Quarterly Technical Progress Report Liquid Metal Engineering Center (LMEC)

January – March 1967

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Liquid Metal Engineering Center

Operated for

the U.S. Atomic Energy Commission by Atomics International

A Division of North American Aviation Inc

Contract: AT(04-3)-700

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The progress report for the previous quarter was NAA-SR-12297.

Program: Liquid Metal Engineering Center	
Project: AEC Assistance and Consultation	
Project Manager: R. W. Dickinson	Project Engineer: R. W. Dickinson
Reporting Period: January-March 1967	AEC Category: 04-01-61-03
General Order: 7693	Subaccount: 12100

I. PROJECT OBJECTIVES

The objectives of this project are to support the Liquid Metal Fast Breeder Reactor (LMFBR) program by preparation of engineering standards, specifications, and practices for liquid metal systems and components; to provide inspection and technical consultation services as requested by the AEC; and to monitor system and component performance as authorized by the AEC.

II. MAJOR ACCOMPLISHMENTS IN FISCAL YEAR 1967

A standards and specifications task unit was organized within the LMEC, with four full-time engineers and additional technical support from the LMEC Technical Staff of 28. A detailed work plan for LMEC effort on LMFBR standards and specifications has been prepared and submitted for approval, and a sodium component cleaning specification has been prepared and submitted.

Contacts have been made with other LMFBR program installations, leading to coordination of the specifications and standards preparation program.

Program guidelines were prepared for development of large pumps and valves suitable for 1,000-Mwe LMFBR service; estimates of dimensions and weights for 60,000- and 120,000-gpm sodium pumps were prepared.

Technical assistance has been provided to AEC-RDT personnel in their direction of the Large Sodium Pump Design Study, by reviewing pump manufacturers' performance in developing conceptual pump designs, and participating in technical review meetings with these contractors and the AEC.

An incident-report collections, evaluation, and dissemination plan was prepared and submitted for RDT review. Review of malfunction data at SRE, SCTI, and HNPF was initiated.

The Sodium Technology, Instrumentation and Control, and Safety Sections of the LMFBR Program Plan were reviewed in depth and comments were forwarded to the Program Office and RDT.

A study to determine the design and fabrication limitations associated with "pot" type LMFBR reactor configurations was initiated; potential problem areas were identified and a systematic approach to examination of these problem areas was prepared for submission early in the next quarter.

III. PROGRESS DURING REPORT PERIOD

A. SPECIFICATIONS AND STANDARDS TASK UNIT (R. J. Edwards)

A Specifications and Standards Task Unit was set up within LMEC. Four engineers are assigned to this unit to work on a full-time basis on LMFBR specifications and standards. In support of this task unit, other members of the LMEC staff are utilized on a part-time basis, where their particular skills or experience can contribute to the specifications effort. This assistance includes reviews of initial outlines and completed drafts of specifications; preparation of specification drafts, where an individual's technical specialty or other LMEC assignment qualifies him as the logical person to develop the specification; and other analytical, development, and literature search assignments as required.

The sodium component cleaning specification was completed and copies were forwarded to RDT and ORNL for review. The specification was based on a detailed review, evaluation, and selection of material from ten cleaning specifications issued by the federal government, industry, and a technical society. Over 25 other specifications, handbooks, and manuals on cleaning and related items were searched for applicable information.

A plan for the LMEC effort on LMFBR specifications and standards was completed and forwarded to RDT and ORNL for comment. The plan outlined the scope of the LMEC effort and interface of the LMEC activity with other LMFBR engineering programs. The plan included: (1) a list of 56 specifications to be prepared by LMEC, with estimated completion dates; (2) a recommended specification format and numbering system; and (3) organization and staffing of the LMEC specifications and standard activity.

Four specifications are in various stages of review and processing. A revised draft of the specification for sodium purity requirements is almost complete. The specification for a large primary sodium pump has been reviewed; the basic requirements outlined in the original draft are being expanded and supplemented by detailed quality assurance provisions. Preparation of the welding specification continues. Review was started of the completed first draft of the specification for an intermediate heat exchanger.

Twenty replies were received to a letter sent to fifty-five AEC contractors and laboratories requesting copies of their liquid metal specifications. A set of FARET specifications has been received from ANL; BNL has furnished copies of several typical liquid metal component specifications. Most of the other respondents are searching their files for pertinent information or have indicated that they are unable to assist LMEC.

B. VALVES TASK UNIT (R. B. Hinze)

A literature study of the effect of impurities in sodium on austenitic-stainless and ferritic steels was completed. Results, purity requirements for sodium used in LMFBR coolant systems, will be issued in a memorandum. Recommendations are included for additional development work to verify certain extrapolations and values used in the study and for work where existing information is insufficient to support a specification.

A draft of the proposed scope of work was received from the Canoga Park RDT Site Representative for the LMFBR valve engineering program and review was completed. Informal comments and recommendations were prepared and submitted to the Site Representative, inviting attention to certain unique liquid metal system valve requirements.

C. PIPING TASK UNIT (E. N. Pearson)

An unsolicited piping development proposal was reviewed at the request of the RDT Site Office. The general conclusions were that the work proposal was too general and that more definitive tasks were required. Detailed comments and recommendations were forwarded to the Site Office.

A memo for file was prepared covering the LMFBR piping work scope received from the Canoga Park Site Representative. The memo proposed additions

and clarifications of some of the requirements and statements presented in the work scopes. Specific comments pointed out the need for testing during the early phases of the program and recommended that a definite purpose of the work scope should be the preparation of a piping specification. This would be in addition to the design guide which was emphasized in the RDT work scope.

Letter No. 67LMEC-1525 was forwarded to CPAO, USAEC. This letter recommended that a task be initiated to examine and evaluate the HNPF main sodium piping. This work would be done concurrently with the HNPF retirement program.

D. PUMPS TASK UNIT (R. W. Atz)

A detailed review of the Westinghouse Large Pump Study project Phase I report was forwarded to RDT. General comments were offered with respect to system optimization, pump type selection, applicability of the proposed pump to sodium service, and the shaft sealing problem. Forty-nine specific comments were also forwarded to RDT.

Discussions were held with the Byron Jackson Pump Company to guide them in preparation of their Phase I report.

The estimated pump weights and sizes for large sodium pumps, developed during this quarter, are shown in Figures 1, 2, and 3. These are for estimating purposes only and represent reasonable extrapolations. They should not be interpreted as the results of detailed designs.

E. INCIDENT REPORT SYSTEM (C. W. Griffin)

Work was started at the beginning of this quarter. A concerted review in breadth was conducted of DOD, NASA, UKAEA, Maritime Administration, and other malfunction and maintenance reporting systems. Their origins, methods, long-range objectives, short-range objectives, and equipment requirements were studied. Cognizance was taken of organizational problems encountered, complexity of input data requirements, cost of operation, and overall relative success of the programs.

These programs and accomplishments were compared against the needs of the LMFBR program.

Figure 1. Estimated Pump Weights

Figure 2. Pump Casing Diameter Estimates

Figure 3. Pump Casing Length

All system programs reviewed were digital, but information in some incident reports are not amenable to digitization. The Naval Ordnance station at Corona, California, was visited to witness the MIRACODE system in field operation and to discuss usage and problems associated with the system. The Naval Ordnance reliability engineers make heavy use of the MIRACODE system to perform quick searches of files to obtain answers to specific questions submitted by field personnel or cognizant Headquarters personnel. Also, extensive re-reviewing of the raw reports is conducted in establishing detailed reliability data on a specific component. Generic data and periodical publications are, however, produced by digital computer analysis and printout of tables. The Naval Ordnance reliability engineers feel that a compatible use of both digital sorting and microfilm sorting is needed for a good reliability program.

Initial conclusions of these studies and visits are that the long-range objective of high confidence level system reliability and availability determination is attainable but is 5 to 7 yr distant due principally to the paucity of data. The initial formats must be designed to record data for this long-range objective. The

storage and retrieval program will use EAM cards for input to whatever system or systems are selected for sorting of categories. Methods and programs exist for developing conservative reliability parameters in the earlier phases of test operation and for establishment of reasonably good distribution functions with respect to environmental parameters. The main effort during early phases, however, will be concentrated in the areas of failure modes, design margins, and maintainability.

The Outline Plan for Collection, Evaluation, and Dissemination of LMFBR Facilities Incident Report Information was formally submitted to the AEC on March 15 for review and evaluation.

A preliminary EAM card format for recording 32 categories associated with identification of component malfunction and maintenance data has been prepared and is shown in Figure 4. Each category has been developed in a detailed breakdown for numerical sorting by whatever system is finally selected. Copies of the full category breakdown are being distributed to computer and microfilm sorting experts for compatibility evaluation with respect to their individual systems.

Review of HNPF and SRE sodium component historical data has been initiated through contract labor and one additional person has been added to the LMEC staff to expedite this contract work and to start a similar evaluation of SCTI data.

F. REACTOR STUDY TASK UNIT (J. E. Owens)

The study of pot-type reactor configuration concepts was initiated with an initial staff of four full-time engineers and technical assistance from the remainder of the LMEC staff as required. Problem areas in design and fabrication were identified and studied in depth, with discussions of alternatives for transmittal to the AEC in early April. A system design description type approach to the solution of these problems was similarly prepared and will be submitted at the same time.

1.		41.	TYPE OF FAILURE
2.	REPORT NUMBER	42.	
3.		43.	
4.		44.	EFFECT OF FAILURE
5.	SITE IDENTIFICATION	45.	SHUTDOWN SCHEDULE
6.		46.	
7.		47.	VENDOR
8.	DATE (JULIAN)	48.	
9.		49.	
10.	YEAR	50.	
11.	MALFUNCTION IMPORTANCE	51.	VENDOR PART NUMBER
12.	(SAFETY IMPLICATION)	52.	
13.		53.	
14.		54.	
15.	SYSTEM AND SUBSYSTEM	55.	
16.		56.	COMPONENT REPAIR (man-days)
17.		57.	
18.		58.	
19.	SIZE	59.	RUN DURATION (days)
20.	SCHEDULE	60.	
21.	ID. NO. OF SUBSYSTEM	61.	REACTOR STATE
22.		62.	
23.		63.	FRACTION OF POWER (%)
24.	COMPONENT TYPE	64.	
25.	(PRIMARY FAILURE)	65.	UNIT OF POWER
26.		66.	OUTLET TEMPERATURE (°F)
27.		67.	INLET TEMPERATURE (°F)
28.		68.	FLOW VELOCITY
29.	COMPONENT MATERIAL	69.	
30.		70.	REPAIR TIME (days)
31.	JULIAN DATE AND YEAR OF	71.	
32.	LAST INSPECTION OR MAINTENANCE	72.	
33.	ON THIS COMPONENT	73.	TOTAL TIME NOT CRITICAL (days)
34.		74.	
35.	SUBSYSTEM	75.	ADDITIONAL TIME GENERATOR OFF (days)
36.	(SECOND FAILURE CAUSED BY	76.	
37.	PRIMARY FAILURE)	77.	CORRECTIVE ACTION - PERFORMED
38.		78.	CORRECTIVE ACTION - RECOMMENDED
39.		79.	FOR FUTURE
40.	METHOD OF SHUTDOWN	80.	CARD IDENTIFICATION

4-18-67 UNC

7694-2423

Figure 4. EAM Card Format

IV. EVALUATION OF EFFORT TO DATE

A. SPECIFICATIONS AND STANDARDS TASK UNIT

Preparation of specifications and standards is proceeding at a currently satisfactory rate.

B. VALVES TASK UNIT

Detailed technical reviews required in the preparation of specifications prove to be an excellent method for identifying specific technical areas where existing information is insufficient for LMFBR needs. While certain specifications prepared at this stage of the LMFBR program must be tentative, the identification of additional development tasks makes the specification preparation effort very valuable.

C. PIPING TASK UNIT

Preliminary steps have been taken in a comprehensive piping program. This program is required for the successful development of large diameter sodium piping in an LMFBR.

D. PUMPS TASK UNIT

The problem of selecting the best pump concept for LMFBR service is not separable from the problem of designing the reactor heat transfer system. For this reason, a broad spectrum of pump concepts must be surveyed to enable the best choice to be made. Continued guidance by RDT is needed to assure development of the required pump designs by the manufacturers (and to prevent them from designing systems). LMEC effort can be of considerable help to RDT by continuing to monitor the efforts of pump manufacturers to develop the designs needed for LMFBR plants.

E. INCIDENT REPORT SYSTEM TASK UNIT

Extensive use of work previously performed by other organizations and published in the following documents has resulted in much faster progress in this program than was initially anticipated and scheduled: (1) "Guide to Nuclear Power Cost Evaluation," TID-7025; (2) "Computer Program for Evaluation of

Data from Military Power Plants," AFWL-TR-65 14; (3) "A. H. S. B. Reactor Fault Reporting System Reactor Fault Code," AHSB(S)R76; and (4) "General Information Manual, Aerospace Information and Control Systems, Reliability Assurance," IBM. The submitted document on the outline plan constitutes a compendium of the state-of-the-art of reliability evaluation in the nuclear industry.

F. REACTOR STUDY TASK UNIT

The effort was initiated this quarter and is considered to be progressing at a satisfactory rate; the problem areas identified represent a very large design and evaluation effort, amounting to possibly several million dollars, to explore in the depth required. These conclusions are, of course, subject to the review and concurrence of RDT.

V. NEXT REPORT PERIOD ACTIVITIES

A. SPECIFICATIONS AND STANDARDS TASK UNIT

A draft specification for welding will be completed. Review, revision, and associated investigations will be continued on the draft specifications for the sodium pump, sodium purity requirements, and IHX. Specifications, standards, and practices received from other contractors and laboratories will be reviewed for applicable information. Contacts with other LMFBR program installations will be increased in an effort to obtain maximum input and coordination.

B. VALVES TASK UNIT

Consultation on purification specifications with the Specifications and Standards Task Unit will be performed as required.

Further consultation on the LMFBR value engineering program will be provided as requested by RDT.

C. PIPING TASK UNIT

Document review and preparation in the piping field will be conducted at the direction of RDT.

D. PUMPS TASK UNIT

It is anticipated that additional discussions between Westinghouse, RDT, and LMEC will be required to resolve problems appearing in the Phase I report.

Another discussion with the Byron Jackson Pump Company will be held to give them additional data so that they can continue with their study.

E. INCIDENT REPORT SYSTEM TASK UNIT

During April, reporting formats will be developed for initial and final Malfunction or Incident Reports and for Maintenance Reports. A draft of category breakdown will be finalized and formal copies forwarded to the AEC if reviews are received in time and no major rework is required.

More detailed planning of future efforts awaits completion of AEC-RDT review of the suggested plan.

F. REACTOR STUDY TASK UNIT

The problem areas, and a system design description type of plan for their solution, will be forwarded to RDT approximately April 10; a meeting to discuss these documents and decide upon implementation action is requested for approximately April 24, at which time the study can proceed in depth.

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Program: Liquid Metal Engineering Center

Project: Data Acquisition and Processing Center Study

Project Manager: R. W. Dickinson

Project Engineer: J. T. Meyer

Reporting Period: January-March 1967

AEC Category: 04-01-61-03

General Order: 7693

Subaccount: 13100

I. PROJECT OBJECTIVES

The overall objective of this project is to perform a conceptual design study as authorized by CPAO-AEC to accomplish the following specific objectives:

- 1) Establish the basic technical requirements for LMEC data acquisition, recording, and processing as indicated by known program objectives and foreseeable needs.
- 2) Establish the capabilities, specifications, and availability of existing data system equipment.
- 3) Perform tradeoff studies and complete conceptual design for satisfying the requirements identified in paragraph (1) above.
- 4) Prepare a final report recommending a system capable of satisfying present and known future LMEC requirements. The report will include a plan of action, proposed schedule, estimated cost for acquisition and installation of the recommended system, and criteria and specifications for the major system components.

II. MAJOR ACCOMPLISHMENTS IN FISCAL YEAR 1967

The study was initiated as requested by AEC. LMEC data processing requirements were determined and a survey of available AEC and commercial data systems was completed. Tradeoff studies were completed on major alternate approaches and conceptual designs to accommodate LMEC data processing requirements were submitted.

III. PROGRESS DURING REPORT PERIOD

Interviews were held with technical and sales representatives of all known major suppliers of data acquisition systems and all applicable information gathered has been incorporated into the study.

The services of a computer programmer to assist in defining total system programming requirements and produce the programming portion of the specifications have been procured. This specialized assistance is required as study results indicated definite benefits will be obtained by use of a computer-controlled data system.

An extension of the study was requested and approved. Tasks I and II indicated a larger and more complex system would be needed to handle LMEC data processing requirements than had been foreseen at the beginning of the study.

The Task I, II, and III portions of the study have been completed and forwarded to the AEC. Work is progressing on Task IV based on the requirements and information in Tasks I and II, and on the recommendations forwarded in Task III.

IV. EVALUATION OF EFFORT TO DATE

A comprehensive evaluation of LMEC data processing requirements has been concluded and an approach has been recommended that will satisfy these requirements. The study has shown that, with the advent of low-cost, digital computers, it is practical and economically advantageous to handle each facility's requirements with a separate computer-controlled data system. This approach also permits maximum flexibility in LMEC data processing operations and the planning for future facilities requirements.

The study schedule was revised to accommodate the increased effort required due to increase in scope of the study and size of the systems. The study is meeting the revised schedule.

V. NEXT REPORT PERIOD ACTIVITIES

The LMEC Data Center Study will be completed during the next quarterly report period. This will include, in the Task IV Report, the recommended plan of action, the schedule for data system procurement and facilities modifications, estimated costs for the data systems, and the data systems specifications. These should be complete by April 28, 1967.

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Program: Liquid Metal Engineering Center

Project: Operation of Sodium Component Test Installation

Project Manager: R. W. Dickinson

Project Engineer: J. A. Leppard

Reporting Period: January-March 1967

AEC Category: 04-01-04-31

General Order: 7693-4

Subaccount: 13200

I. PROJECT OBJECTIVES

The project objective is to operate the Sodium Component Test Installation and to test, obtain data on, and evaluate the performance of prototype intermediate heat exchangers and prototype steam generators.

II. MAJOR ACCOMPLISHMENTS IN FISCAL YEAR 1967

Repair of the sodium heater was accomplished and the plant returned to normal operation. Operation of the plant on a steaming cycle totalled 88 hours. Initial steps have been taken to effect repair of the main steam line.

III. PROGRESS DURING REPORT PERIOD

A partial resolution of steps to be taken in repairing the main steam line was accomplished. Written approval (from RDT Washington) was given to the contract with Bechtel Corporation for re-design of the main steam piping using 2-1/4 Cr - 1 Mo ferritic steel, procurement of long-leadtime materials, and review of the adequacy of the entire steam and feedwater systems.

As a result negotiations with Bechtel were instituted and engineering work was started. Three preliminary specifications for pipe, pipe fittings, and control valves have been transmitted to SCTI for review. Contract negotiations were delayed because of several difficulties in work statement definition and administrative provisions. These differences have been resolved and a contract will be signed early in the next quarter.

Because of certain reservations of the RDT Staff, AI-LMEC was requested to obtain the services of an A-E firm having experience in the use of austenitic

steels in power plants, as well as a research institute to independently review the entire history of the steam piping failure. The intent of these investigations is to determine the probable cause of the failure. Responses were received from two A-E firms and two research firms. Contracts with one of each will be signed early in the next quarter.

In connection with the steam piping problem, an internal report was published on the metallurgical examination of specimens from the failed piping; this report concluded that the cause of failure was chloride stress corrosion. A report covering the operational history of the steam line, conditions surrounding the failures, and recommended repair actions was prepared. A System Design Description of the proposed steam line modification was also prepared.

Additional inspection of existing steam piping, in consideration of a possible interim fix, has revealed the presence of extensive cracking not previously found. The desuperheater, which is just downstream of the first-stage pressure reducing valve, was disassembled; the atomizing nozzle had three massive crack systems characteristic of those seen previously. Figure 5 shows one side of the desuperheating nozzle; dye check indicates the cracks. This nozzle is a cast piece and is subjected to very low stress during operation. A 10-in., 2500-lb flange, the largest single part of the desuperheater assembly, was found to be very badly cracked although the crack systems had not propagated completely through the material. Figure 6 shows dye check indication of the cracks (this pictures the inner surface of the 10-in. weld neck flange). Samples from a total of six locations have been metallographically examined and the cracks are very typical of stress corrosion. Figure 7 is a photomicrograph of a typical crack system progressing from the inner surface of the flange of Figure 6. On the basis of these additional examinations it appears that none of the existing 347 SS piping can be used. The reason for considering an interim fix was to seek an alternative to the replacement of the piping with a ferritic steel (2-1/4 Cr - 1 Mo) so that the SCTI could be returned to normal operation at an earlier date. There does not appear to be a reasonable interim fix.

All six bellows expansion joints have been removed from the secondary sodium system. Replacement piping spools and piping expansion loops have been installed. Final welding is nearly completed. Application of preheaters and thermal insulation will be completed within the next quarter.

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7694-2525

Figure 5. SCTI Desuperheater Atomizing Nozzle

3-14-67 UNC

7694-4003CN

Figure 6. SCTI Desuperheater Flange

NAA-SR-12416
24

4-17-67 UNC

7694-2524

Figure 7. Typical Crack System in SCTI
Desuperheater Flange
(347 Stainless Steel) 125X

NAA-SR-12416

Considerable preventive maintenance work has been performed on various major components of the plant. For example, the steam condenser was cleaned and inspected, and a static pressure leak test confirmed that the condenser tubes are all leak tight. The cooling tower was concurrently drained and the basin washed free of silt. Shaft gas seals for the primary sodium pump were refaced and reinstalled. The primary sodium pump was returned to normal service; circulation of primary sodium continued through most of the quarter. Extensive repair and rework was performed on thermal insulation of all weather-exposed sections of the primary sodium piping and the fill and drain piping and the primary drain tank. New sealed bearings were applied to the drive motors for the two preheat air compressors. Extensive leak checking of the instrument air system was completed.

A test plan to obtain vibration data from the ALCO IHX was completed. Described were the test method, vibration pick-up installation, and data acquisition requirements.

The final section of the as-built System Design Description was completed and transmitted to the AEC for review. A final editing effort to combine the 12 sections into a homogenous report is scheduled for the next quarter.

Additional historical Incident Reports were transmitted to the AEC; a total of 117 Incident Reports have been transmitted to date.

IV. EVALUATION OF EFFORT TO DATE

Failure of the high-pressure steam line and the delays encountered in resolving the method of repair has caused a serious hiatus in the SCTI program. Completion of design work required for the revision of the steam piping and procurement of long-leadtime items is being expedited as much as possible. Ultimate repair of the system should permit an increase in future plant availability.

V. NEXT REPORT PERIOD ACTIVITIES

Redesign of the main steam piping will be completed. Purchase orders for long-leadtime items will be placed. Construction work to eliminate bel-lows from the secondary system will be completed. The last of the historical Incident Reports will be transmitted. The as-built System Design Description will be published.

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Program: Liquid Metal Engineering Center	
Project: Liquid Metals Information Center	
Project Manager: R. W. Dickinson	Project Engineer: J. J. Droher
Reporting Period: January-March 1967	AEC Category: 04-01-61-03
General Order: 7593	Subaccount: 13300

I. PROJECT OBJECTIVES

The project objective is to operate and maintain the Liquid Metals Information Center which serves as a focal point for technically evaluated information and data on liquid metals technology and components, with initial emphasis on sodium and NaK alloys as heat transfer and transport fluids. State-of-the-art reports and an updated version of the Liquid Metals Handbook, covering unclassified material on sodium and NaK, are to be prepared.

II. MAJOR ACCOMPLISHMENTS IN FISCAL YEAR 1967

The Liquid Metals Information Center became operational on July 1, 1966 and now has information from 4455 documents stored within the computerized search and retrieval system. The Center has responded to 219 separate requests for information from various organizations, including practically all of the major laboratories engaged in liquid metals technology. These requests have involved 732 separate subject categories, for which computerized searches were performed resulting in a total of 89,600 printouts containing bibliographic data and abstracts of documents containing pertinent information.

III. PROGRESS DURING REPORT PERIOD

During this quarter 365 additional documents were processed, making a total of 4820 documents in the LMIC data bank. The Center responded to 65 inquiries for information during the quarter, of which 58 were for specific technical information while the remainder were for general information about the Center and its activities. Many of the requests for specific technical information involved more than one question, so that responding to these requests required computerized

searches covering 175 different subject categories and yielding a total of 33,600 computer-produced printouts.

Work continued on the revision of the Sodium-NaK Supplement to the Liquid Metals Handbook. Additional computer printouts from the LMIC data bank have been distributed to the authors of individual chapters covering the particular topics involved.

IV. EVALUATION OF EFFORT TO DATE

No major problem areas have been encountered in data storage and retrieval.

The Liquid Metals Information Center has received technical guidance from the Division of Reactor Development and systems guidance from the Division of Technical Information of the U. S. Atomic Energy Commission. Information on liquid metals technology is being provided to a broad spectrum of potential users including national laboratories, other government agencies, R&D companies, and universities. Inquiries have been received at rates higher than anticipated and all indications are that the Center is performing a vital service and is fulfilling a definite mission in the Liquid Metal Fast Breeder Reactor Program.

Additional effort will be required to meet the target schedule for preparation of a draft copy of the Revised Handbook (Sodium-NaK Supplement). In recognition of this fact, additional personnel were assigned to this activity near the end of this quarter and this accelerated effort will continue throughout the next quarter.

V. NEXT REPORT PERIOD ACTIVITIES

The Liquid Metals Information Center will continue to collect, evaluate, store, and disseminate information on liquid metals technology. Additional sources of information will be sought and requests for future services will be honored. Preparation of a first draft of the Revised Handbook will be completed.

Program: Liquid Metal Engineering Center	
Project: Sodium Pump Test Facility	
Project Manager: R. L. Cummings	Project Engineer: S. L. Pfahler
Reporting Period: January-March 1967	AEC Category: 04-01-61-03
General Order: 7693	Subaccount: 13400

I. PROJECT OBJECTIVES

The objectives of this project are to: (1) perform a detailed review of the Sodium Pump Test Facility (SPTF) conceptual design as presented in WCAP-2526 and modify as necessary the design and performance criteria to fit the site at Santa Susana, (2) prepare conceptual system design descriptions, (3) prepare a cost estimate and schedule, (4) develop specific instructions and guidelines within which an Architect-Engineering (A-E) firm will optimize the SPTF concept for minimum capital costs, (5) select and contract for an A-E for the design of the SPTF.

II. MAJOR ACCOMPLISHMENTS IN FISCAL YEAR 1967

The planning, organization, conceptual engineering and evaluation to accomplish the first four objectives listed above were completed on schedule. Proposals for the design of the SPTF were received from seven Architect-Engineering (A-E) firms.

III. PROGRESS DURING REPORTING PERIOD

A. A-E SELECTION

The seven proposals submitted by prospective Architect-Engineering firms were reviewed and evaluated. A meeting was held with RDT, Washington, to discuss the A-E selection criteria. Two finalists were chosen and visited for detailed evaluation. A report containing the Contractor Selection Board's recommendation was mailed to CPAO on February 17, 1967. Approval of the Board's recommendation was received March 21, 1967 and C. F. Braun & Co.

was notified that it had been selected for negotiation leading to a contract for SPTF engineering.

B. SPTF CONCEPTUAL DESIGN

An outline of the Overall Conceptual Systems Design Description (OCSDD) was approved by RDT. The OCSDD (NAA-SR-MEMO-12160) was issued February 23, 1967. In this document the facility objectives, design criteria, and general requirements for safety, maintainability, reliability, and operability are defined. Also included are descriptions of all the systems that comprise the SPTF, as well as guidelines and a schedule for completion of the optimization studies.

C. A-E PRE-CONTRACT COORDINATION

Copies of the OCSDD along with the proposed contract, including the work statement and RDT's instructions for preparation of System Design Descriptions, were given to the C. F. Braun Co. on March 21, 1967. Braun presented a preliminary manhour and cost estimate for their Titles I, II, and III services.

D. REVISED COST ESTIMATE

A revised cost estimate for the total cost of engineering and construction was completed. Changes from the original estimate were:

- 1) NAA will be prime construction contractor instead of AEC.
- 2) The A-E will provide full field inspection, shop drawing reviews, as-builts, and progress reports for Title III.
- 3) The data acquisition and control system was increased from 200 to 700 points.

The cost breakdown by fiscal year showing line and operating items for Titles I, II and III was mailed to the AEC on March 10, 1967.

IV. NEXT REPORT PERIOD ACTIVITIES

Contract negotiations will be completed with C. F. Braun & Co. for Titles I, II, and III; surveillance of Title I design effort will commence.

Program: Liquid Metal Engineering Center	
Project: Sodium Pump Bearing and Seal Test Program	
Project Manager: R. W. Dickinson	Project Engineer: L. B. Copeland
Reporting Period: January-March 1967	AEC Category: 04-01-61-03
General Order: 7693, 7694	Subaccount: 14100

I. PROJECT OBJECTIVE

The project objective is to determine, by study and experiment, the suitability of candidate bearings and seals for the large sodium pumps being designed as a part of the LMFBR program of the USAEC. From evaluation of test data and performance characteristics to be obtained, suitability will be determined in relation to reliability, life, efficiency, and maintenance requirements.

II. MAJOR ACCOMPLISHMENTS IN FISCAL YEAR 1967

Program plans were prepared and submitted for review. An Overall Conceptual System Design Description for seal testing was prepared and submitted for review. Design of seal test apparatus was initiated and is proceeding on schedule.

III. PROGRESS DURING REPORT PERIOD

Project authorization was received in January 1967; estimated period for completion is two years. Attainment of the project goal basically entails: (1) procurement of bearings and seals designed by the large pump study contractors and (2) test and evaluation of those components. Three phases will be involved; namely, Planning and Design, Procurement and Fabrication, and Test and Evaluation.

A program plan was prepared and submitted to AEC. The plan describes the following approach: (1) obtain design and schedule information from the pump study contractors; (2) prepare specifications, system design descriptions, and test plans and procedures; (3) obtain component and test apparatus designs; (4) procure test components and apparatus; and (5) test and evaluate three sets each of full-size candidate bearings and seals. An appendix to the plan states

assumptions used in the basic plan, perturbations that could reasonably occur, and the cost and schedule effects of two alternate plans. Also submitted was a project worksheet (Form 189) for FY 1968-69 reflecting a reduced budget accomplished by eliminating test of a third seal and a third bearing in FY 1968.

Preliminary bearing and seal design data and recommended test facility capabilities were received from the study contractors and have been evaluated. On the basis of the first-received initial information from one contractor, an Overall Conceptual System Design Description for the seal test facility was prepared and submitted to AEC. A work plan and a design specification were prepared, and design of the apparatus was initiated. Design analyses were completed and documented; areas covered were structural and pressure vessel stress, final process calculations, and piping stress. These were reported, respectively, by Engineering Documents No. TI-682-14-001, TI-682-14-002, and TI-682-30-001. Evaluation of initial information subsequently received from the other study contractor did not result in design change requirements for the seal test rig. Except for sizing minor components after receiving specific seal designs, design completion is expected by April 14. Procurement action was initiated and several items from AEC surplus were obtained.

After completing evaluation of the first information received from a study contractor, a request for additional information concerning bearing and seal design data, design criteria, and facility capability requirements was made through the CPAO of the AEC. Upon evaluation of information received from the other contractor, a similar request was made during a meeting between LMEC, AEC-RDT, and contractor representatives. Review and evaluation of bearing test facility requirements, especially for hydrostatic bearings, resulted in postponing submission of the Overall Conceptual System Design Description. The parametric nature of one pump design study, in particular, inherently results in a range of possible bearing sizes and requirements too broad to establish facility design bases.

Agreement as to requirements is necessary prior to proceeding to OCSDD finalization and test rig design. At present, several alternatives for test systems are available. These are at least: (1) use of LCTL; (2) a completely new test rig; and (3) use of the Auxiliary Component Test Installation, modified

to provide the required sodium supply. On the basis of current information, a search was started for a suitable sodium supply pump for hydrostatic bearing tests. Minimum capability being sought is 7000 gpm and 450 ft at 1200°F.

IV. EVALUATION OF EFFORT TO DATE

Initiation of design of the seal test apparatus prior to receipt of complete data from the study contractors appears justified. Seal testing is expected to proceed essentially per the project schedule. Preparation for bearing testing is now behind the projected schedule due to inadequate information from bearing suppliers. Net effect to the overall project schedule is presently indeterminate since it is not known when required input will be received. Regaining the lost time is presently considered to be possible; or probable, if more than one bearing test facility is considered. Therefore, in spite of delays encountered and foreseen, timely submission of supporting information required by related LMFBR programs is expected.

V. NEXT REPORT PERIOD ACTIVITIES

Final design of the seal test apparatus will be completed, procurement of components nearly completed, and assembly started. Preparation of seal test plans, specifications, and procedures will be started. Action to procure detail designs of bearings and seals from both study contractors will be started. The bearing test OCSDD will be submitted and, possibly, quotations for design of the bearing test apparatus will be solicited.

Program: Liquid Metal Engineering Center

Project: Precision Mechanisms in Sodium

Project Manager: R. W. Dickinson

Project Engineer: W. J. Freede

Reporting Period: January-March 1967

AEC Category: 04-01-61-03.1

General Order: 7693, 7694

Subaccount: 24100

I. PROJECT OBJECTIVES

Objective of this project is to obtain special engineering information needed for design of mechanical elements required to operate reliably in sodium liquid and vapor to 1200°F in nuclear reactors. It is intended that this information may be used in the design of fuel handling devices, control rod drives, and fuel hold-down mechanisms for sodium-cooled fast breeder reactors planned for the immediate future.

II. MAJOR ACCOMPLISHMENTS IN FISCAL YEAR 1967

Static contact tests were completed to determine self-welding characteristics of 50 candidate material combinations in 1200°F cold-trapped, circulating liquid sodium. Similar tests were performed with the same candidate materials in 1200°F hot-trapped, circulating liquid sodium and sodium vapor. Oxygen impurity levels in each series of experiments were controlled and monitored according to test specifications.

Experiments were conducted using sliding friction and wear test fixtures to provide basic information regarding coefficient of friction and wear characteristics in 800 to 1200°F liquid and vapor sodium.

III. PROGRESS DURING REPORT PERIOD

Static contact (self-welding) data were obtained and are being evaluated regarding 50 material combinations which were exposed for 2 months to 1200°F liquid sodium, cold-trapped to 20 to 25 ppm O₂. Static contact (self-welding) data were also obtained and are being evaluated regarding the same candidate

material combinations which were also exposed to 1200°F liquid sodium but which were hot-trapped to less than 5 ppm O₂ and 1200°F sodium vapor. In each case, the exposure period was 1 month. Specimen materials involved are shown in Table 1.

TABLE 1
STATIC CONTACT MATERIALS

Plate	Pin	Plate	Pin
Tungsten Carbide			
K-95	K-95	AISI M2	AISI M2
K-95	K-162B	AISI M2	AISI M3 Type 1
K-95	AISI T1	AISI M2	Stellite 6B
K-95	AISI M1	AISI M2	Colmonoy 4
K-95	AISI M2	AISI M2	Hastelloy C
K-95	AISI M3 Type 1	AISI M3 Type 1	AISI M3 Type 1
K-95	Stellite 6B	AISI M3 Type 1	Stellite 6B
K-95	Colmonoy 4	AISI M3 Type 1	Colmonoy 4
K-95	Hastelloy C	AISI M3 Type 1	Hastelloy C
Titanium Carbide			
K-162B	K-162B	Stellite 6B	AISI M1
K-162B	AISI T1	Stellite 6B	AISI M2
K-162B	AISI M1	Stellite 6B	Molybdenum
K-162B	AISI M2	Stellite 6B	Stellite 6B
K-162B	AISI M3 Type 1	Stellite 6B	Colmonoy 4
K-162B	Stellite 6B	Stellite 6B	Hastelloy C
K-162B	Colmonoy 4	Hastelloy C	AISI M3 Type 1
K-162B	Hastelloy C	Hastelloy C	Hastelloy C
K-162B	Molybdenum	Colmonoy 4	Colmonoy 4
AISI T1	AISI T1	Colmonoy 4	Hastelloy C
AISI T1	AISI M1	Molybdenum	Stellite 6B
AISI T1	AISI M2	Molybdenum	Hastelloy C
AISI T1	AISI M3 Type 1	Molybdenum	Molybdenum
AISI T1	Stellite 6B	Tungsten	Tungsten
AISI T1	Colmonoy 4	Tungsten	Molybdenum
AISI T1	Hastelloy C	HastelloyC	Hastelloy C

Experiments were conducted using sliding friction and wear test fixtures to provide basic information regarding coefficient of friction and wear characteristics in 800 to 1200° F liquid and vapor sodium. Tests on 43 combinations of candidate materials were completed. Fundamental data obtained from this effort to date are listed in Table 2.

The dimension of $\text{cm}^3/\text{cm-kg}$ indicates cubic centimeter of pin material worn off per centimeter of travel, per kilogram of pressure on the test rubbing surfaces. As such, it is a recognized standard means for expressing the phenomenon of wear. Thus, in examining the data, one will note that molybdenum and TZM wore excessively against tungsten. On the other hand, tungsten had a low degree of wear against Hastelloy C. Where "Imbedded Material Buildup" is indicated, the length of rubbed pins increased instead of decreased. Analyses performed on the buildup material indicated that hard constituents apparently had been torn from the plate involved, and these particles had become imbedded and welded into and onto the pin contact surfaces. Exploratory tests were initiated to determine parameters which are critical in this buildup action. Results will be reported at a later date.

Temporary settlement of the labor strike at the Stellite Division of Union Carbide resulted in shipment of several key candidate test materials. These items were fabricated into specimens for future static contact and sliding friction and wear tests.

In accordance with instructions relayed through CPAO-AEC, experimental activities pertaining to this program were limited to continuance of tests in progress at the beginning of the quarter. Before these instructions were established, procurement arrangements had been made for various bearing and gear test specimens. A number of these items were received and were placed in storage pending future guidance.

Preparation of the literature/experience survey report was initiated and the basic outline was completed. Compilation of this topical report was judged to be 60% completed with the initial draft scheduled to be issued May 15, 1967.

TABLE 2
SLIDING FRICTION AND WEAR TEST DATA

Test Number	Materials		Sodium Environment			Coefficient of Sliding Resistance	Specific Wear on Pins (Average) (cm ³ /cm·kg)
	Pin	Plate	Temperature (°F)	State			
				LCT*	V†		
11	AISI-TI (Tool Steel)	Hastelloy C	1200	x		0.47	6.7 × 10 ⁻¹¹
A-1	K 95 (Tungsten Carbide)	K-162 B (Titanium Carbide)	1200	x		0.27	Imbedded material buildup
A-2	K-162 B (Titanium Carbide)	K-95 (Tungsten Carbide)	1200	x		0.24	2.5 × 10 ⁻¹¹
A-3	Stellite 6B	Stellite 6B	1200	x		0.40	9.4 × 10 ⁻¹¹
B-1	AISI-MI (Tool Steel)	AISI-MI (Tool Steel)	1200	x		1.07	Galled and welded
B-2	AISI-T15 (Tool Steel)	AISI-TI (Tool Steel)	1200	x		0.94	Galled and welded
B-3	17-4 PH	AISI-M15 (Tool Steel)	1200	x		1.07	Galled and welded
C-1	AISI-M3 Type 2 (Tool Steel)	AISI-M4 (Tool Steel)	800	x		0.31	4.9 × 10 ⁻¹¹
C-2	AISI-M4 (Tool Steel)	AISI-M43 (Tool Steel)	800	x		0.29	2.5 × 10 ⁻¹¹
C-3	AISI-M43 (Tool Steel)	AISI-M3 Type 2 (Tool Steel)	800	x		0.45	7.1 × 10 ⁻¹¹
21	Stellite 3	K-162 B (Titanium Carbide)	1200	x		0.35	Imbedded material buildup
D-1	Molybdenum	Stellite 6B	1200	x		0.36	3.6 × 10 ⁻¹¹
D-2	Tungsten	Hastelloy C	1200	x		0.29	4.7 × 10 ⁻¹¹
D-3	Hastelloy C	K-95 (Tungsten Carbide)	1200	x		0.67	2.9 × 10 ⁻¹¹
E 1	AISI-M3 Type 2 (Tool Steel)	AISI-M4 (Tool Steel)	800		x	0.33	2.2 × 10 ⁻¹¹
E-2	AISI-M4 (Tool Steel)	AISI-M43 (Tool Steel)	800		x	0.36	2.9 × 10 ⁻¹¹
E-3	AISI-M43 (Tool Steel)	AISI-M3 Type 2 (Tool Steel)	800		x	0.33	1.4 × 10 ⁻¹¹
F-1	Stellite 6B	Stellite 6B	1200		x	0.40	12.8 × 10 ⁻¹¹
F-2	Hastelloy C	Hastelloy C	1200		x	0.47	50.4 × 10 ⁻¹¹
30	AISI-M43 (Tool Steel)	AISI-M3 Type 2 (Tool Steel)	800	x		0.33	1.0 × 10 ⁻¹¹
G 1	Hastelloy C	Molybdenum (Plasma Spray)	1200	x		-	Molybdenum separated from 304 SS plate
G-2	TZM	Tungsten (Plasma Spray)	1200	x		0.34	215 × 10 ⁻¹¹
G-3	Molybdenum	Tungsten (Plasma Spray)	1200	x		0.45	213 × 10 ⁻¹¹
H-1	Rex 49 (Tool Steel)	Rex 49 (Tool Steel)	1200	x		-	Self-welded to plate
H-2	Molybdenum	Rex 49 (Tool Steel)	1200	x		-	Self-welded to plate
H-3	Rex 49 (Tool Steel)	Hastelloy C	1200	x		0.38	38.7 × 10 ⁻¹¹
37	TZM	Stellite 6B	1200	x		0.63	Imbedded material buildup
I-1	Stellite 3	Hastelloy C	1200	x		0.41	7.15 × 10 ⁻¹¹
I-2	Molybdenum	Tungsten	1200	x		0.54	1088 × 10 ⁻¹¹
I-3	TZM	Tungsten	1200	x		0.65	936 × 10 ⁻¹¹
41	Tungsten	Hastelloy C	1200	x		0.33	2.88 × 10 ⁻¹¹
J-1	Stellite 3	Colmonoy 75 (Hard Face)	1200	x		0.52	4.40 × 10 ⁻¹¹
J 2	Hastelloy C	Colmonoy 5 (Hard Face)	1200	x		0.42	37.6 × 10 ⁻¹¹
J-3	Stellite 6B	Colmonoy 6 (Hard Face)	1200	x		0.36	Imbedded material buildup
45	17-4 PH	Colmonoy 70 (Hard Face)	1200	x		0.36	Imbedded material buildup
K-1	Tungsten	Stellite 6B	1200	x		0.36	5.15 × 10 ⁻¹¹
K-2	Stellite 6B	K-95 (Tungsten Carbide)	1200	x		0.49	7.30 × 10 ⁻¹¹
K 3	Colmonoy 6 (Hard Face)	K-95 (Tungsten Carbide)	1200	x		0.63	75.4 × 10 ⁻¹¹
49	Colmonoy 4 (Hard Face)	Colmonoy 5 (Hard Face)	1200	x		0.40	25.8 × 10 ⁻¹¹

*LCT = Liquid, Cold Trapped
†V = Vapor

IV. EVALUATION OF EFFORT TO DATE

Preliminary evaluation of static contact and sliding friction and wear tests in 1200°F cold-trapped liquid sodium indicated qualified acceptable motion contact surface properties in Stellite 3 and 6B, Hastelloy C, tungsten, some hard facings, and K-95 (tungsten carbide). AISI T1, T15, M1, M2, M3, and M43 tool steels, which exhibited good friction and wear characteristics during tests in 932°F liquid sodium (cold-trapped) conducted by other laboratories, showed excessive wear and galling in 1200°F liquid cold-trapped sodium. Sliding tests conducted on the latter materials in 800°F cold-trapped liquid and vapor sodium indicated excellent wear resistance. Titanium carbide was subject to rapid oxidation attack in 1200°F cold-trapped liquid sodium and was rendered unsuitable for any use in this environment.

V. NEXT REPORT PERIOD ACTIVITIES

Thirty-day tests regarding static contact (self-welding) pertaining to a different set of 50 candidate material combinations will be completed in 1200°F cold-trapped and hot-trapped liquid sodium environments.

Sliding contact tests in 800 to 1200°F cold-trapped liquid and vapor sodium will be continued. Similar tests in hot-trapped liquid sodium will be initiated. Exploratory tests will be conducted to determine parameters which are critical in buildup of material on certain specimen contact surfaces.

The literature/experience survey topical report pertaining to mechanisms in sodium will be completed, and final review drafts will be forwarded to concerned AEC offices. Following this action, it is anticipated that guidance will be formulated regarding the future course of test activities. In this latter connection, high priority probably will be directed toward starting various rolling friction and wear tests in 1000 to 1200°F liquid and vapor sodium environments.

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Program: Liquid Metal Engineering Center

Project: Mechanisms in Sodium

Project Manager: R. W. Dickinson

Project Engineer: W. J. Freede

Reporting Period: January-March 1967

AEC Category: 04-01-61-03.1

General Order: 7693, 7694

Subaccount: 27110

I. PROJECT OBJECTIVES

Objectives of this project are as follows:

1) Develop information concerning depositions from sodium vapor to provide basic data which will be useful for the design of mechanisms required to operate in sodium vapor environments.

2) Evaluate the use of wafer-type 347 CRS bellows as linear seals for exclusion of contaminants from cover gas in vessels containing sodium at elevated temperatures.

3) Operate an existing stroke multiplication mechanism, manufactured from Hastelloy C, in 1200° F liquid sodium. Evaluate the performance obtained to determine general information on friction and wear for this type of mechanism and any specific performance attributable to this specific configuration.

II. MAJOR ACCOMPLISHMENTS IN FISCAL YEAR 1967

A. VAPOR DEPOSITION EFFECTS

Equipment and test fixtures were completed and test operations were initiated.

B. LINEAR BELLOWS SEALS

Testing was completed on two pairs of wafer-type CRS bellows fabricated by two manufacturers. These operated in 900° F sodium vapor for limited periods of time and a predetermined number of cycles. Failure occurred in three of the four bellows before completion of all scheduled tests. However, both bellows from one manufacturer showed a definite superiority.

C. STROKE MULTIPLICATION MECHANISM

The originally planned test program was completed in which 46,500 stroke cycles were registered. The mechanism performed with little increase in backlash or friction. Cycling was continued for endurance determinations.

III. PROGRESS DURING REPORT PERIOD

A. VAPOR DEPOSITION TEST

All test system details were completed and cover gas supply devices were calibrated. In Figure 8, the glove box above the test vessels facilitates specimen removal in an inert atmosphere. Individual specimen cover gas lines are shown penetrating the box. A preliminary test was conducted to shake down equipment components and examine test procedures. Initial performance was inadequate, and modifications subsequently were made to fixtures to facilitate inspection of the deposition areas and permit precipitation to occur at proper locations. Upon completion of alterations, planned vapor deposition tests were initiated.

B. LINEAR BELLOWS SEALS

Two Belfab bellows previously cycled 30,000 times in 900°F sodium vapor (above a 1200°F sodium pool) were reinstalled for further testing after cleaning and inspection. A drive time of 1.1 min/cycle was used with a dwell period of 1 hour between half cycles. One of the two bellows, Figure 9, failed after an additional 480 cycles (1000-cycle test objective). Sodium vapor depositions may be seen between the wafer convolutions (Figure 9). At this point, testing on the one remaining unfailed bellows was discontinued to permit a pre-failure metallographic examination.

C. STROKE MULTIPLICATION MECHANISM

The stroke multiplier device, Figure 10, completed a total of 54,000 cycles in 1200°F liquid sodium. After 41,000 cycles, the mechanism was cleaned and inspected; then, loading was doubled to 60 lb and testing was resumed. A bellows failure at 46,500 cycles caused a shutdown for replacement. The stroke multiplier device is shown in Figure 10. Racks and pinions which comprise the

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Figure 8. Sodium Vapor Deposition Test System

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Figure 9. Failed Linear Bellows Seal

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7682-4002

Figure 10. Stroke Multiplication Device

NAA-SR-12416

stroke amplification (4:1) mechanism have been partially removed from the support housing. Test loads may be varied by changing cylindrical weights.

Total system clearances increased from an average 0.035 in. initially to an average of 0.058 in. at 45,000 cycles. This reflects an increase in clearance of 1.29×10^{-6} in./cycle or 2.15×10^{-7} in./in. of input stroke. This minor increase was reasonably linear in rate.

System frictional loads increased 17.4% on the down stroke and 28.6% on the up stroke over the first 41,000-cycle service with the 30-lb load (half load). Frictional loads were approximately 15% of the total load at the input shaft, neglecting bellows loads.

IV. EVALUATION OF EFFORT TO DATE

From a standpoint of design criteria, successful operation was exhibited by the Belfab wafer-type bellows when operated continuously in sodium vapor at 900°F. Conclusions will be formed on long-term intermittent cycling after the two bellows subjected to such cycling have been examined metallographically to determine why one failed.

Proof testing of the stroke multiplication mechanism at various loadings over a substantial number of stroke cycles has indicated that the device as designed and fabricated is a very reliable piece of equipment for use in 1200°F sodium environments. All that remains to be obtained from additional testing are data for calculating service life and possible failure mode.

V. NEXT REPORT PERIOD ACTIVITIES

Rates of precipitation plus various physical and chemical properties will be obtained from vapor deposition tests in which air with water vapor added will contaminate an inert gas atmosphere above a 1200°F sodium pool. Another variable which will be introduced will involve deposition surface temperatures.

Operation of the stroke multiplication mechanism will be continued under full stroke, full load (60-lb) conditions. Friction values and backlash will be

measured periodically during the experiment. After concluding all testing, mechanism parts will be measured and compared to original data.

Testing of the bellows linear seals has been completed. Examination and evaluation efforts will be concluded during the final quarter.

Program: Liquid Metal Engineering Center

Project: Installation of B&W Steam Generator

Project Engineer: R. W. Dickinson

Project Engineer: R. L. Rehorst

Reporting Period: January-March 1967

AEC Category: 04-01-61-03

General Order: 7693

Subaccount: 41310

I. PROJECT OBJECTIVES

The objective of this project is to install the B&W steam generator in the SCTI in preparation for testing.

II. MAJOR ACCOMPLISHMENTS IN FISCAL YEAR 1967

The preliminary system description for the installation of the B&W steam generator in the SCTI was completed. One technical review meeting was held between AI and B&W.

III. PROGRESS DURING REPORT PERIOD

Approval to proceed with the final design was received and this effort has been initiated.

The data acquisition system planning report, submitted last quarter, will not be utilized in the preparation of the design documents, because the experimental data requirements of the B&W steam generator will be provided for by a data system currently under study by the LMEC Staff.

A purchase requisition was written for B&W to provide the special reducing tee required on the steam generator steam outlet.

No additional information on the proposed test program was received from B&W. Their review of an AI internal report dealing with SCTI control system capabilities is in progress.

IV. EVALUATION OF EFFORT TO DATE

The system description and all analytical work required to proceed with final design have been completed. It is not anticipated that the current SCTI shutdown will delay the start of the B&W test program as it is currently scheduled.

V. NEXT REPORT PERIOD ACTIVITIES

A substantial amount of final design work will be accomplished, including: a final system description, final design of the B&W steam generator installation, final design of the necessary process system modifications, and preparation of an equipment removal package. No coordinating meetings with B&W are scheduled during the next quarter.

Program:	Liquid Metal Engineering Center		
Project:	High Temperature Strain Measurements		
Project Manager:	R. W. Dickinson	Project Engineer:	M. M. Lemcoe
Reporting Period:	January-March, 1967	AEC Category:	04-01-61-03
General Order:	7693	Subaccount:	52110

I. PROJECT OBJECTIVES

The objective of this project is to develop suitable, reliable, high-temperature strain gages for experimental stress or strain measurements, or for application in process instrumentation components. Commercially available gages will be tested to determine their limits, applicability, and reliability as analytic instruments for use on component test loops and systems, and as sensing elements in pressure transducer and force-arm applications. Suitable high-temperature strain gages will be developed, as well as application techniques for high-temperature use. Methods of accomplishing temperature compensation and sealing of the sensitive element will be investigated to permit use of the strain gages in contact with sodium or sodium vapor.

II. MAJOR ACCOMPLISHMENTS IN FISCAL YEAR 1967

A topical report, "Characteristics of Two Commercial High Temperature Electric Resistance Strain Gages," NAA-SR-12118, was completed and published. Considerable information on the steady-state and transient characteristics of the Microdot type SG420 and BLH Type HT 1212-5A gages is contained in that report.

A foil gage geometry-material combination has been developed which permits flame-spray bonding of foil-type gages, without damage to the gage. This is regarded as a significant advancement for several reasons: (1) there are no commercial foil gages on the market that can be flame-spray bonded directly without damage; (2) foil gages offer several distinct advantages over wire gages, including greater uniformity from gage to gage and the elimination of joints within the gage itself, which results in greater gage reliability; and (3) flame-spray bonding is rapid and eliminates the need for curing the cement required for bonding commercial foil gages. This is of particular

importance in the instrumentation of LMFBR components where mass and size are so large as to make field curing of the cement unfeasible, or impossible. Flame-spray-bonded foil gages may be installed in the field, without any curing whatsoever.

III. PROGRESS DURING REPORT PERIOD

Development continues on fabrication procedures to minimize variations in characteristics or performance from gage to gage. Evaluation of the gages fabricated using white-glove techniques showed there was no marked improvement in gage performance over those gages fabricated without gloves. This indicates that the primary source(s) of any contamination is not related to the handling of the gage materials during gage assembly. Attention will now be focused on establishment of procedures for cleaning the wire and ribbon prior to gage assembly, using suitable solvents such as alcohol or acetone or ultrasonic cleaning methods, if feasible. The necessity of having to carry out gage fabrication in a dust-free environment, or having to perform the welding operation in an inert atmosphere is also under study. Evaluation also showed that no improvement in gage performance resulted from the use of Hoskins Alloy 875 ribbon, in lieu of Nichrome V ribbon; hence, future gages will be fabricated with the Nichrome V ribbon. Figure 11 shows a typical strain gage installation for two flame-spray-bonded gages with the ribbon tabs protruding from each end of the aluminum-oxide coating.

Both laser beam and electron beam welding techniques were investigated for making gage joints. The sample joints made using these techniques were not as strong or as reliable as those made with a capacitance discharge welder. Although satisfactory joints could be made with larger diameter wire (3 to 5 mils), these techniques and/or equipment do have serious limitations when used to weld 1-mil-diameter wire, because of loss of accurate regulation of the equipment at the very low energy levels required, relatively large beam diameter, and other factors. Major attention is now being focused on advanced microcircuit capacitance discharge welding equipment, with parallel gap weld heads and electrodes specially designed for welding materials whose thickness or diameter is as small as 1 mil. Pilot joints have been fabricated with such equipment and they are now in the process of being evaluated.

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Figure 11. Typical Strain Gage Installation

Evaluation of several pilot "one-piece" Armour-D gages, with thickened gold shanks, has been completed. Tests were conducted at 1200°F. It was found that the gages became unstable after only a brief period at 1200°F. This instability is believed due to the migration of gold into the Armour-D alloy. This instability did not occur at temperatures below 950°F. It is therefore concluded that gages with gold-plated shanks are not reliable above 950°F, regardless of whether the gage filament is an iron base alloy such as used in the LMEC gage, or whether it is platinum base alloy, such as in the Microdot gage.

Negotiations are virtually complete with a vendor for reducing the 0.2-in.-diameter Armour-D rod into wire ranging in size from 2 to 70 mils in diameter and for platinum cladding the wire. Several vendors were contacted before one was found who had the necessary hot-swaging, drawing facilities, and experience for performing this work.

Pilot evaluation of the flame-spray-bonded foil gages (Section II) was completed. The results were most encouraging. None of the gages showed signs of

any measurable damage; and they faithfully measured the strains imposed upon them -- in tension and compression.

Receipt of pilot gages "sodium-proofed" by means of chemical vapor deposition is expected from the vendor shortly, after which time they will be evaluated in sodium at 900 and 1200°F. Gages are also being procured from Microdot which can supposedly be used for measurement of strain in sodium. The gages are designated by the manufacturer as the SG425 gage. These gages, except for the joints, are similar to the SG423 integral lead gage.

IV. EVALUATION OF EFFORT TO DATE

The additional data generated to date on the LMEC gage still indicate that it is the most promising gage for testing LMFBR components above 900°F. Nevertheless, a concerted effort is being made to improve the life of the gage which is presently about 300 to 500 hours, and the uniformity from gage to gage, concurrent with the effort of developing more advanced gage types. It is proposed to accomplish this in part by eliminating all significant sources of contamination and using microcircuit capacitance discharge welding equipment and techniques.

V. NEXT REPORT ACTIVITIES

Statistical analysis of the data obtained to date from evaluation of the LMEC gage will be completed. (It was hoped that this would have been accomplished by the end of the last report period; however, an unexpected delay resulted from the conversion from IBM 7094 to the IBM 360 system at the computer center.) Evaluation of the "sodium-proofed" gages (Section III) at 900 and 1200°F will be completed, as well as the pilot drawing and cladding of the Armour-D alloy wire. The new Microdot SG425 gage which, according to the manufacturer, may be used in sodium will be fully evaluated to determine its reliability in sodium.

Design of the remaining fixtures and sodium capsules for evaluating gages in sodium should be completed, and additional flame-spray-bonded foil gages will be evaluated to obtain statistical information on gage-to-gage variations in this type of gage.

Program:	Sodium Component Development		
Project:	LMEC Laboratory Support		
Project Manager:	R. W. Dickinson	Project Engineer:	R. K. Wagner
Reporting Period:	January-March, 1967	AEC Category:	04-01-61-03
General Order:	7693	Subaccount:	89110

I. PROJECT OBJECTIVES

The objectives of this project are to plan and execute a systematic metallurgical and chemical surveillance of materials and coolants used in the Liquid Metals Engineering Center; to maintain operating histories of the equipment to allow correlation of surveillance data with operating environments; and to compile materials behavior data for large liquid metal heat transfer systems.

II. MAJOR ACCOMPLISHMENTS IN FISCAL YEAR 1967

Primary accomplishments during this period have been to define the basic program for the operation of the Metallurgical and Chemical Laboratory and to direct the preparation of the laboratory plans and layout. Final design was completed and approved, and a contract for construction was issued following AEC approval. Delivery of all equipment available from AEC surplus and suitable for use in the laboratory is over 90% complete. Evaluation, rework, and upgrading of this equipment is partially complete.

A work plan for metallurgical and chemical surveillance of materials used in LMEC test facilities was prepared. In addition, long-range LMFBR development plans for System Materials, Chemical Analysis, Sampling, and In-Line Monitoring Methods was prepared.

III. PROGRESS DURING REPORT PERIOD

The final design and specifications for the Metallurgical and Chemical Laboratory were completed. This design was approved and bids for the construction work were obtained. Following AEC approval, a construction contract was awarded with the initiation of work scheduled for April 10, 1967. The

construction start date is one week behind that defined in the original schedule. Completion of construction is now scheduled for July 10, 1967.

Five items of equipment were delivered from surplus to the laboratory holding area in Building 013. Two balances were requisitioned from surplus and orders placed for their reconditioning. This completed the acquisition of all equipment suitable for use in the laboratory from current surplus stocks. Drafts of purchase requisitions were submitted to Facilities Engineering for all equipment not available as expected from surplus and for all equipment originally included as new purchases in the laboratory outfitting plan.

The purchase order for the one long-leadtime item of equipment, the Bausch and Lomb Model Research II Metallograph, was placed, with delivery scheduled for July 15, 1967, or earlier. This will now coincide with the scheduled date for occupancy of the laboratory.

IV. EVALUATION OF EFFORT TO DATE

Major progress toward establishing the Metallurgical and Chemical Laboratory has been made. Space requirements and utilization were established for the area available. Final layouts and plans for the laboratory were approved. Construction was scheduled to begin a week later than the original schedule. This will not hamper any laboratory work which arises, since other non-LMEC facilities are still available.

The procurement of equipment requisitioned from AEC surplus was completed. However, considerable rework and upgrading of this equipment is required. The upgrading effort is proceeding satisfactorily although the procurement of some replacement components may introduce minor delays. Purchase requisitions have been prepared for most of those equipment items not available from surplus. The delivery of most items is scheduled for this fiscal year or very early in FY 1968.

The basic plan for the Materials Surveillance Program has been completed. Initiation of work is, of course, dependent on the construction or modification of the LMEC testing facilities.

V. NEXT REPORT PERIOD ACTIVITIES

Construction of the laboratory and partial installation of the equipment should approach completion. A coordination and consultation effort will be maintained for the duration of the activity. Reconditioning of surplus equipment will be completed. Additional equipment and material requisitions will be submitted with acquisition dates selected to meet scheduled installation dates during construction. Project and facilities consultation and servicing activities will be maintained with services available for all metallurgical and chemical problems.

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Program:	Liquid Metals Engineering Center		
Project:	Maintenance of Temporarily Idle Equipment		
Project Manager:	R. W. Dickinson	Project Engineer:	W. T. McSweeney
Reporting Period:	January-March 1967	AEC Category:	04-01-61-03
General Order:	7693	Subaccount:	89200

I. PROJECT OBJECTIVES

Objectives of this project are to: (1) initiate a preventative maintenance program for major components of temporarily idle equipment at the LMEC, (2) maintain surveillance over the test installation to identify and correct unusual potential deterioration, and (3) provide material for maintenance and repairs required to adequately preserve equipment.

II. MAJOR ACCOMPLISHMENTS IN FISCAL YEAR 1967

Excess material, old equipment, and other miscellaneous unusable gear were removed from the premises of the three test installations now idle, i. e., Large Component Test Loop, Core Component Test Facility, and Auxiliary Equipment Test Facility. Extensive inspection, overhaul, and repair of components and equipment have been completed to return the LCTL to a ready-to-run condition. A routine preventative maintenance program was established for the LCTL.

III. PROGRESS DURING REPORT PERIOD

A new cold trap and plugging loop economizer were installed in the LCTL. This completes the repair of sodium systems; circulation tests are scheduled early in the next quarter.

Defective and obsolete components are in the process of being removed from the Auxiliary Component Test Installation and discarded to salvage. The portable melt station has been overhauled and is ready for use as required. Studies to make recommendations for refurbishing this facility are in progress.

IV. EVALUATION OF EFFORT TO DATE

Conditions and appearance of the test facilities continues to improve. The preventative maintenance program at the LCTL sustains that improvement. The removal of the defective and obsolete components from the Auxiliary Component Test Installation has improved its appearance and aided the inspection, overhaul, and repair of the serviceable parts. The objectives of the task are being satisfied.

V. NEXT REPORT PERIOD ACTIVITIES

Completion of the installation of the LCTL cold trap and plugging loop now in progress will permit the circulation of sodium. The LCTL will be operated for a period of two weeks. Preparation of standard operating procedures for use in operating the LCTL will be initiated. Studies will continue on the refurbishing and/or rebuilding of the Auxiliary Components Test Installation.