF	1 ⁰⁰	.15		550			83		
	4" METAL STUDS x 9' 6" (16" c/c)	210	LF	5 ⁸⁰	.19		1220			40		
	5/8" THK. GYPSUM BOARD (TYPE X)	1650	SF	0 ³⁰	.015		500			25		
	5/8" THK. GYPSUM BOARD	2280	SF	0 ²⁰	.015		460			34		
	SUSPENDED PLASTER CEILING	600	SF	1 ¹⁵	.05		690			30		
	SUSPENDED ACOUSTICAL CEILING	750	SF	0 ⁸⁰	.02		600			15		
	CERAMIC TILE WALLS	130	SF	1 ⁴⁵	.10		190			13		
	CERAMIC TILE FLOORING	250	SF	1 ⁴⁵	.10		360			25		
	VINYL ASBESTOS TILE FLOORING	850	SF	0 ⁶⁰	.04		430			34		
	SUB-TOTAL						24820			1739		
	PRODUCTIVITY (1.80 x 1739)	3130	MH			19 ³⁰				3130	60410	
	SUB-TOTAL						24820				60410	85230
	SUB-CONTRACTOR MARK-UP		%	35	80		8690			48380		57070
	TOTAL						33510			108790		142300

THE RALPH M. PARSONS COMPANY

ESTIMATE WORKSHEET

M.T.O. BY <u>RM</u>		PRICED BY <u>RM</u>		DATE <u>JULY, 1981</u>		SHEET <u> </u> OF <u> </u>	
JOB NO.: <u>6154-3</u>		CLIENT: <u>US DOE</u>		TYPE OF ESTIMATE: <u> </u>		CKD BY: <u> </u>	
UNIT/AREA	DESCRIPTION	QUANTITY	COST OR M/HRS PER UNIT	MATERIAL	SUBCONTRACT	LABOR	TOTAL DOLLARS
	CAPACITY						
500 BUILDINGS							
PAINTING & SPECIAL COATING							
PAINTING							
	Gypsum Board	3930 SF	.12	.03	470	116	
	Masonry Block	1740 SF	.12	.05	210	87	
	Piping (EST)	1000 SF	.12	.05	120	50	
	Ductwork (EST)	3000 SF	.12	.04	360	120	
SPECIAL COATING							
	Plaster Walls & Ceiling	600 SF	.20	.05	120	30	
	Concrete Walls	2800 SF	.20	.06	560	168	
	Concrete Floors	2100 SF	.20	.06	420	126	
	Piping (EST)	1000 SF	.20	.06	200	60	
	Ductwork (EST)	2000 SF	.20	.05	400	100	
SUB-TOTAL							
	PRODUCTIVITY (1.80 x 859)	1546 MMH			1950		
SUBCONTRACTOR MARK-UP							
	%	35	80		1000		
TOTAL							
					3960	54340	58200

THE RALPH M. PARSONS COMPANY

ESTIMATE WORKSHEET

M.T.O. BY <i>RW</i>		PRICED BY <i>RW</i>		DATE <i>JULY, 1981</i>				SHEET <i> </i> OF <i> </i>				
JOB NO.: <i>6154-3</i>		CLIENT: <i>US DOE</i>		TYPE OF ESTIMATE:				CKD BY:				
UNIT/AREA	DESCRIPTION	QUANTITY	UNIT	COST OR M/HR PER UNIT			MATERIAL EXPENSE	SUBCONTRACT		LABOR		TOTAL DOLLARS
CAPACITY				MATL	M/H	LAB \$		M/HR	DOLLARS	M/HR	DOLLARS	
ACCNT												
500	BUILDINGS											
	<u>DOORS & WINDOWS</u>											
	TORNADO PROOF DOORS											
	8'-0" x 8'-0" METAL OVERHEAD	1	EA	4200 ⁰⁰	16		4200			16		
	3'-0" x 7'-0" METAL GLAD	3	EA	1200 ⁰⁰	12		3600			36		
	HOLLOW METAL DOORS											
	3'-0" x 7'-0"	7	EA	300 ⁰⁰	6		2100			42		
	HOLLOW CORE WOOD											
	2'-9" x 7'-0" x 1 3/4"	8	EA	80 ⁰⁰	4		640			32		
	METAL DOOR (RAD. RESIST.)											
	3'-0" x 7'-0"	4	EA	480 ⁰⁰	3		1920			12		
	EXPLOSION PROOF DOOR											
	3'-6" x 7'-0"	2	EA	1200 ⁰⁰	12		2400			24		
	3'-0" x 4'-0" SLIDING	1	EA	1600 ⁰⁰	8		1600			8		
	OFFICE WINDOW											
	11'-0" x 4'-0"	1	EA	800 ⁰⁰	16		800			16		
	WIRE GLASS											
	12" x 24"	6	EA	80 ⁰⁰	4		480			24		
	SUB-TOTAL						17740			210		
	PRODUCTIVITY (1.80 x 210)	378	MH			1950				378	7370	
	SUB-TOTAL						17740				7370	25110
	SUBCONTRACTOR MARK-UP		%	35	80		6210				5880	12090
	TOTAL						23950				13250	37200

THE RALPH M. PARSONS COMPANY

ESTIMATE WORKSHEET

M.T.O. BY <u>RW</u>		PRICED BY <u>RW</u>		DATE <u>JULY, 1981</u>		SHEET <u> </u> OF <u> </u>							
JOB NO.: <u>G/ISA-3</u>		CLIENT: <u>US DOE</u>		TYPE OF ESTIMATE:		CKD BY:							
UNIT/AREA	DESCRIPTION	QUANTITY	UNIT	COST OR M/HR PER UNIT			MATERIAL EXPENSE	SUBCONTRACT		LABOR		TOTAL DOLLARS	
CAPACITY				MATL	M/H	LAB \$		M/HR	DOLLARS	M/HR	DOLLARS		
ACCNT													
500	BUILDINGS												
	<u>SPECIALTIES</u>												
	BATH ACCESSORIES												
	TOILET PARTITION	2	EA	250	6		500			12			
	URINAL SCREEN	1	EA	60	2		60			2			
	MIRROR W/ SS FRAME & LEDGE	2	EA	30	2		60			4			
	COMP. TOWEL DISP. & RECEPT.	2	EA	200	4		400			8			
	FEMININE NAPKIN DISPENSER	1	EA	170	2		170			2			
	TOILET PAPER DISPENSER	2	EA	20	1		40			2			
	SOAP DISPENSER	2	EA	24	1		50			2			
	TOILET SEAT DISPENSER	2	EA	30	1		60			2			
	CABINET WORK												
	24x72x36 w/ Lam. Top & SS SINK	1	EA	1650	20		1650			20			
	12x72x24 WALL HUNG	1	EA	300	4		300			4			
	36x168x36 w/ Lam. Top	1	EA	1450	24		1450			24			
	15x18x60 METAL LOCKERS	10	EA	60	1		600			10			
	SUB-TOTAL						5340			92			
	PRODUCTIVITY (1.80x92)	166	MH			1950				166		3240	
	SUB-TOTAL						5340					3240	
	SUBCONTRACTOR MARK-UP		%	35	80		1870					2650	
	TOTAL						7210					5890	13100

ESTIMATE WORKSHEET

M.T.O. BY <u>L. BROOKS</u>		PRICED BY <u>RW</u>		DATE <u>JULY, 1981</u>		SHEET <u>1</u> OF <u>14</u>						
JOB NO.: <u>6154-3</u>		CLIENT: <u>US DOE</u>		TYPE OF ESTIMATE:		CKD BY:						
UNIT/AREA	DESCRIPTION	QUANTITY	UNIT	COST OR M/HR PER UNIT			MATERIAL EXPENSE	SUBCONTRACT		LABOR		TOTAL DOLLARS
CAPACITY				MATL	M/H	LAB \$		M/HR	DOLLARS	M/HR	DOLLARS	
500	BUILDINGS											
	<u>PIPING SUMMARY</u>											
	FROM SHT. 2						1830				28	
	" " 3						11890				277	
	" " 4						1427				114	
	" " 5						2110				229	
	" " 6						1215				91	
	" " 7						2895				99	
	" " 8						1214				65	
	" " 9						1256				96	
	" " 10						940				69	
	" " 11						4351				146	
	" " 12						4870				153	
	" " 13						7119				361	
	" " 14						7466				209	
	SUBTOTAL						48580				1937	
	FIELD WELD & TEST (EST)						800				80	
	UTILITY SUPPORTS (ALLOW)						8000				80	
	CLEAN & TEST (ALLOW)						5000				120	
	SUB-TOTAL						62380				2217	
	PRODUCTIVITY (1.80 x 2217)	3991	MH			2120					3991	86610
	SUB-TOTAL						62380				86610	148990
	SUBCONTRACTOR MARK-UP		%	35	80		21830				69280	91110
	TOTAL						84210				155890	240100

ESTIMATE WORKSHEET

M.T.O. BY <u>J. Brooks</u>		PRICED BY <u>AW</u>		DATE <u>JULY, 1981</u>				SHEET <u>2</u> OF <u>14</u>						
JOB NO.: <u>6154-3</u>		CLIENT: <u>USDOE</u>		TYPE OF ESTIMATE:				CKD BY:						
UNIT/AREA	DESCRIPTION	QUANTITY	UNIT	COST OR M/HR PER UNIT			MATERIAL EXPENSE			SUBCONTRACT		LABOR		TOTAL DOLLARS
CAPACITY				MATL	M/H	LAB \$				M/HR	DOLLARS	M/HR	DOLLARS	
	HIGH PRESSURE STEAM													
	SPEC N, CARBON STEEL													
	PIPE													
	3", STD. WT, BEVELED ENDS	25	LF	4 ²⁰	.35			105				9		
	FITTINGS,													
	TEES 3"x3"x3"			1	12 ⁵⁰	-		13						
	ELBOWS 3" LR			3	5 ²⁰	-		16						
	VALVES			1										
	GATE 3", 150 # ANSI			2	364	4.5		730				9		
	PRESSURE CONTROL V. 3"			1	850	6		850				6		
	STRAINER 3", 150 # ANSI			1	120	4		120				4		

THE RALPH M. PARSONS COMPANY

ESTIMATE WORKSHEET

SHEET 3 OF 14

DATE July 1981

PRICED BY *EW*

M.T.O. BY L. BEARS

CKD BY:

TYPE OF ESTIMATE:

CLIENT: IIS DAVE

JOE NO: 6151-3

UNIT/AREA	KRYPTON [ENCAPSULATION]
100	100
200	200
300	300
400	400
500	500
600	600
700	700
800	800
900	900
1000	1000
1100	1100
1200	1200
1300	1300
1400	1400
1500	1500
1600	1600
1700	1700
1800	1800
1900	1900
2000	2000
2100	2100
2200	2200
2300	2300
2400	2400
2500	2500
2600	2600
2700	2700
2800	2800
2900	2900
3000	3000
3100	3100
3200	3200
3300	3300
3400	3400
3500	3500
3600	3600
3700	3700
3800	3800
3900	3900
4000	4000
4100	4100
4200	4200
4300	4300
4400	4400
4500	4500
4600	4600
4700	4700
4800	4800
4900	4900
5000	5000
5100	5100
5200	5200
5300	5300
5400	5400
5500	5500
5600	5600
5700	5700
5800	5800
5900	5900
6000	6000
6100	6100
6200	6200
6300	6300
6400	6400
6500	6500
6600	6600
6700	6700
6800	6800
6900	6900
7000	7000
7100	7100
7200	7200
7300	7300
7400	7400
7500	7500
7600	7600
7700	7700
7800	7800
7900	7900
8000	8000
8100	8100
8200	8200
8300	8300
8400	8400
8500	8500
8600	8600
8700	8700
8800	8800
8900	8900
9000	9000
9100	9100
9200	9200
9300	9300
9400	9400
9500	9500
9600	9600
9700	9700
9800	9800
9900	9900
10000	10000

DESCRIPTION	7EQUITE ENCABEDATION)

CAPACITY

1000

Low Pressure: STEAM

SPEC N, CARBON STEEL

पिपे

2" SCH XS THREADED ENDS

1 1/2" SCH XS THREADED ENDS

1" SCH XS THREADED ENDS

FITTING

Tees 2x2x2

EL 130115 2' LR

177

1.2 L.R.

VALVES

GAT 6"

354

6815

GALE

11/2 1209

GATE 2

REV. 2

752

Ted

Feb. 1

TRAVIS

10

100

ESTIMATE WORKSHEET

PRICED BY

(a)

CLIENT:

TYPE OF ESTIMATE:

DATE JULY, 1981

SHEET _____
CKD BY: _____

5-03-14

[illegible]

ESTIMATE WORKSHEET

[illegible]

ESTIMATE WORKSHEET

M.T.O. BY L. BROOKS

PRICED BY *EW*

DATE JULY 1981

SHEET 7 OF 14

JOB NO.: 6154-3

CLIENT: US DOE

TYPE OF ESTIMATE:

CKD BY:

[illegible]

ESTIMATE WORKSHEET

SHEET 8 OF 14

CKD BY:

**TOTAL
DOLLARS**

12

65

ESTIMATE WORKSHEET

M.T.O. BY L. Brooks DATE JULY, 1981 SHEET 9 OF 14

JOB NO.: 054-3 CLIENT: US DOE
TYPE OF ESTIMATE:
CKD BY:

UNIT/AREA	EXPENSE	COST OR M/HRS
KRISTEN	EXPENSE	

DESCRIPTION	QUANTITY	PER UNIT	MATERIAL	SUBCONTRACT	LABOR	TOTAL
DESCRIPTION	QUANTITY	PER UNIT	MATERIAL	SUBCONTRACT	LABOR	TOTAL

[illegible][illegible][illegible][illegible][illegible]SPEC α , CARBON STEEL[illegible][illegible][illegible]

PIPE	00	17	290	55	072	35
2" SCH XS THREADED						

[illegible][illegible][illegible][illegible][illegible][illegible][illegible][illegible]

7	9	2	3	4	5	6	8	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99	100
---	---	---	---	---	---	---	---	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	-----

[illegible][illegible][illegible]

DATE	2	280	4	560	ω
------	---	-----	---	-----	---

CHECK 3"	3	95	3	190	6
----------	---	----	---	-----	---

[illegible][illegible][illegible][illegible][illegible][illegible][illegible][illegible][illegible][illegible][illegible]

1256	90
------	----

[illegible]

ESTIMATE WORKSHEET

[illegible]

ESTIMATE WORKSHEET

[illegible]

ESTIMATE WORKSHEET

PRICED BY

M.T.O. BY 7. Brooks

JOB NO.: 6154-3 CLIENT: US DOE

6154-3

CLIENT: J S DOE

TYPE OF ESTIMATE:

CKD BY:

SHEET 12 OF 14

[illegible]

ESTIMATE WORKSHEET

M.T.O. BY L. BROOKS

PRICED BY *EW*

DATE JULY 1981

SHEET 3 OF 14

JOB NO.: 6154-3

CLIENT: US DOE

TYPE OF ESTIMATE:

CKD BY:

UNIT/AREA		QUANTITY	UNIT	COST OR M/HRS PER UNIT			MATERIAL EXPENSE	SUBCONTRACT		LABOR		TOTAL DOLLARS
DESCRIPTION	CAPACITY			MATL	M/H	LAB \$		M/HR	DOLLARS	M/HR	DOLLARS	
KRYPTON ENCAPSULATION ZEOLITE ENCAPSULATION												
PRESSURIZED FEED GAS MIX SYSTEM												
300 PSIA												
SPEC V, CARBON STEEL												
PIPE 1" SCH XS, PLAIN ENDS		250	LF	.80	.25		325			63		
FITTINGS												
FLANGES 300# WN RF		20		.85	1.5		1700			30		
ELBOWS 1" LR ELLS		45		.60	1.5		279			68		
1" 45° ELLS		5		.60	1.5		31			8		
TEES 1" x 1" x 1"		18		.80	1.5		148			27		
1" x 1" x 1/2"		4		.80	1.5		33			6		
1 1/2" x 1 1/2" x 1 1/2"		4		1.00	1.7		42			7		
REDUCERS 1 1/2" x 1"		8		.60	1.5		51			12		
VALVES 1" 300# GATE		5		.240	4		1200			20		
1" 300# SOLENOIDS		19		1.60	6		3040			114		
FLOW ELEMENTS		3		.90	2		270			6		
							7119			361		

ESTIMATE WORKSHEET

[illegible]

THE RALPH M. PARSONS COMPANY

ESTIMATE WORKSHEET

M.T.O. BY <u>RW</u>		PRICED BY <u>RW</u>		DATE <u>JULY, 1981</u>				SHEET <u> </u> OF <u> </u>				
JOB NO.: <u>0154-3</u>		CLIENT: <u>US DOE</u>		TYPE OF ESTIMATE:				CKD BY:				
UNIT/AREA	DESCRIPTION	QUANTITY	UNIT	COST OR M/HR PER UNIT			MATERIAL EXPENSE	SUBCONTRACT		LABOR		TOTAL DOLLARS
CAPACITY				MATL	M/H	LAB \$		M/HR	DOLLARS	M/HR	DOLLARS	
ACCNT												
500	BUILDINGS											
	<u>INSTRUMENTATION</u>											
	CONTROL INSTRUMENTATION (15% OF PIPING)	LS					9400			333		
	HVAC (10% OF HVAC)	LS					14000			146		
	RADIATION MONITORING (ALLOW)	LS					10000			100		
	PROCESS CONTROLS (ALLOW)	LS					15000			150		
	DATA PROCESSING (ALLOW)	LS					20000			100		
	SUB-TOTAL						68490			829		
	PRODUCTIVITY (1.80 x 829)	1492				20%				1492	31180	
	SUB-TOTAL						68490				31180	99670
	SUBCONTRACTOR MARK-UP		%	35	80		23970				24761	48930
	TOTAL						92460				56440	148600

M.T.O. BY		SHR		PRICED BY		RW		DATE		JULY, 1981		SHEET		OF			
JOB NO.:		6154-3		CLIENT:		US DOE		TYPE OF ESTIMATE:				CKD BY:					
DESCRIPTION		KRYPTON ENCAPSULATION		QUANTITY		UNIT		COST OR M/HR\$ PER UNIT		MATERIAL EXPENSE		SUBCONTRACT		LABOR		TOTAL DOLLARS	
		ZEOLITE ENCAPSULATION						MATL M/H LAB \$				M/HR\$ DOLLARS		M/HR\$ DOLLARS			
ACCT																	
500		BUILDINGS															
		ELECTRICAL SUMMARY								164300				3973			
		PRODUCTIVITY (1.80 x 3973)		7151		MH								7151		149170	
		SUB-TOTAL								164300						149170	
		SUBCONTRACTOR MARK-UP				%		35 80		57560						126820	
										221810						275990 497800	

2

M.T.O. BY <u>SH Rowe</u>		PRICED BY	DATE	SHEET	OF
JOB NO: <u>6154-3</u>		CLIENT: <u>DOE</u>	DATE	1	2
UNIT/AREA		TYPE OF ESTIMATE:	CKD BY:		
DESCRIPTION		COST OR M/HR PER UNIT	SUBCONTRACT		LABOR
CAPACITY		MATL M/H LAB \$	M/HR	DOLLARS	DOLLARS
AGCT	QUANTITY	UNIT	TOTAL DOLLARS		
ELECTRICAL					
300 KVA Unit Substation	1	EA			
MCCI 480 / 277V CLD Type B	1	EA			
45 KVA Xfm 480-208Y/120V	1	EA			
9 KVA Xfm 480-208Y/120V	1	EA			
Panelboard ELA, 8 CKT	1	EA			
Panelboard ELB, 4 CKT	1	EA			
Panelboard LPA 42 CKT	1	EA			
Panelboard ELPB 12 CKT	1	EA			
60A Welling Recp & SW	1	EA			
30A Disc SW	2	EA			
480 V Motor & Load Conn < 10 HP	11	EA			
15 HP	2	EA			
30 HP	4	EA			
40 KW	2	EA			
Area Ltg, Wire & Conduit	4300 SF	EA			
Special Cell Lts.	8	EA			
Recp, Wire & Conduit	4300 SF	EA			
Multiplex & Terminal Bd	1	EA			

M.T.O. BY		5 H Rowe		PRICED BY				DATE		6/12/81		SHEET		2		OF		2				
JOB NO.:		6134-3		CLIENT:				TYPE OF ESTIMATE:		Conceptual		CKD BY:										
UNIT/AREA				QUANTITY		UNIT		COST OR M/HR PER UNIT			MATERIAL EXPENSE			SUBCONTRACT			LABOR			TOTAL DOLLARS		
DESCRIPTION		Zeolite Encapsulation																				
CAPACITY																						
ACCT																						
Grounding				15							2000						80					
Lightning Protection				15							5000						110					
Cathodic Protection				15							25000						750					
Intercom				15							9000						320					
Fire Alarm				15							8000						260					
Evacuation Alarm				15							5500						160					
Conduit Fittings				15							700						75					
Connect Instrumentation				15							6000						500					
Motor Wire & Conduit				15							6000						560					
Solenoid Valve Wire & Conduit				15							3000						200					
TOTAL											164296						3973					

THE RALPH M. PARSONS COMPANY

ESTIMATE WORKSHEET

M.T.O. BY <u>E. Hom</u>		PRICED BY <u>E. Hom/RW</u>		DATE <u>JULY, 1981</u>		SHEET <u>1</u> OF <u>5</u>						
JOB NO.: <u>0154-3</u>		CLIENT: <u>US DOE</u>		TYPE OF ESTIMATE:		CKD BY:						
UNIT/AREA	DESCRIPTION	QUANTITY	UNIT	COST OR M/HR PER UNIT			MATERIAL EXPENSE	SUBCONTRACT		LABOR		TOTAL DOLLARS
CAPACITY				MATL	M/H	LAB \$		M/HR	DOLLARS	M/HR	DOLLARS	
ACCENT												
500	BUILDINGS											
	<u>HVAC SUMMARY</u>											
	FROM SHT. 2						9600			142		
	" " 3						108900			306		
	" " 4						4900			173		
	" " 5						17490			835		
	SUB-TOTAL						140890			1456		
	PRODUCTIVITY (1.80 x 1456)	2621	MH			1990				2621	50850	
	SUB-TOTAL						140890			2621	50850	191740
	SUBCONTRACTOR MARK-UP		%	35	80		49310				40650	89960
	TOTAL						190200				91500	281700

THE RALPH M. PARSONS COMPANY

ESTIMATE WORKSHEET

M.T.O. BY <u>E. HOM</u>		PRICED BY		DATE <u>6-9-81</u>				SHEET <u>2</u> OF <u>5</u>				
JOB NO.: <u>6154-3</u>		CLIENT: <u>DOE</u>		TYPE OF ESTIMATE:				CKD BY:				
UNIT/AREA		QUANTITY	UNIT	COST OR M/HR PER UNIT			MATERIAL EXPENSE	SUBCONTRACT		LABOR		TOTAL DOLLARS
DESCRIPTION				MATL	M/H	LAB \$		M/HR	DOLLARS	M/HR	DOLLARS	
CAPACITY												
ACCNT												
<u>HVAC</u>												
<u>SUPPLY FAN</u>		<u>2</u>	<u>EA</u>	<u>1500</u>	<u>20</u>		<u>3000</u>			<u>40</u>		
<u>CAP. 2670 CFM AT 3" SP, 3 HP</u>												
<u>BUFFALO FORGE CO.</u>												
<u>TYPE BL-AEROFOIL SIZE 270</u>												
<u>SWSI - ARRG. 3 W/INLET VANES</u>												
<u>EXHAUST FAN</u>		<u>2</u>	<u>EA</u>	<u>2500</u>	<u>20</u>		<u>5000</u>			<u>40</u>		
<u>CAP. 2800 CFM AT 10" SP, 10 HP</u>												
<u>BUFFALO FORGE CO.</u>												
<u>INDUSTRIAL EXHAUSTER</u>												
<u>RADIAL BLADE SIZE 30 MV</u>												
<u>SWSI, ARRG. 9</u>												
<u>STEAM PREHEAT COIL</u>		<u>2</u>	<u>EA</u>	<u>600</u>	<u>24</u>		<u>1200</u>			<u>48</u>		
<u>2670 CFM & 168,000 BTU/HR</u>												
<u>5-FT² FACE AREA, 2-ROW</u>												
<u>-20°F ENT. & +50°F LV. AIR</u>												
<u>15 PSIG STEAM</u>												
<u>STEAM HEATING COIL</u>		<u>1</u>	<u>EA</u>	<u>150</u>	<u>6</u>		<u>150</u>			<u>6</u>		
<u>570 CFM & 26,000 BTU/HR</u>												
<u>1-FT² FACE AREA, 1-ROW</u>												
<u>+40°F ENT. & 90°F LV. AIR</u>												
<u>15 PSIG STEAM</u>												
<u>STEAM HEATING COIL</u>		<u>1</u>	<u>EA</u>	<u>250</u>	<u>8</u>		<u>250</u>			<u>8</u>		
<u>1180 CFM & 32,000 BTU/HR</u>												
<u>2-FT² FACE AREA, 1-ROW</u>												
<u>+40°F ENT. & +70°F LV. AIR</u>												
<u>15 PSIG STEAM</u>												
							<u>9600</u>			<u>142</u>		

THE RALPH M. PARSONS COMPANY

ESTIMATE WORKSHEET

M.T.O. BY <u>E.HOM</u>		PRICED BY		DATE <u>6-9-81</u>		SHEET <u>3</u> OF <u>5</u>						
JOB NO.: <u>6154-3</u>		CLIENT: <u>DOE</u>		TYPE OF ESTIMATE:		CKD BY:						
UNIT/AREA	DESCRIPTION	QUANTITY	UNIT	COST OR M/HR PER UNIT			MATERIAL EXPENSE	SUBCONTRACT		LABOR		TOTAL DOLLARS
				MATL	M/H	LAB \$		M/HR	DOLLARS	M/HR	DOLLARS	
ACCNT	<u>HVAC</u>											
	<u>STEAM HEATING COIL</u>	<u>1</u>	<u>EA</u>	<u>200</u>	<u>6</u>		<u>200</u>			<u>6</u>		
	<u>CAP. 920 CFM & 41400 BTU/HR</u>											
	<u>1.5 FT² FACE AREA, 1-ROW</u>											
	<u>+40°F ENT. & 90°F LV. AIR</u>											
	<u>15 PSIG STEAM</u>											
	<u>SPRAY COOLING CHAMBER</u>	<u>2</u>	<u>EA</u>	<u>4000</u>	<u>40</u>		<u>8000</u>			<u>80</u>		
	<u>FILTER FIRE PROTECTION</u>											
	<u>2800 CFM & 5.6 FT² FACE AREA</u>											
	<u>1-BANK SPRAY NOZZLES,</u>											
	<u>MOISTURE SEPARATOR, DRAIN PAN</u>											
	<u>EXHAUST AIR HEPA FILTER</u>	<u>2</u>	<u>EA</u>	<u>50000</u>	<u>100</u>		<u>100000</u>			<u>200</u>		
	<u>PLENUM, 3000 CFM RATING</u>											
	<u>FLANDERS FILTER CO.</u>											
	<u>2-STAGES OF HEPA FILTERS</u>											
	<u>24"X24"X11 1/2" FLUID SEAL TYPE</u>											
	<u>ARRANGED 3-WIDE BY 1-HIGH</u>											
	<u>BAG-OUT TYPE E-4 FILTER</u>											
	<u>HOUSINGS WITH IN-PLACE</u>											
	<u>REMOTE DOP TEST SECTIONS</u>											
	<u>T-I, T-C, & T-D.</u>											
	<u>SUPPLY AIR FILTER BOX</u>	<u>2</u>	<u>EA</u>	<u>350</u>	<u>10</u>		<u>700</u>			<u>20</u>		
	<u>CAP. 2670 CFM</u>											
	<u>FARR CO. SIDE LOADING</u>											
	<u>MODEL 3P UNIVERSAL GLIDE PACK</u>											
	<u>WITH 2-24"X24"X4" TYPE 30/30</u>											
	<u>30% EFF. PREFILTERS &</u>											
	<u>2-24"X24"X12"-90% EFF.</u>											
	<u>TYPE HP-200 HIGH EFF. FILTERS</u>											
							<u>108900</u>			<u>306</u>		

ESTIMATE WORKSHEET

M.T.O. BY E. HOM		PRICED BY		DATE 6-9-81		SHEET 5 OF 5		CKD BY:	
JOB NO. 6154-3		CLIENT: DOE		TYPE OF ESTIMATE:					
UNIT/AREA		QUANTITY UNIT		COST OR M/HRS PER UNIT		MATERIAL EXPENSE		SUBCONTRACT	
DESCRIPTION KRYPTON ENCAPSULATION				M/H LABS		M/HRS DOLLARS		LABOR	
CAPACITY HIGH PRESSURE CONCEPT				M/H LABS		M/HRS DOLLARS		TOTAL DOLLARS	
HVAC									
DUCTWORK, GALV. STEEL		2000 LB	1.50	0.08		3000		160	
DUCTWORK, STAINLESS STEEL		1300 LB	3.90	0.10		5070		130	
GRILLES & REGISTERS		1 LS				1500		50	
MAINTAL, BALANCING, BACKDRAFT DAMPERS		1 LS				2000		40	
REFRIG. TUBING, COPPER TYPE "L"		1 LS				100		20	
20' - 1/2" OD		1 LS				120		20	
20' - 3/8" OD		1 LS				400		35	
INSULATION		1 LS				2000		200	
AUTOMATIC CONTROLS - HONEYWELL		1 LS				2500		100	
PRESS. DIFFERENTIAL CONTROL		1 LS				800		80	
AIR. MONITOR		1 LS							
TEST & BALANCE		1 LS							
								835	
								17490	

THE RALPH M. PARSONS COMPANY

ESTIMATE WORKSHEET

M.T.O. BY <u>RW</u>		PRICED BY <u>RW</u>		DATE <u>JULY, 1981</u>				SHEET <u> </u> OF <u> </u>					
JOB NO.: <u>6154-3</u>		CLIENT: <u>U.S DOE</u>		TYPE OF ESTIMATE:				CKD BY:					
UNIT/AREA	DESCRIPTION	QUANTITY	UNIT	COST OR M/HR PER UNIT			MATERIAL EXPENSE		SUBCONTRACT		LABOR		TOTAL DOLLARS
CAPACITY				MATL	M/H	LAB \$			M/HR	DOLLARS	M/HR	DOLLARS	
ACCNT													
500	BUILDINGS												
	FIRE PROTECTION, Est	4400	SF	5 ⁰⁰	.10		22000				440		
	PRODUCTIVITY (1.80 x 440)	792	mh			21 ²⁰					792	17190	
	SUB-TOTAL						22000					17190	
	SUBCONTRACTOR MARK-UP		%	35	80		7700					13710	
	TOTAL						29700					30900	60600

THE RALPH M. PARSONS COMPANY

ESTIMATE WORKSHEET

M.T.O. BY <u>AW</u>		PRICED BY <u>AW</u>		DATE <u>JULY, 1981</u>				SHEET <u> </u> OF <u> </u>				
JOB NO.: <u>6154-3</u>		CLIENT: <u>USDOE</u>		TYPE OF ESTIMATE:				CKD BY:				
UNIT/AREA <u>KRYPTON ENCAPSULATION</u>		QUANTITY	UNIT	COST OR M/HR PER UNIT			MATERIAL EXPENSE	SUBCONTRACT		LABOR		TOTAL DOLLARS
DESCRIPTION <u>ZEOLITE ENCAPSULATION</u>				MATL	M/H	LABS		M/HR	DOLLARS	M/HR	DOLLARS	
CAPACITY												
ACCNT												
500	BUILDINGS											
	<u>PLUMBING</u>											
	ROOF DRAINS, EST.						4000			200		
	LAVATORY FIXTURES, EST.						5000			100		
	DRAINS AND VENTS, EST.						8000			400		
	WATER SERVICES, EST.						3000			200		
	SUB-TOTAL						20000			900		
	PRODUCTIVITY (1.80 x 900)	1620				2170				1620	36150	
	SUB-TOTAL						20000				36150	56150
	SUBCONTRACTOR MARK-UP		%	35	80		7000				28150	35150
	TOTAL						27000				54300	91300

THE RALPH M. PARSONS COMPANY

ESTIMATE WORKSHEET

M.T.O. BY <u>RW</u>		PRICED BY <u>RW</u>		DATE <u>JULY, 1981</u>		SHEET <u> </u> OF <u> </u>						
JOB NO.: <u>6154-3</u>		CLIENT: <u>US DOE</u>		TYPE OF ESTIMATE:		CKD BY:						
UNIT/AREA	DESCRIPTION	QUANTITY	UNIT	COST OR M/HR PER UNIT			MATERIAL EXPENSE	SUBCONTRACT		LABOR		TOTAL DOLLARS
CAPACITY				MATL	M/H	LAB \$		M/HR	DOLLARS	M/HR	DOLLARS	
ACCNT												
700	EQUIPMENT											
	<u>SUMMARY</u>											
	VESSELS & TANKS						176380			440		
	PUMPS						20400			220		
	AGITATORS						4400			40		
	HEAT EXCHANGERS						64000			240		
	COMPRESSORS						29000			160		
	HOT ISOSTATIC PRESS						261400			240		
	PROCESS SPECIALTIES						19650			44		
	OTHER MAJOR EQUIPMENT						544000			2090		
	<u>SUB-TOTAL</u>						1169230			3474		
	SENSING QUALIFICATION (@ 20% OF MAT'L)						233840					
	PRODUCTIVITY (1.80 x 3474)	6110	MH		20 ³⁰					6110	124030	
	<u>SUB-TOTAL</u>						1403070				124030	
	SUBCONTRACTOR MARK-UP		%	35	80		491070				99270	
	<u>TOTAL EQUIPMENT</u>						1894140				223320	
	<u>USE</u>						1895000				230000	2125000

THE RALPH M. PARSONS COMPANY

ESTIMATE WORKSHEET

M.T.O. BY *RW* PRICED BY *RW*

M.T.O. BY *RW* PRICED BY *6*
JOB NO.: *9154-3* CLIENT: *U.S. DOE*

TYPE OF ESTIMATE:

DATE JULY, 1981

SHEET _____

CKD BY: _____

SHEET _____ OF _____

M.T.O. BY <u>RW</u>		PRICED BY <u>RW</u>		DATE <u>JULY, 1981</u>		SHEET <u> </u> OF <u> </u>	
JOB NO.: <u>0154-3</u>		CLIENT: <u>U.S. DOE</u>		TYPE OF ESTIMATE:		CKD BY:	
UNIT/AREA	DESCRIPTION	QUANTITY	UNIT	COST OR M/HR PER UNIT		MATERIAL EXPENSE	
CAPACITY				MAT'L	M/H	M/HR	DOLLARS
700	EQUIPMENT						
	<u>VESSELS & TANKS</u>						
	KEF-HP-TK1, SUMP CATCH TANK 3'-6" ϕ x 6'-0" T/T, T304L SS, 15 PSIG DESIGN	4750	LB	7.50	Lot	35030	40
	KEF-HP-TK101 DECON. SOLUTION MAKE-UP TANK, 3'-6" ϕ x 4'-0" T/T, T304L SS, 15 PSIG DESIGN	3200	LB	7.50	Lot	24000	40
	KEF-HP-TK2, 3 LAG STORAGE & RUN TANKS (TOTAL FOR 10) 12" ϕ x 12'-0" T/T, T316L SS, 1270 PSIG DESIGN w/ SUPPORT FRAME	12500	LB	7.50	Lot	87500	240
	KEF-HP-TK4, ISOSTATIC RUN TANKS, (TOTAL OF 2) 12" ϕ x 12'-0" T/T T316L SS, 1100 PSIG DESIGN	2300	LB	8.00	Lot	18400	60
	KEF-HP-TK102, ISOSTATIC SUPPLY CYLINDERS, 9" ϕ x 52" T/T, w/ SUPPLY HEADERS (TOTAL OF 3)	900	LB	4.50	Lot	4050	30
	KEF-HP-TK5, PRESSURE RELIEF ACCUMULATOR, 18" ϕ x 4'-6" T/T, T316L SS, 900 PSIG DESIGN	850	LB	8.00	Lot	6800	30
	SUB-TOTAL					176380	440

THE RALPH M. PARSONS COMPANY

ESTIMATE WORKSHEET

M.T.O. BY <u>AW</u>		PRICED BY <u>AW</u>		DATE <u>July, 1981</u>		SHEET <u> </u> OF <u> </u>		
JOB NO.: <u>0154-3</u>		CLIENT: <u>USDOE</u>		CKD BY:				
UNIT/AREA <u>KRYPTON ENCAPSULATION</u>		TYPE OF ESTIMATE:		SUBCONTRACT		LABOR		TOTAL DOLLARS
DESCRIPTION <u>ZEOLITE ENCAPSULATION</u>		QUANTITY	UNIT	MATL	M/H	LAB \$	M/HR	
CAPACITY								
ACCNT								
700 EQUIPMENT								
PUMPS								
KEF-HP-PIOL, DECON SOLUTION PUMP, HORIZONTAL CENTRIFUGAL, 1800 RPM, 50 GPM W/ 40 TDH, 316 SS		1	EA	4000	80			80
KEF-HP-PI112, COOLING WATER PUMP, HORIZONTAL CENTRIFUGAL, 1800 RPM, 15 GPM W/ 60 TDH, DUCTILE IRON		2	EA	700	20			40
KEF-HP-VP112, KRYPTON VACUUM PUMP		2	EA	3200	20			40
KEF-HP-VP314, HELIUM VACUUM PUMP		2	EA	2800	20			40
SUMP & CATCH TANK EJECTOR, STEAM JET, 30 GPM, 304L SS		2	EA	1500	10			20
SUB-TOTAL								220
AGITATORS								
SUMP CATCH TANK AGITATOR, 1 HP, 304L SS WETTED PARTS		1	EA	2200	20			20
DECON SOLUTION TANK AGITATOR, 1 HP, 304L SS WETTED PARTS		1	EA	2200	20			20
SUB-TOTAL								40

THE RALPH M. PARSONS COMPANY

ESTIMATE WORKSHEET

M.T.O. BY <i>ku</i>		PRICED BY <i>ku</i>		DATE <i>July, 1981</i>		SHEET <i>OF</i>	
JOB NO.: <i>6154-3</i>		CLIENT: <i>US DOE</i>		TYPE OF ESTIMATE:		CKD BY:	
UNIT/AREA	DESCRIPTION	CAPACITY	QUANTITY	UNIT	COST OR M/HRS PER UNIT	MATERIAL	EXPENSE
						SUBCONTRACT	LABOR
<div style="display: flex; justify-content: space-between;"> M/HRS DOLLARS M/HRS DOLLARS M/HRS DOLLARS TOTAL DOLLARS </div>							
<div style="display: flex; justify-content: space-between;"> 700 Equipment Heat Exchangers KEF-HP-HEI, Feed Gas Cooler, 20,000 BW/HR, 316 SS Shell & Tubes, C.S. Channel, 600 PSIG Design KEF-HP-HE2, Cooling Water Heat Exchanger, 200,000 BW/HR, C.S. Shell & Bonnet, Admiralty Tubes Sub-Total </div>							
<div style="display: flex; justify-content: space-between;"> 1 EA 18000 LOT 18000 80 </div>							
<div style="display: flex; justify-content: space-between;"> 1 EA 40000 LOT 40000 160 </div>							
<div style="display: flex; justify-content: space-between;"> 2 EA 14500 LOT 29000 160 </div>							
<div style="display: flex; justify-content: space-between;"> KEF-HP-COM1 & 2, Feed Gas Mixer Compressor, Triple Diaphragm, 200 PSIG Inlet, 500 PSIG Outlet, 1 CFM, 400 RPM, 316 SS </div>							

THE RALPH M. PARSONS COMPANY

ESTIMATE WORKSHEET

M.T.O. BY <u>RW</u>		PRICED BY <u>RW</u>		DATE <u>JULY, 1981</u>		SHEET <u> </u> OF <u> </u>		
JOB NO.: <u>6154-3</u>		CLIENT: <u>US DOE</u>		CKD BY: <u> </u>				
UNIT/AREA <u>KRYPTON ENCAPSULATION</u>		TYPE OF ESTIMATE:		SUBCONTRACT		LABOR		TOTAL DOLLARS
DESCRIPTION <u>ZBOLITE ENCAPSULATION</u>				M/HR	DOLLARS	M/HR	DOLLARS	
CAPACITY		COST OR M/HR PER UNIT		MATERIAL EXPENSE				
		MATL	M/H	LAB \$				
QUANTITY	UNIT							
<u>700</u>	<u>EQUIPMENT</u>							
	<u>HOT ISOSTATIC PRESS</u>							
	<u>KEF-HP-HIP-1, TOP LOADING, SINGLE LEVEL, GRAPHITE, NATURAL CONVECTION STYLE HIP FURNACE WITH ISOLATED DUAL GAS DELTA P CAPABILITY. INCLUDES VESSEL W/ YOKE (5800*), PRESSURE GAS SYSTEM W/ CONTROL PANEL AND COMPRESSORS KEF-HP-COM3 & 4 AND KEF-HP-COM5 & 6 (3800*), CONTROL PANEL (400*), POWER PANEL (400*), TRANSFORMER (500*) AND VACUUM PUMP (250*), 50 KW MAXIMUM POWER, 41,000 BTU/hr HEAT INPUT, 15,000 PSI DESIGN, ASME SECT. VIII, DIV. 2</u>	<u>1</u>	<u>Lot</u>				<u>240</u>	<u>261400</u>
	<u>ESTIMATE BASIS: \$30/LB ELECTRICAL & CONTROL, \$25/LB COMPRESSORS, \$ PUMPS, \$15/LB VESSEL, ALLOW 15% FOR INTERCONNECTIONS</u>							

THE RALPH M. PARSONS COMPANY

ESTIMATE WORKSHEET

M.T.O. BY <u>AW</u>		PRICED BY <u>AW</u>		DATE <u>JULY, 1981</u>		SHEET <u> </u> OF <u> </u>	
JOB NO.: <u>6154-B</u>		CLIENT: <u>US DOE</u>		TYPE OF ESTIMATE:		CKD BY:	
DESCRIPTION		QUANTITY	UNIT	COST OR M/MHS PER UNIT		SUBCONTRACT	
				MATL	M/H	M/MHS	DOLLARS
EQUIPMENT							
PROCESS SPECIALTIES							
KEF-HP-FI, FEED GAS FILTER, IN-LINE 24", 750 PSIG DESIGN, 316 SS		1	EA	450	8	450	8
SUMP SAMPLER, SUMP CATCH TANK SAMPLER, PLUNGER TYPE, AIR OPERATED, SOLENOID ACTIVATED, MANUAL INITIATED		2	EA	600	6	1200	12
KEF-HP-AFI SUBSTRATE ACTIVATION FURNACE, 40 KW HEAT INPUT		2	EA	900	12	1800	24
SUB-TOTAL						19650	44
TOTAL DOLLARS							

THE RALPH M. PARSONS COMPANY

ESTIMATE WORKSHEET

M.T.O. BY <u>A. SMITH</u>		PRICED BY <u>A. SMITH/RW</u>		DATE <u>JULY, 1981</u>		SHEET <u> </u> OF <u> </u>						
JOB NO.: <u>6154-3</u>		CLIENT: <u>U.S. DOE</u>		TYPE OF ESTIMATE:		CKD BY:						
UNIT/AREA	DESCRIPTION	QUANTITY	UNIT	COST OR M/HR PER UNIT			MATERIAL EXPENSE	SUBCONTRACT		LABOR		TOTAL DOLLARS
CAPACITY				MATL	M/H	LAB \$		M/HR	DOLLARS	M/HR	DOLLARS	
ACCNT												
700	EQUIPMENT											
	<u>OTHER MAJOR EQUIPMENT</u>											
	MINITRAILER ROBO CARRIER	2	EA	100,000	50		200,000			100		
	BRIDGE CRANE 5T/2-1/2T	1	EA	150,000	1200		150,000			1200		
	AUTOMATIC WELDER	1	EA	80,000	200		80,000			200		
	LEAK DETECTOR	1	EA	20,000	150		20,000			150		
	MASTER SLAVE MANIPULATORS, MODEL F	4	EA	21,000	60		84,000			240		
	SPECIAL TOOLS AND FIXTURES	1	LOT	50,000	160		50,000			160		
	2T MONORAIL HOIST	1	EA	10,000	40		10,000			40		
	SUB-TOTAL						594,000			2090		