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TITLE

Sodium Testing of Intermediate-Size Inducer Pump in SPTF at ETEC

REQUESTED BY/DATE	DEPT	MAIL ADDR
J. O. Pfouts 8-8-78	731	JB05

APPROVALS/DATE

L. Stabinsky 8/11/78
T. Boardman 8/14/78
R. Anderson 8/14/78
R. Schnurstein 8/14/78

MASTER

DISTRIBUTION

*	NAME	MAIL ADDR
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STATEMENT OF PROBLEM

The applicability of inducers to large, high-temperature sodium pumps for reactor service needs to be demonstrated.

DOE/SF/76026--T67

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REV	SUMMARY OF CHANGE	APPROVALS AND DATE
A	Incorporated comments in accordance with the following: (1) DOE Letter RRT:EC:330 dated August 10, 1978, J. J. Morabito to J. B. LaGrone, "AI Intermediate Inducer Test Request; RRT Comments" (2) ETEC Letter 78ETEC-DRF-2543 dated September 18, 1978, R. E. Fenton to R. V. Anderson, "ETEC Comments to ISIP Test Request" (3) DOE Letter FTF:KRA:E007 dated October 17, 1978, A. J. Rizza to J. B. LaGone, "Intermediate-Size Inducer Pump (ISIP) Request for Test" Changes indicated by black line on right border	L Stabinsky 12/18/78 J. O. Plouts L.S. 12/18/78 R. E. Schumpf 12/18/78 Boardman 12/18/78 12/18/78 Rel. Date: 12-19-78

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TABLES

NOTE: The appendices and tables in this document have been numbered in accordance with the corresponding data in WDTRS 25.14, Revision 18 in order to facilitate comparison.

1.0 INTRODUCTION

This test program will demonstrate the applicability of inducers to large, high-temperature sodium pumps for reactor services. Tests will be performed to provide steady-state head/flow performance data, to provide cavitation performance data at reduced NPSH, and to demonstrate operational capability under thermal transient conditions. To accomplish these objectives, the FFTF prototype pump will be modified by replacing the standard impeller with an inducer, impeller and the other components needed to adapt the existing pump for the use of the new pump rotating elements. The modified pump will be tested in the Sodium Pump Test Facility (SPTF) which was previously used to test the unmodified FFTF prototype pump.

2.0 ABSTRACT

The overall test program includes pump assembly, installation, testing, removal from the test loop, disassembly and final inspection of the entire pump. Testing will include checkout tests, head/flow and efficiency characterizations at selected speeds and sodium temperatures, suction performance determination, a 2000 hour design point endurance test, a 300 hour off design endurance test, and thermal transient tests. The pump will be cleaned of sodium, disassembled, and examined before the 2000 hour endurance test and after the thermal transient tests to determine the effects that long-term operation at 200 percent NPSH margin and off design operation at the same flow and NPSH have on the pump components.

The testing will be done at Energy Technology Engineering Center (ETEC). Assembly, sodium removal, disassembly, and initial inspection will be performed at Component Handling and Cleaning Facility (CHCF) and sodium testing will be done at Sodium Pump Test Facility (SPTF).

3.0 OBJECTIVES

Testing of the Intermediate-Size Inducer Pump in sodium will demonstrate the applicability of inducers to large, high-temperature sodium pumps and will demonstrate the capability of applying specific inducer design technology, which was originally developed for rocket engine application and subsequently extended to long-life commercial pumping applications, to primary sodium pumps in order to improve suction performance over that previously available with conventional impeller designs.

Successful testing will provide increased confidence in the use of Rockwell's advanced inducer technology for primary coolant pumps and will permit future pumps to run at higher speeds with the same, or increased, margins against cavitation. The higher speeds will permit significant reductions in the size and resulting cost of future pumps.

Nonperformance or failure of the test will result in continuation of the same previously used impeller design technology and increasingly large-size and -cost pumps as the demand for higher flow rates increase with reactor power requirements. It is anticipated that physical size limitations, based on fabrication and transportation limits, would eventually require the use of more pumps for the same reactor power output which would be a less economic investment in capital equipment for each plant.

4.0 SCHEDULE (Tentative)

The milestone schedule requirements for this test program are listed below:

June 1978	AI Complete OMM Addendum for ISIP
Sep 1978	ETEC Complete Assembly Procedure (AI approval)
Oct 1978	ETEC Complete Detail Test Procedure (AI approval of Part I)
Nov 1978	ETEC Start ISIP Instrument Installation. AI Deliver ISIP Parts to ETEC
Dec 1978	ETEC Start Pump Internals Assembly
Feb 1979	ETEC Complete Internals Assembly
Mar 1979	ETEC Complete Installation Pre-Op Checkout and Sodium Fill
Apr 1979	ETEC Start Running Tests and Data Reduction
Sep 1979	ETEC Complete Running Tests
Feb 1980	ETEC Complete Removal, Cleaning, and Disassembly
Apr 1980	ETEC Complete Data Reduction and Final Report

5.0 TEST METHODS

Sodium tests of the ISIP will be basically similar to those tests previously run on the FFTF prototype pump. Initial testing will be at low temperatures during which the noncavitating performance (constant speed head vs flow characteristics) will be measured at various speeds.

Testing will proceed from least severe operating conditions (low temperature and low speed) to increasingly severe conditions by first increasing the speed in specified increments to the design speed, while measuring the head-flow characteristic at each speed, and then increasing the temperature in increments and repeating the head-flow measurements at the various speeds.

Following the noncavitating performance tests, the NPSH demonstration tests and cavitation performance tests originally performed during Phase B of the prototype pump will be repeated. These tests consist of running for approximately 1 hr at 40-ft NPSH, then running constant (full) speed cavitation tests to the 3.5% head drop condition from initial flow rates of 18,000 gpm, 16,000 gpm, 14,500 gpm, and 14,000 gpm.

After the NPSH tests, the pump internals will be removed from the pump tank, cleaned, disassembled, and inspected. The inspection will include detail examination of the inducer, impeller, diffuser, and diffuser tunnel. As part of this examination, surface replicas will be prepared and compared to those replicas from the initial assembly to assess the effects of cavitation, and will be maintained in archive files as a record of surface conditions existing prior to endurance testing. After this interim inspection, the pump will be reassembled replacing those hardware items and instruments which were damaged during tests and which are designated as nonreusable by HEDL or ESG.

The next series of tests after reassembly and reinstallation into the pump tank will include a 2000 hour endurance test to be run at the design condition with a 200% NPSH margin, a 300 hour off-design endurance test using the same suction (cover gas) pressure and flow but at a reduced speed and higher relative flow (Q/N). Following the two (design and off-design) endurance tests, the ISIP will be subjected to thermal transient tests during which those thermal transients run for Phase B testing of the FFTF Prototype Pump are planned to be repeated, specifically: Transient Numbers 201 through 208, and Number 210 from WDTRS 25.14, Revision 18.

After completion of the sodium tests, the pump will be cooled, then removed from SPTF and cleaned using anhydrous alcohol in the CHCF cleaning tank. Tank cleaning will be followed by disassembly, final (spot) cleaning, and inspection.

For data recording, instrumentation, data acquisition, and monitoring will be the equivalent to that used during Phase B of the FFTF Prototype Pump tests. External instrumentation systems are to be provided by ETEC except signal conditioning equipment to be provided by HEDL. Internal instrumentation sensors (Proximity probes, accelerometers, and thermocouples) will be provided by ESG.

A handling bag system, including adapters and inert gas supply, is to be provided by ETEC in order to protect the pump during transfer from SPTF to the cleaning tank.

6.0 TEST RESULTS

Expected results include obtaining performance characteristic curves, suction performance curves, and data on exposures of the test hardware to an environment that includes simulated reactor thermal transients.

The hydraulic test results will be obtained by using standard pump analysis and data reduction procedures as used for the prototype pump tests. Performance characteristic curves will show the interrelation of head, capacity, power, and efficiency. Cavitation characteristic curves will show the critical NPSH values at three flow levels. From these values, the NPSH margin for operation can be determined and the suction specific speed will be calculated.

Data on the exposure to simulated reactor conditions will consist of test measurements that define the conditions that were actually imposed on the pump, and the results of the post test examinations that will show the condition of the parts exposed to the test.

Testing will be concluded when the test objectives are attained or when failure criteria are encountered which prevent continuation of the testing.

Attainment of the test objectives includes successful completion of the test sequences and obtaining the test results which will:

1) Characterize pump head-flow and efficiency.
2) Establish pump critical NPSH over a range of pump flows at design rpm.
3) Show that the pump has been exposed to a simulated sodium reactor environment without detrimental effects.

Failure criteria and the operational limits of the pump are given in Appendix F, "Design Restriction Limits," in Appendix H, Reaction to Alarms," and in Appendix J "Operational Restriction Limits."

7.0 DESCRIPTION OF TEST

7.1 DESCRIPTION OF TEST ARTICLE

The test article is a vertical, free-surface sodium pump. The pump will be fabricated by replacing the impeller in the existing FFTF Prototype Pump with an inducer-impeller assembly plus other internal parts, including an adapter-diffuser and a shaft extension, which would permit use of the existing prototype pump assembly. Measurements as previously taken by ETEC for the Phase B tests are expected to remain essentially unchanged. Some modification in assembly procedure and in special assembly tools will be required. Parts and labor needed to modify or replace existing special assembly tools will be provided by AI.

Outwardly, the Intermediate-Size Inducer Pump will be identical to the FFTF Prototype Pump previously tested at ETEC. Physical interfaces will be identical and, except for improved suction performance, functional interfaces are expected to remain basically unchanged.

7.2 TEST ARTICLE HANDLING

Handling and assembly of the test article will be basically in accordance with the FFTF Prototype Pump Operations and Maintenance Manual (OMM), as modified by an addendum which will cover those changes in the manual necessary for assembling ISIP components, to be provided by ESG. Formal issuance of the OMM addendum will be preceded by specific assembly instructions as required by ETEC for planning and preparation of assembly procedures.

One set of FFTF Primary Pump special tools, as required for pump assembly at ETEC will be provided by HEDL. Special tools peculiar to the ISIP configuration will be provided by ESG. As with the FFTF

Prototype Pump tests, it is expected that ETEC will provide the required general purpose tools and those plant peculiar tools needed to adapt tooling provided by HEDL and ESG to CHCF.

7.3 DESCRIPTION OF TEST FACILITY REQUIREMENTS

The facilities required for handling, assembly/disassembly, testing, and sodium removal for the test article are almost entirely the same as those used by ETEC in performing similar operations on the FFTF Prototype Pump, which was previously tested at ETEC. Because of the lower NPSH requirements, this test program will require lower liquid level in the pump tank and lower cover gas pressure than were used in the previous FFTF Pump test program.

To minimize the effects of air in-leakage during endurance tests with subatmospheric cover gas pressure (estimated 38.4 ft NPSH) it is anticipated that the cover gas space in the pump will be run with a small, continuous purge, exhausted through the vacuum pump(s) connected to the lower leakage reservoir. Endurance tests may be interrupted temporarily as required to perform facility maintenance or to reestablish operating conditions (such as sodium purity) within the acceptable range of test variables.

The following ranges of basic test variables are expected to be controlled and measured during the tests:

RANGE OF TEST VARIABLES

Flow	500-18000	gpm
Sodium Temperature	400-1050	^{o}F
Discharge Pressure	0-250	psig
Sodium Level	4-14.5	feet above impeller discharge centerline
Cover Gas Pressure	0.5-24	psia
Thermal Transients	Max rate Max Δt	$3^{o}F/sec$ $330^{o}F$

7.4 TEST SEQUENCE AND LOGIC

This test series is intended to provide data for the evaluation of the performance, particularly suction performance, of an inducer-impeller pump and to provide information related to operating life capabilities under reactor conditions. Because of the similarities of both hardware and test conditions, this program will also provide data for comparison of the inducer pump to the conventional FFTF Prototype Pump. The sodium tests of the ISIP will include most of the test conditions specified for Phase B testing of the prototype pump in Westinghouse Test Request WDTRS25114, Revision 18.

The test sequence is as follows:

1) Pump Assembly and Installation
2) Auxiliary Systems Check
3) Preheat to 400°F and Sodium Fill at 400°F
4) Initial Startup at 400°F and Operation During Wetting to 680°F
5) Pony Motor Flow Scan at 600°F
6) Main Motor Speed Scans at 600°F
7) 500 rpm Flow Scan at 600°F
8) 700°F Checkout
9) 750°F Checkout and Speed Scan and Endurance Test
10) 800°F Checkout
11) 850°F Checkout
12) 900°F Checkout
13) 950°F Checkout and Speed Scan and Endurance Test
14) High Temperature Checkout (1000°F and 1050°F)
15) 1050°F Speed Scans and Endurance Test
16) Minimum NPSHA Demonstration at 1050°F
17) Cavitation Performance at 1050°F

18) Post Cavitation Checkout at 1050^{o}F
19) Pump Interim Disassembly and Inspection
20) Pump Reassembly and Reinstallation
21) Preheat to 400^{o}F and sodium fill at 400^{o}F
22) Startup at 400^{o}F and Operation During Wetting to 680^{o}F
23) Main Motor Speed Scans at 700^{o}F
24) 500 rpm Flow Scan at 700^{o}F
25) 800^{o}F Checkout
26) 900^{o}F Checkout
27) 1050^{o}F Speed Scans
28) 2000 Hour Design Point Endurance Test at 1050^{o}F with 200% NPSH Margin
29) 300 Hour Off-Design Endurance Test at 1050^{o}F and Reduced Speed
30) Low Temperature Thermal Transients
31) Mid Temperature Thermal Transients
32) High Temperature Thermal Transients
33) Pump Final Disassembly and Inspection

7.5 DETAILED PERFORMANCE TEST SERIES

The instrumentation lineup and data collection requirements are summarized in Appendix M. The paragraph heading included in certain tests below entitled "Special Post Test Data Reduction" is intended to identify expeditious offline reduction of data for preliminary test evaluation. This effort should not be confused with offline reduction required for report preparation.

7.5.1 Initial Pump Assembly & Installation

Note: Test Requester Hold Point

Purpose - to assemble the pump in preparation for testing.

<u>Test Description</u> - Assemble and install the pump using O&M Manual procedures including the Addendum prepared by AI, or procedures prepared by the test performer and approved by the test requester. Deviations from the O&M Manual require test requester approval.

<u>Data Collection and Use</u> - Data collection shall consist of recording critical assembly parameters. Data recording requirements are specified in the appropriate section of the O&M Manual and Addendum.

In addition, prior to start of assembly, coordinates of the inducer blade surfaces shall be measured and recorded, and replicas of inducer, impeller, and diffuser blade surfaces shall be made and maintained for comparison with post-test replicas of the same regions. Blade coordinate measurement and preparation of surface replicas shall be performed by ESG.

7.5.2 <u>Auxiliary System Check</u>

<u>Purpose</u> - To verify that all pump auxiliaries are operating properly prior to initiation of testing.

<u>Test Description</u> - Operations & Maintenance Manuals, or their technical equivalent, will be supplied with each auxiliary system component or subsystem supplied. Each component or subsystem must have been thoroughly checked out to verify safe operating conditions prior to pump testing.

<u>Data Collection and Use</u> - This block of testing has no specific data collection requirements. Any data taken will be used to verify proper performance of the auxiliaries and as reference material in the event of a hardware failure. Design limits for the auxiliary equipment are specified in Section 3.0 of Reference 2.

<u>Expected Results and Completion Criteria</u> - This section is complete when the checkouts are complete and all nonconformances are resolved.

7.5.3 Preheat and Sodium Fill

Note: Test Requester Hold Point

Purpose - To preheat the pump at 400°F, to fill the pump, and to wet the surfaces of the redesigned pump components and proximity probes at 680°F.

Test Description - The pump is to be completely installed including utilities and auxiliaries prior to initiation of preheating testing. The maximum heating rate for the pump tank skin and the hydrostatic bearing is 10°F/hr for a dry pump and 20°F/hr during the wetting cycle.

Torque measurements (8 points) will be recorded once an hour for at least three hours prior to initiation of preheating. The pump structure below the designated maximum sodium level shall be heated from room temperature to the nominal preheat temperature (400 + 25°F) at a maximum rate of 10°F/hr. It is understood that during the preheat process, the temperature readings will vary widely and that, in order to obtain temperature in the desired range, some of the temperatures will have to exceed the desired range and rate. Rotor torque measurements must be taken and recorded at least every hour. Heating shall not be slowed or stopped unless the rotor torque exceeds a value of 1.25 times the room temperature torque values. Action in the event of high torque readings shall be determined by the cognizant test requester representative on a case-to-case basis. The maximum permissible torque shall be 200 ft-lb. For maximum allowable side-to-side temperature variation within the heated and unheated parts of the pump tank, see Appendix J. At this stabilized temperature, a minimum of four rotor torque readings shall be taken to assure consistency. Fill the pump with sodium. The pump metal temperature must be the same as the incoming sodium within ±40°F. Flushing operations will be performed as part of this test as proposed by the test performer. A level and bearing proximity probe system calibration will be performed during the fill operation and/or after completing the sodium fill at 400°F.

The pump will be filled to 125 inches above impeller discharge centerline prior to initiation of the wetting sequence.

Data Collection - Data needs during this test will include rotor torque measurements (8 points) and L-Delta-T computation at one hour intervals in the initial test phase while heating the tank skin to 400°F. During the thermal soak period for the internals, the data interval may be relaxed to two hours.

Special Post Test Data Reduction - Plot of maximum and minimum temperatures for each zone vs time and plot of L-Delta-T vs time for unheated zone and for overall pump.

Expected Results and Completion Criteria - This section is complete when the pump is filled with sodium and the temperature is stabilized at 400°F ± 25°F. The rotor torque measurements must be less than 1.25 times the measured room temperature torque values and the bearing/journal radial clearance must be within the 75% limit.

7.5.4 Initial Startup and Operation During Wetting

Note: Test Requestor Hold Point

Purpose - To initiate powered operation in an orderly sequence; and to define pump operation sequence during the planned wetting cycle.

Test Description - The following sequence of operations will be followed to initiate powered operation and complete the wetting cycle. Unless specified below, all pump operation will be with sodium level at 125 in. above the impeller centerline and at R4 flow conditions as defined in Table A-3. The flushing details during this operating period will be as proposed by the test performers.

1) Complete Pretest Instrument Checkout. The checkout acceptance criteria shall include requirements for all instrument and data systems to be operable together as needed for accumulation of test data, monitoring pony motor operation, and initiating alarms. Instrument systems shall be calibrated, DAS coefficients shall be entered and performance calculation programs shall be functional in the DAS as required for pony motor operation. Note: This is a hold point. Do not proceed with the test until the instrument checkout is complete.
2) Pony Motor Startup Per Appendix K. ($T=400^{o}F$)
3) 30-Minute Pony Motor Run. ($T=400^{o}F$)
4) Main Motor Startup Per Appendix K. ($T=400^{o}F$)
5) Instrument and Data System Verfication. Note: This is a hold point. Do not proceed with the test until the operational verfication of the instrument and data system is complete for main motor operation.
6) Increase temperature to $500^{o}F$ at $20^{o}F/hr$ maximum rate and 600 rpm maximum speed. Stabilize at $500^{o}F$ for 30 minutes.
7) Perform Bearing Probe System Calibration.
8) Increase temperature to $600^{o}F$ at $20^{o}F/hr$ maximum rate and 600 rpm maximum speed. Stabilize at $600^{o}F$ for 30 minutes.
9) Perform Bearing Probe System Calibration.
10) Increase temperature to $680/700^{o}F$ at $20^{o}F/hr$ maximum rate and 600 rpm maximum speed. Stabilize for 30 minutes.
11) Perform Bearing Probe System Calibration.
12) Hold $680/700^{o}F$ temperature for 8 hours; 600 rpm maximum speed.
13) Cool Pump to $600^{o}F$ at 400 to 600 rpm.
14) Perform Bearing Probe and Fluid Level Instrument Calibration at $600^{o}F$.

Data Collection - As Specified in Table M2.

Special Post Test Data Reduction - Plot bearing probe calibration constants (A and B) vs temperature for each channel.

7.5.5 Initial Low Temperature Checkout at 600^{o}F

Note: Test Requestor Hold Point

7.5.5.1 Pony Motor Flow Scan

Set sodium level at 125 in. above the impeller centerline - Five-minute stabilization at each flow scan set point called out in Table A1.

Data Collection - As specified in Table M2.

Caution

Do not exceed the hydrostatic bearing limits given in Appendix J. If operation of the pump at any of the set points called out in Table A1 causes the pump to reach the bearing limits, immediately change the loop resistance toward the R-4 resistance.

7.5.5.2 Main Motor Speed Scan

1) Verify that the sodium level is 125 inches above the centerline of the impeller discharge.
2) Verify that the rheostat electrolyte concentration is adequate for full-speed operation.
3) Perform an upramp speed scan at R-4 loop resistance. Stabilize operation for 15 minutes at each speed plateau listed for R-4 in Table A3 for increasing speed.
4) Perform an upramp speed scan at R-5 loop resistance. Stabilize operation for 15 minutes at each speed plateau listed for R-4 (in lieu of R-5) in Table A3 for increasing speed.

5) Perform an upramp speed scan at R-3.3 loop resistance. Stabilize operation for 15 minutes at each speed plateau listed for R-4 (in lieu of R-3.3) in Table A3 for increasing speed.
6) Perform an upramp speed scan at R-6 loop resistance. Stabilize operation for 15 minutes at each speed plateau listed for R-4 (in lieu of R-6) in Table A3 for increasing speed until a flow of 18,000 gpm is reached.
7) Initiate 8 hours, 1110 rpm R4 endurance run immediately following last data point in above speed scans.

Data Collection - As specified in Table M2.

Special Post Test Data Reduction - Prepare plots and tabulations of actual KW vs Q, and H vs Q corrected to 750 rpm.

7.5.5.3 Main Motor Flow Scan

With the sodium level at 125 inches above the impeller discharge centerline and the pump speed set at 500 rpm, perform a flow scan with five minute stabilization at each flow scan set point called out in Table A1.

Caution

Do not exceed the hydrostatic bearing limits given in Appendix J. If operation of the pump at any of the set points causes the pump to reach the bearing limits, immediately change the loop resistance toward R-4 resistance.

Data Collection - As Specified in Table M2.

Special Post Test Data Reduction - Prepare plots and tabulations of KW vs Q, and of H vs Q corrected to 94 rpm and to 500 rpm.

Expected Results and Completion Criteria - The bearing journal clearance should be within the 75% limit. The pump should operate without observable variations in the operating parameters.

7.5.6 Mid-Temperature Checkout

Note: Test Requester Hold Point

Test Description - Unless otherwise specified below, all testing in this section will be performed at R4 loop resistance and tank fluid level 125 in. above impeller centerline.

7.5.6.1

1) Increase temperature to 700°F at 20°F/hr maximum rate and 750 rpm maximum speed. Stabilize at 700°F for 1/2 hour.
2) Perform bearing probe system calibration. (T = 700°F)

7.5.6.2

1) Increase temperature to 750°F at 20°F/hr maximum rate and 750 rpm maximum speed. Stabilize at 750°F for 1/2 hour.
2) Perform bearing probe system calibration. (T = 750°F)
3) Perform an upramp speed scan per Table A3 - 15-minute stabilization at each speed plateau.
4) Perform an 8-hour endurance test at 1110 rpm.

7.5.6.3 800°F Checkout

Note: Test Requestor Hold Point

1) Increase temperature to 800°F at 20°F/hr maximum rate and 750 rpm maximum speed. Stabilize at 800°F for 1/2 hour.
2) Perform bearing probe system calibration. (T = 800°F)

7.5.6.4 850°F Checkout

1) Increase temperature to 850°F at 20°F/hr maximum rate and 750 rpm maximum speed. Stabilize at 850°F for 1/2 hour.
2) Perform bearing probe and fluid level systems calibrations.
3) Perform an upramp R4 speed scan using speed plateau setpoints per Table A3; 15-minute stabilization at each speed plateau.

Data Collection - As specified in Table M2.

Special Post Test Data Reduction - Prepare plots and tabulations of actual KW vs Q, and of H vs Q corrected to 750 rpm.

7.5.6.5 900°F Checkout

1) Increase temperature to 900°F at 20°F/hr maximum rate and 750 rpm maximum speed. Stabilize at 900°F for 2 hours.
2) Perform bearing probe system calibration. (T = 900°F)

7.5.7 950°F Testing and Temperature Increase

7.5.7.1 Steady-State Base Line Testing

Note: Test Requester Hold Point

Test Description - Unless otherwise specified below, all testing in this section will be performed at 950°F and tank fluid level at 125 in. above impeller centerline.

1) Increase temperature to 950°F at 20°F/hr maximum rate and 750 rpm maximum speed. Stabilize at 950°F for two hours.

2) Perform bearing probe system and fluid level instrument system calibrations.
3) Perform an upramp speed scan at R-4 loop resistance. Stabilize operation for 15 minutes at each speed plateau listed for R-4 in Table A3 for increasing speed.
4) Perform an upramp speed scan at R-5 loop resistance. Stability operation for 15 minutes at each speed plateau listed for R-4 (in lieu of R-5) in Table A3 for increasing speed.
5) Perform an upramp speed scan at R-3.3 loop resistance. Stabilize operation for 15 minutes at each speed plateau listed for R-4 (in lieu of R-3.3) in Table A3 for increasing speed.
6) Perform an 8-hour endurance test at R4 flow at 1110 rpm.

Data Collection - As specified in Table M2.

Special Post Test Data Reduction - Prepare plots and tabulations of actual KW vs Q, and of H vs. Q corrected to 750 rpm.

7.5.8 High Temperature Checkout

Note: Test Requester Hold Point

Test Description - Unless otherwise specified below, all testing in this section will be performed at R4 loop resistance and tank fluid level 125 in. above impeller centerline.

1) Increase temperature to $1000^{O}F$ at $20^{O}F/hr$ maximum rate and 750 rpm maximum speed. Stabilize at $1000^{O}F$ for 2 hours.
2) Perform bearing probe system calibration. ($T = 1000^{O}F$)

3) Increase temperature to 1050°F at 20°F/hr maximum rate and 750 rpm maximum speed.

4) Perform bearing probe system and fluid level instrument system calibrations.

7.5.9 1050°F Testing

7.5.9.1 Steady-State Base Line Testing

Note: Test Requester Hold Point

Test Description - Repeat baseline testing specified in Paragraph 7.5.7.1 with the exception that test will be performed at 1050°F.

7.5.10 Cavitation Tests

1) Minimum NPSHA Demonstration at Runout Flow

Purpose - This test will be performed to demonstate the pump's ability to operate at the design base suction specific speed of approximately 9500. Specifically, the design base for the suction side of the pump is at operating point of 18,000 gpm at 1110 rpm, at 1050°F sodium temperature, and an NPSH of 39 ft at the pump suction nozzle.

Test Description - Minimum NPSH test will be performed at 1050°F sodium and at the following conditions:

a. Establish stable operation at:

1. Flow - 18,000 gpm ±200
2. Speed - 1110 rpm ±10
3. Sodium level - 48 $^{+3}_{-0}$ in. above impeller centerline
4. Cover gas pressure - 1 psig
5. Sodium temperature - 1050°F ±10

These conditions should produce operation at a suction specific speed of approximately 7500 which is well below the design limit and as such, no suction cavitation should be present.

b. Operate at above defined conditions for a minimum of 1 hour taking typical data at 15-minute intervals. Typical data is as follows:
   1. Computer calculated performance summary
   2. 60 sec FM recorder slice at 15 IPS (ANL hydrophone should be recorded at 60 IPS)
   3. Digital tape slice at 1 sec scan rate

c. Reduce cover gas pressure to approximately 10 psia while holding all other operating parameters constant. The gas pressure should be reduced in approximate 1 to 2 psia increments with a typical data set as defined above taken at each increment. Of particular interest will be any noted trend drop in head output. In particular, the gas pressure must be fine tuned to produce an indicated "net positive suction head" of 39 ±.5 ft on the computer calculated data summary. The calculated "suction specific speed" on same computation should be approximately 9500.

d. Maintain pump operation at reduced cover gas pressure conditions for 1 hour taking a typical data set at 30-minute intervals. Of particular interest will be any noted decreasing trend in indicated overall operating efficiency.

2) Cavitation Performance

Purpose - To explore the characteristic relationship between pump cavitation and available net positive suction head (NSPH).

Test Description - Cavitation tests will be performed in 1050^{o}F sodium at each of the following initial speed/flow conditions:

13000 gpm at 1110 rpm (Baseline data only)
14000 gpm at 1110 rpm
14500 gpm at 1110 rpm

15000 gpm at 1110 rpm (Baseline data only)
16000 gpm at 1110 rpm
17000 gpm at 1110 rpm (Baseline data only)
18000 gpm at 1110 rpm

All cavitation tests will be performed with the sodium level at 48 $^{+3}_{-0}$ in. above impeller discharge centerline. The tests at 13000, 15000, and 17000 gpm will be run for baseline data only (60 ft NPSH). Actual cavitation testing will be done only at 14000, 14500, 16000, and 18000 gpm. The general procedure to be followed for this test series is as follows:

a. Establish stable steady-state operation at defined initial temperature, speed, and flow conditions.

b. Adjust cover gas pressure to obtain at least 60 ft NPSH as indicated by computer calculated parameter summary.

c. Operate for at least 1 hour at 60 ft NPSHA conditions to establish baseline parameters. Take a typical data slice* once every fifteen minutes. The nominalized 1110 rpm head output from the last performance summary will be used as a baseline head.
Calculate 96.5% of the baseline head. This head value will serve as the "head drop limit" for this test.
Do not make any adjustment to loop throttle valves from this point on to the completion of the test.

d. Reduce cover gas pressure in approximate 2 psi increments (5.6 ft suction head increments) until an NPSH value of approximately 38 ft is indicated by the computer calculated parameter summary.
Stabilize for 10 minutes and take a typical data slice at each pressure plateau.

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*Typical Data Slice defined in Paragraph 7.5.10 1) Test Description above.

e. Continue reducing cover gas pressure in approximate 1 psi increments (i.e., 2.8 ft NPSH increments) until a nominalized 1110 rpm head output equal to the "head drop limit" (calculated in Step c) is indicated by the computer calculated parameter summary. Stabilize for 10 minutes and take a typical data slice at each pressure plateau.

f. As an alternative to Step e above, the cover gas pressure can be reduced continuously until a normalized 1110 rpm head output equal to the "head drop limit" is indicated by the computer-calculated parameter summary. A typical data slice shall be taken at approximately 1 psi increments as the cover gas pressure is being reduced. During the periods when the data slices are being taken, the rate of decrease of cover gas pressure shall not exceed 0.1 psi per minute. If this alternate procedure is used, stabilization at the "head drop limit" is not required after the data slice at that condition has been obtained.

g. Raise the cover gas pressure in increments not exceeding 0.5 psi (i.e., not exceeding 1.4 ft NPSH increments). Continue to raise gas pressure at this rate until the indicated nominalized 1110 rpm head output is within 2 ft of the noncavitation head output established in Step c above. This criteria must be met at three consecutive pressure plateaus. During this portion of the test, a required 15-minute stabilization with typical data slice applies at each pressure plateau.

h. As an alternative to Step g above, the cover gas can be raised continuously to within 2 feet of the noncavitating head. Data slices shall be taken at

1 psi increments as the cover gas pressure is being raised. During the periods when the data slices are being taken, the rate of pressure increase shall not exceed 0.1 psi per minute.

i. Continue to raise cover gas pressure until 60 ft suction head condition is established. An approximate 4 psi increment step may be used to increase pressure. Stabilize at each pressure plateau for 10 minutes and obtain a typical data slice.

j. Continue to operate at 60 ft suction head conditions for 1 hour taking a typical data slice once every 15 Minutes.

Data Collection - Presented as part of Test Description above and as required by Table M2.

Post-Test Data Reduction - Plots of head vs NPSH at the inducer inlet and of head vs NPSH at the suction nozzle, for each of the four flow/speed test conditions. Also, prepare curves of noncavitating head vs flow and 97 percent head vs flow with superimposed curves of NPSH vs flow at the inducer inlet.

7.5.11 Post Cavitation Checkout

Purpose - To verify the stability of hydraulic and mechanical performance of the pump.

Test Description - The pump is started at R4 loop resistance on pony motor and then transferred to main motor power at minimum control speed. Prior to increasing the speed to 1110 rpm, adjust the sodium level to 125 in. above impeller centerline. Increase the speed from minimum control to 1110 rpm at R4 loop resistance and operate the pump for 8 hours under these conditions. Should problems, which are unrelated to the pump, force an interruption of the test, the test will be resumed after the problem is cleared with all test hours counting towards the total 8 hour requirement.

Data Collection - As specified in Table M2.

Special Post Test Data Reduction - None

7.6 PRE-ENDURANCE TEST INSPECTION

7.6.1 Interim Disassembly and Inspection

Note: Test Requester Hold Point

Purpose - To inspect and record the condition of the pump prior to endurance testing at the specified NPSH margin and prior to thermal transient testing.

Test Description - The pump internals will be removed from the pump tank, cleaned, disassembled, and inspected. Disassembly and inspection will be performed in accordance with the O&M Manual procedures including the Addendum prepared by AI. Detail disassembly and inspection procedures will be prepared by the test performer and approved by the test requester. Disassembly is to be performed in a manner to preserve functioning instrumentation for use during subsequent endurance and thermal transient tests. To this effect, the bearing will not be removed from the bearing support flange unless the bearing proximity probes are designated as not usable for testing. Instrument electrical characteristics shall be checked to determine the need for replacement.

Data Collection - Make photographic records of pump condition during disassembly and note observations of condition (normal and abnormal). Record disassembly measurements such as clearances and bolt loosening torques corresponding to those measurements made during initial assembly. Note any problems with disassembly procedures and complete inspection forms in the O&M Manual and in the Addendum provided by AI.

NOTE: This data set will include inducer blade coordinate measurements and preparation of blade surface replicas of the inducer, impeller, and diffuser by ESG.

7.7 ENDURANCE AND TRANSIENT TEST SERIES

7.7.1 Pump Reassembly and Reinstallation

Note: Test Requester Hold Point

Test Description - Reassemble the pump using the methods and procedures previously used for Paragraph 7.5.1.

7.7.2 Auxiliary System Recheck

Test Description - Verify proper operation of all pump auxiliaries using the methods and procedures previously used for Paragraph 7.5.2.

7.7.3 Preheat and Sodium Refill

Note: Test Requester Hold Point.

Test Description - Preheat and fill the pump with sodium using the methods and procedures previously used for Paragraph 7.5.3.

7.7.4 Restart and Operation During Rewetting

Note: Test Requester Hold Point.

Test Description - Start up the pump at 400^{o}F and perform a wetting operation cycle at 680/700^{o}F using the methods and procedures previously used for Paragraph 7.5.4.

7.7.5 Second Cycle Low Temperature Checkout at 700^{o}F

Note: Test Requester Hold Point.

7.7.5.1 Second Cycle Main Motor Speed Scans at 700^{O}F

Test Description - Perform a main motor speed scan using the methods and procedures previously used for Paragraph 7.5.5.2 excepting the temperature which shall be 700^{O}F.

7.7.5.2 Second Cycle Main Motor Flow Scan at 700^{O}F and 500 rpm

Test Description - Perform a main motor flow scan using the methods and procedures previously used for Paragraph 7.5.5.3 excepting the temperature which shall be 700^{O}F.

Special Post-Test Data Reduction - Prepare plots and tabulations showing the results from Paragraphs 7.7.5.1 and 7.7.5.2 and comparative results from Paragraphs 7.5.5.2 and 7.5.5.3.

Expected Results and Completion Criteria - Results from the Paragraphs 7.5.5.2 and 7.5.5.3 should agree with those from Paragraphs 7.7.5.1 and 7.7.5.2 within expected test accuracy (approximately ± 2 percent). Deviations beyond the expected range should be verified by retest and the reason(s) for the discrepancies identified prior to proceeding. (Note: Power requirement should be slightly lower.)

7.7.6 Mid-Temperature Recheck

Note: Test Requester Hold Point.

Test Description - All testing in this section will be performed at R4 loop resistance and a sodium 125 in. above the impeller discharge centerline.

7.7.6.1 800^{O}F Recheck

1) Increase temperature to 800^{O}F at 20^{O}F/hr maximum rate and 750 rpm maximum speed. Stabilize at 800^{O}F for 1/2 hour.

2) Perform bearing probe system calibration at 800°F.
3) Perform an upramp speed scan at R4 loop resistance per Table A3 - 15-minute stabilization at each speed plateau.
4) Compare speed scan results with results from Paragraph 7.5.6.2. Deviations beyond the expected range should be verified by retest and the reason(s) for the discrepancies identified prior to proceeding. (Note: Power requirements should be slightly lower.)

7.7.6.2 900°F Recheck

1) Increase temperature to 900°F at 20°F/hr maximum rate and 750 rpm maximum speed. Stabilize at 900°F for 1/2 hour.
2) Perform bearing probe system calibration and fluid level measurement systems calibrations at 900°F.
3) Perform an upramp speed scan of R4 loop resistance per Table A3 - 15-minute stabilization at each plateau.
4) Caompre speed scan results with results from Paragraph 7.5.6.4. Deviations beyond the expected range should be verified by retest, and the reason(s) for the discrepancies identified prior to proceeding. (Note: Power requirement should be slightly lower.)

7.7.6.3 1050°F Speed Scans Repeat

1) Increase temperature to 1000°F at 20°F/hr maximum rate and 750 rpm maximum speed. Stabilize at 1000°F for 1/2 hour.
2) Perform bearing probe system calibration at 1000°F.
3) Increase temperature to 1050°F at 20°F/hr maximum rate and 750 rpm maximum speed.
4) Perform bearing probe system calibration and fluid level measurement systems calibrations at 1050°F.

5) Perform upramp speed scans and 8-hour endurance test at 1050°F using the methods and procedures previously used for Paragraph 7.5.7.1, subparagraphs 3) through 6).

Special Post-Test Data Reduction - Prepare plots and tabluations showing the speed scan test results from Paragraph 7.7.6.2 and comparative results from Paragraph 7.5.9.1.

Expected Results and Completion Criteria - Speed scan test results from Paragraphs 7.7.6.2 and 7.5.7.1 should agree within expected test accuracy (approximately ±2%). Deviations beyond the expected range should be verified by retest and the reason(s) for the discrepancies identified prior to proceeding. (Note: Power requirement should be slightly lower.)

7.7.7 2000 Hour Design Point Endurance Test at 1050°F with 200% NPSH Margin

Note: Test Requester Hold Point.

Purpose - To expose the ISIP to extended term operation under the design temperature, flow, and NPSH margin conditions in order to assess its capability for long-term operation without an unacceptable damage rate due to cavitation. Final evaluation of this criteria will be after pump disassembly and cleaning when the impeller will be accessible for detail examination.

Test Description - The pump will be operated at 1050°F, with a flow rate of 14,500 gpm and a speed of 1110 rpm. The sodium level and cover gas pressure will be adjusted to achieve an NPSH margin of 200% above the value determined under Paragraph 7.5.10, Subparagraph 2), for a 3 percent head drop. NPSH values to be used for this test are to be referenced to the inducer inlet elevation only. The sodium level used for this test shall be within the range from 48 in. (-0/±3) to 125 in. (±2) above the impeller discharge centerline. The particular level selected shall be based on minimizing the vacuum to be used in the cover gas space.

The pump shall be operated continuously under these conditions for 2000 hours. Should problems which are unrelated to the pump force an interruption of the test, the 2000-hour operation shall not be reinitiated, but shall be continued after resolution of the problems until 2000 hours are accumulated. Should problems which are related to the pump force an interruption of the test, the test requester will evaluate the nature of the problem to determine whether it is significant to the purpose of the test, then designate whether the test should be reinitiated or continued after resolution of the problem.

The permissible range of set point variables to qualify for valid test point operation during this test shall be:

Temperature	+5F	-20F
Speed	+5 rpm	-10 rpm
Flow	+200 gpm	-200 gpm
Sodium Level	+2 in.	-2 in. (excepting +3.0/-0.0 at 48 in.)
Cover Gas Pres.	+0.5 psi	-0.5 psi

Data points showing one or more of the above set point variables outside of the specified range shall be cause for disqualifying all test time back to the last data set showing all of the set point variables within the specified range.

<u>Data Collection and Use</u> - Data recording shall be according to the requirements of Table M2. A continuous plot of the set point variables

plus pump head, pump power, and sodium bearing temperature difference (average outlet structural temperatures minus average inlet sodium temperature to the bearing) shall be maintained during the test to permit on-the-spot evaluation of performance trends.

In addition, an up to date log shall be maintained to permit on-the-spot identification of cumulative acceptable test operation time and cumulative nonacceptable (out of tolerance) test point operation.

7.7.8 300 Hour Off-Design Endurance Test at 1050^{o}F and Reduced Speed

Note: Test Requester Hold Point.

Purpose - To expose the ISIP to extended term operation under the design temperature, flow, and NPSH conditions (corresponding to 200% margin at design flow and speed) but a higher relative flow (Q/N = 16.22) and reduced speed.

Test Description - From the design point conditions of the 2000 hour endurance test (14,500 gpm, 1110 rpm, 1050^{o}F, 200% NPSH margin), the pump speed will be reduced to rpm while maintaining constant temperature and cover gas pressure. The test facility MFL valves will then be opened to achieve a flow rate of 14,500 gpm (R5 loop resistance) and the cover gas pressure adjusted as required to yield an NPSH value equal to that calculated for 200% nargin at design conditions in Paragraph 7.7.7.

Caution: The pump speed should be reduced at R4 loop resistance prior to opening the MFL valves to the R5 positions.

NPSH valves to be used for this test are to be referenced to the inlet elevation only. The sodium level used for this test shall be within the range from 48 in. (-0.0/+3.0) to 125 in. (±2) above the impeller discharge centerline. The particular level selected shall be that based on minimizing the vacuum to be used in the cover gas space.

The pump shall be operated continuously under these conditions for 300 hours. Should problems which are unrelated to the pump force an interruption of the test, the 300 hour operation shall not be reinitiated but shall be continued after resolution of the problems until 300 hours are accumulated. Should problems which are related to the pump force an interruption of the test, the test requester will evaluate the nature of the problem to determine whether it is significant to the purpose of the test, then designate whether the test should be reinitiated or continued after resolution of the problem.

The permissible range of set point variables to qualify for valid test point operation during this test shall be:

Temperature	± 10°F.
Speed	± 5 rpm
Flow	± 200 gpm
Sodium Level	± 2 in.
Cover Gas Pressure	± 0.5 psi.

Data points showing one or more of the above set point variables outside of the specified range shall be cause for disqualifying all test time back to the last data set showing all of the set point variables to be within the specified range.

Data Collection and Use - Data recording shall be according to the requirements of Table M2. A continuous plot of the set point variables plus pump head, motor electrical power, and sodium bearing temperature difference (average outlet structural temperature difference minus average inlet sodium temperature to the bearing) shall be maintained during the test to permit on-the-spot evaluation of performance trends.

In addition, an up to date log shall be maintained, manually or automatically, to permit on-the-spot identification of cumulative acceptable test operation time and cumulative nonacceptable (out of tolerance) test point operation.

7.7.9 Thermal Transients

7.7.9.1 Low Temperature Transients

Note: Test Requester Hold Point Prior to Each Transient (See Table III)

The pump shall be exposed to Events 201 through 203 described in Table V. Each consist of the following:

1) Stabilized pre-transient running at conditions defined by Column A, B, and C of Table V.
2) Application of transient event as defined by Columns C, D, E, and F of Table V.
3) Thermal soak at conditions defined by Columns D, G, and H of Table V.
4) Post transient R_4 upramp speed scan at Column D temperature. Speed set points per Table A3; 15-minute stabilization at each speed setpoint.
5) An 8-hour post transient endurance run at R_4 flow at 1110 rpm.

Data Collection - As specified in Table M2.

Special Post-Test Data Reduction

1) Tabulation of pump internal temperatures vs time at 5 sec intervals during the transient application period and

first 15 minutes of soak period. Temperatures to be included in this listing are indicated in Table M1 as Item Nos. 420 and 503 through 542 inclusive.

2) Tabulation of pump performance parameters vs. time at 5 sec intervals (or as limited by data reduction systems) during transient application period and first 15 minutes of soak period. Parameter to be included in this listing are: Temperature TE-120, Speed SE-20, Power JE75B, Flow FT101BM, ZE-82/83 Orbit, ZE-84/85 Orbit, ZE-86/87 Orbit, ZE-88/89 Orbit, ZE-82/83 Film, ZE-84/85 Film, ZE-86/87 Film, ZE-88/89 Film. The availability of this data online will negate the need for offline evaluation.

3) Spectral Plots (g's vs Hz) 0-250 Hz and 0-5000 Hz range for the following parameters at stability point prior to transient application: VE-07Z, VE-07X, VE-08Z, VE-08X, VE-09A, NE-23, NE-24.

7.7.9.2 <u>Mid-Range Thermal Transients</u>

Note: Test Requester Hold Point Prior to Each Transient (see Table III).

The pump shall be exposed to Events 204 through 205 described in Table V. Each transient event will consist of the events described in Paragraph 7.7.9.1.

7.7.9.3 <u>High Temperature Thermal Transients</u>

Note: Test Requester Hold Point prior to each transient specified below.

Test Description - Performed thermal transient events 206 through 208 and 210 described in Table V. Basic test elements and data collection will be identical to Paragraph 7.7.8.1 tests.

7.8 DISASSEMBLY AND INSPECTION

7.8.1 Final Disassembly and Inspection

Note: Test Requester Hold Point

Purpose - To inspect and record the condition of the pump after endurance testing at the specified NPSH margin and after thermal transient testing.

Test Description - The test will be performed using the methods and procedures previously used for Paragraph 7.6.1 except that all instrumentation will be removed and the bearing will be removed from the bearing support flange.

7.8.2 Disposition of Equipment

Upon successful completion of the test program, which includes post test disassembly and inspection, the components that were provided by AI shall be returned to AI at Santa Susana for packaging and storage. The components that were provided by HEDL shall be treated in accordance with instructions from HEDL or DOE. The test requester expects that these instructions will be to package the components in accordance with the FFTF instructions and ship the components to HEDL.

In the event that the program is terminated by a failure that prevents further testing, special instructions will be prepared regarding failure investigation and disposition of components.

8.0 DATA

8.1 DATA HANDLING

Data recording requirements are given in Appendix M. Processing of data will be conducted to provide the test requester two copies of on-line printouts daily while the testing is in process.

8.2 DATA REDUCTION AND ANALYSIS

Raw data will be processed and reduced using the techniques similar to those that were in use for Phase B testing of the FFTF Prototype Pump in accordance with Reference 1.

8.3 DATA IDENTIFICATION AND STORAGE

Data will be annotated, identified, and stored according to procedures established by ETEC except that data is to be stored for at least three years. No duplicates of raw data are requested by AI; however, ANL may find it necessary to request duplicates of the hydrophone data types.

8.4 INTERIM REPORTING

The test requester plans to have a representative on the test site for most of the important testing and expects to receive on-line printout data on a daily basis. In addition, monthly reports of test activity and reduced test data shall be prepared.

8.5 FINAL REPORT

The ETEC final report should include descriptions of:

1) Test Facility
2) Test Article Installation
3) Testing
4) Test Article Removal and Cleaning
5) Test Data.

AI will prepare the analysis of test results and inspection results for the final program report with ETEC technical support.

9.0 SYSTEM SAFETY

The precautions and procedures established by ETEC for testing with high temperature sodium and for handling large components shall be adhered to in this program. Reactions to alarms that may occur during testing are given in Appendix H, "Reaction to Alarms."

10.0 QUALITY ASSURANCE REQUIREMENTS

Test procedures should be in accordance with the quality assurance standards, practices and procedures required by the direct contract(s) which is (are) in existence between the test performer(s) and the Department of Energy. If no such contract exists, then the minimum requirements are those contained in Section 3.6 of RDT Standard F2-2T (Quality Assurance Program Requirements, June 1969). Beyond these, no special requirements exist for this particular test specification.

11.0 ORGANIZATIONAL INTERFACE

Participation and responsibilities of the test requester organization involved in this test program are defined as follows:

1) Follow test activities from initial approach through final report to assure that program objectives are fulfilled.
2) Coordinate test request requirements with ETEC including critical procedures.
3) Promptly notify ETEC of potential changes in test requests, procedures, or schedules, including potential changes in the test component delivery date.
4) If unexpected test results or testing anomaly occurs, coordinate with ETEC the corrective action or revisions to the test request required.
5) Review all data for validity and acceptance.
6) Analyze all data and prepare interim and final reports.
7) Responsible test requester personnel are:
   - T. J. Boardman
   - R. V. Anderson
   - G. J. Hallinan
   - J. O. Pfouts
   - R. E. Schnurstein

12.0 REFERENCES

1. Westinghouse Document WDTRS25.14, "Sodium Testing of the FFTF Prototype Pump," Revision 18

2. Westinghouse Electric Corporation, Electro-Mechanical Division, Test Specification No. 921602, "Testing of Westinghouse Model LMP-1 (FFTF Prototype) Main Coolant Pump in Water," Revision 0

3. LMFBR Low Capacity Prototype Pump and FFTF Primary Pump Specification, HWS-1551, Revision 0, January 1972, and all Addenda

4. Operation and Maintenance Manual for Westinghouse Model LMP-1 Pump, OMM-051-00-005, plus the ESG addendum for assembly of ISIP.

TABLE I

Deleted

TABLE II

PUMP INSTRUMENTATION

Number	Description	Readout Location	Range	Accuracy
TE 02 A,B,C,D	Hydrostatic Bearing Temperatures	C201B	300-1200°F	± 4%
TE 11	Main Motor Upper Guide Bearing Temperature	C201B	100-400°F	± 4%
TE 12	Main Motor Lower Guide Bearing Temperature	C201B	100-400°F	± 4%
TE 13	Pony Motor Stator Temp.	C201B	100-400°F	± 4%
TE 14 A,B,C	Main Motor Stator Temp	C201B	100-400°F	± 4%
TE 15	Main Motor Thrust Bearing Temperature	C201B	100-400°F	± 4%
TE 18	Seal/Bearing Housing Inlet Oil Temperature	C201B	0-250°F	± 4%
TE 19A	Lower Seal Outlet Oil Temperature	C201B	0-250°F	± 4%
TE19B	Thrust Bearing Outlet Oil Temperature	C201B	0-250°F	± 4%
TE 19C	Upper Seal Outlet Oil Temperature	C201B	0-250°F	± 4%
TISH 24	Electrolyte Temperature Alarm Switch	N/A	N/A	N/A
TISH 24	Electrolyte Temperature Alarm Switch	N/A	N/A	N/A
TE 25	Electrolyte Temperature	C201B	0-200°F	± 5%
TE 26	Electrolyte Temperature Control Valve	N/A	N/A	N/A
TE 27	Heat Exchanger Inlet Cooling Water Temperature	C201A	0-200°F	± 5%
TE 28	Heat Exchanger Outlet Cooling Water Temperature	C201A	0-200°F	± 5%
TE 30A	Radiation Baffle Temperature	N/A	0-1200°F	± 4%
TE 30B	Shield Temperature	N/A	0-1200°F	± 4%

TABLE II

PUMP INSTRUMENTATION
(Continued)

Number	Description	Readout Location	Range	Accuracy
TI 46 TSH 47	Seal/Bearing Housing Inlet Oil Temperature	Oil Circ Skid	0-200°F	± 2%
TI 49 TE 49 TSH 50	Lower Seal Outlet Oil Temperature	Oil Circ Skid	0-200°F	± 2%
TI 52 TSH 53	Thrust Bearing Oil Outlet Temperature	Oil Circ Skid	0-200°F	± 2%
TE 55 TSH 56	Upper Seal Oil Outlet Temperature	Oil Circ Skid	0-200°F	± 2%
TE 119	Sodium In	Control Console	0-1200°F	± 1.6%
TE 120	Sodium Out	Control Console	0-1200°F	± 1.6%
E901-61 thru 71	Tank Skin Temperature	HTB	0-1200°F	± 1.75%
VE 06 X,Y,Z	Motor Vibration	Control Console	5-5000 Hz 0-200 g Pk	± 2%
VE 07 X,Y,Z	Pump Tank Vibration	Control Console	5-4000 Hz 0-200 g Pk	± 10%
VE 08 X,Y,Z	Shaft Seal Housing Vibration	Control Console	5-5000 Hz 0-200 g Pk	± 10%
VE 09 A, B	Sodium Bearing Vibration	N/A		
SE 20	Shaft Speed (Digital Display)	Control Console		
LSL 04 LIT 16	Oil Supply Reservoir Level	C283/ C201B	0-100%	± 1%
LI 23	Sump Tank Level	C201A	-5" to +5"	±5%
LSH 34	Lower Seal Leakage Reservoir High Oil Level Alarm Switch	N/A	N/A	N/A
LSL 35	Lower Seal Leakage Reservoir Low Oil Level Switch	C283 (Indicator Light)	N/A	N/A
LSH 36	Upper Leakage Reservoir High Oil Leakage Alarm Switch	N/A	N/A	N/A

TABLE II

PUMP INSTRUMENTATION
(Continued)

Number	Description	Readout Location	Range	Accuracy
LIT 37 LSHH37 LSLL37	Lower Seal Leakage Reservoir Oil Level	C283	0-100%	± 4%
LT 40	Pump Tank Sodium Level	C201B	-8.5 to ±0.5 feet	± 4%
LE 42	Pump Tank Sodium Level	Control Console	0-10 psid	± 2%
PI 03	Oil Supply Reservoir Blanket Gas Pressure	Oil Circ Skid	0-30 psi	± 1%
PDSH 05	Oil Circ Filter P High Switch	N/A	N/A	N/A
PD 17	Seal/Bearing Housing P	C283/C299	0-50 psid	± 4%
PDT 26	Pump P Low Range	Control Console	-30-200 in H_2O	± 2.3%
PI 40	Oil Lift Pressure	Oil Circ	0-1500 psi	± 1%
PS 41	Oil Lift Pressure Established	N/A	N/A	N/A
PDSH 42	Oil Lift Filter P High Switch	N/A	N/A	N/A
PI 45	Seal/Bearing Housings Inlet Oil Pressure	Oil Circ Skid	0-160 psi	± 4%
PI 48	Lower Seal Outlet Oil Pressure	Oil Circ Skid	0-160 psi	± 1%
PI 51	Thrust Bearing Outlet Oil Pressure	Oil Circ Skid	0-160 psi	± 1%
PI 54	Upper Seal Outlet Oil Pressure	Oil Circ Skid	0-160 psi	± 1%
PDSL 57	Seal/Bearing Housing P Low	N/A	N/A	N/A
PI 58	Oil Circ Pump Outlet Pressure	Oil Circ Skid	0-160 psi	± 1%
PDSH 59	Oil Circ Pump P Low Switch	N/A	N/A	N/A
PI 60	Oil Circ Pump Inlet Pressure	Oil Circ Skid	(-)30 in to 0 to 15 psi	± 1%

TABLE II

PUMP INSTRUMENTATION
(Continued)

Number	Description	Readout Location	Range	Accuracy
PI 63	Oil Fill Reservoir Blanket Gas Pressure	Oil Circ Skid	0-30 psi	± 1%
PSH 70	Sodium Pump Main Motor Oil Lift Pressure Switch	N/A	N/A	N/A
PT 105	Sodium Pump Discharge	Control Console	0-300 psig	± 2.3%
PT 111	Sodium Pump Inlet	Control Console	0-50 psia	± 2.3%
PT 113	Pump Tank Cover Gas Pressure	Control Console	0-50 psia	± 2.1%
PT 115	Pump Tank Cover Gas Pressure			
ZE 82 A&B	Proximity Probes	PIP Panel	169	169
ZE 83 A&B	Proximity Probes	PIP Panel	169	169
ZE 86 A&B	Proximity Probes	PIP Panel	169	169
ZE 87 A&B	Proximity Probes	PIP Panel	169	169
ZE 88 A&B	Proximity Probes	PIP Panel	169	169
ZE 89 A&B	Proximity Probes	PIP Panel	169	169
ZS 21	Electrode Position	C201A	0-60 in.	± 5%
ZC 21	Rheostat Control Signal Fault	N/A	N/A	N/A
ZS 39	Lower Leakage Reservoir Pump Relief Alarm Switch	N/A	N/A	N/A
ZS 43	Oil Lift Pump Relief Alarm Switch	N/A	N/A	N/A
ZS 61	No. 1 Oil Circ Pump Relief Alarm Switch	N/A	N/A	N/A
ZS 62	No. 2 Oil Circ Pump Relief Alarm Switch	N/A	N/A	N/A
ZS 64	Seal/Bearing Housings Relief Alarm Switch	N/A	N/A	N/A
-	Back-Up Oil Circ Pump Running	N/A	N/A	N/A
-	Back-Up Oil Cooler Fan Running	N/A	N/A	N/A
EE 71	Pony Motor Voltage	Control Console	0-460 v	± 2%

TABLE II

PUMP INSTRUMENTATION
(Continued)

Number	Description	Readout Location	Range	Accuracy
IE 72	Pony Motor current	"	0-10 amps	± 2%
EE 73ABC	Main Motor Voltage(3-Phase)	"	0-4160 volts	± 2%
IE 74ABC	Main Motor Current(3-Phase)	"	0-328 amps	± 2%
JE 75B	Main Motor Power	"	0-2000 kW	± 2%
SE 47	Speed	C201A	0-1200 rpm	± 2%
FI 10	Seal/Bearing Housing Oil Flow	Oil Circ Skid	0-30 gpm	± 2%
FI 33	Purge Gas In	Control Console	0-0.5 cfm	± 10%
FT 101A	Sodium Flow - Venturi - Low Range	Control Console	0-4000 gpm	± 7.5%
FT 101B	Sodium Flow - Venturi - High Range	Control Console	0-20000 gpm	± 7.5%
FE 104	Sodium Flow	Operator's Console	0-20000 gpm	± 7.5%
FI 920	Purge Gas Out	Local	0-0.5 cfm	± 10%
CE 22	Electrolyte Conductivity	C201A	0-5%	± 5%
NE 23	Airborne Noise			

Notes: 1. Deleted.

2. Instrumentation panels are defined as follows:

C283 - Local lube oil system panel. This panel will be supplied by the lube oil system supplier and will be an integral part of the pump lube oil system package.

C201A - Liquid Rheostat Panel. This panel is being provided as part of the liquid rheostat system and will be provided ready for installation.

C999 - Pump Local Control Panel. This panel is manufactured by Honeywell as part of the General Instrumentation System.

TABLE III

SUMMARY OF TEST REQUESTER HOLD POINTS

Paragraph No.	Hold	Action Needed to Remove Hold Point	Approval Needed
1. 7.5.1	Do not initiate assembly of the pump without prior test requester approval	Confirmation by AI, HEDL, and ETEC that the components on hand are correct and ready for assembly	Test Requester Site Rep.
2. 7.5.3	Do not preheat or fill the pump without prior test requester approval	Pump fully assembled and installed, oil syst. checked out	Test Requester Site Rep.
3. 7.5.4	Do not initiate powered operation of the pump without prior test requester approval	Preheat satisfactorily completed	Test Requester Site Rep.
4. 7.5.4 (1)	Do not initiate powered operation without prior test requester approval	Pretest instrumentation checkout satisfactorily completed	Test Requester Site Rep.
5. 7.5.4 (5)	Do not initiate main motor operation without prior test requester approval	Pony motor operation satisfactorily and operational instrumentation checkout complete	Test Requester Site Rep.
6. 7.5.5	Do not perform flow scans without prior test requester approval	Initial operation of pump satisfactorily	Test Requester Site Rep.
7. 7.5.6	Do not initiate powered operation above 600^{o}F	Review of 600^{o}F test data and pump operation	Test Requester Site Rep.
8. 7.5.6.3	Do no inititate powered operation at 800^{o}F	Review of lower temp test data	Test Requester Site Rep.
9. 7.5.7.1	Do not initiate 950^{o}F baseline tests	Review heatup performance data	Test Requester Site Rep.
10. 7.5.8	Do not initiate high temperature testing	Review of lower temp test data	Test Requester Site Rep.
11. 7.5.9.1	Do not initiate 1050^{o}F testing	Review of previous temp test data	Test Requester Site Rep.
12. 7.6	Do not initiate interim disassembly of pump without prior test requester approval	Confirmation by AI that NPSH test data is complete and that data anomalies are resolved satisfactorily	Test Requester Site Rep.

TABLE III (CONTINUED)

SUMMARY OF TEST REQUESTER HOLD POINTS

Paragraph No.	Hold	Action Needed to Remove Hold Point	Approval Needed
13. 7.7.1	Do not initiate reassembly of pump without prior test requester approval	Confirmation by AI and HEDL that Interim Inspection is complete and that parts are in a satisfactory condition for reassembly	Test Requester Site Rep.
14. 7.7.3	Same as 7.5.3		
15. 7.7.4	Same as 7.5.4 (1) and (5)		
16. 7.7.5	Same as 7.5.5		
17. 7.7.6	Same as 7.5.6		
18.	Do not initiate 2000-hr endurance test without prior test requester approval	Confirmation by AI that 1050°F speed scan data has been reviewed and that no unacceptable anomalies have been left unresolved	Test Requester Site Rep.
19. 7.7.8.1	Do not initiate Thermal Transient Test No. 201	Review of data from the completed testing	Test Requester Site Rep.
20. 7.7.8.1	Do not initiate Thermal Transient Test No. 202	Review of data from Transient No. 201	Test Requester Site Rep.
21. 7.7.8.1	Do not initiate Thermal Transient Test No. 203	Review of data from Transient No. 202	Test Requester Site Rep.
22. 7.7.8.2	Do not initiate Thermal Transient Test No. 204	Review of data from the completed testing	Test Requester Site Rep.
23. 7.7.8.2	Do not initiate Thermal Transient Test No. 205	Review of data from Transient No. 204	Test Requester Site Rep.
24. 7.7.8.3	Do not initiate Thermal Transient Test No. 206	Review of data from the completed testing	Test Requester Site Rep. & HEDL
25. 7.7.8.3	Do not initiate Thermal Transient Test No. 207	Review of data from Transient No. 206	Test Requester Site Rep.
26. 7.7.8.3	Do not initiate Thermal Transient Test No. 208	Review of data from Transient No. 207	Test Requester Site Rep.

TABLE III (CONTINUED)

SUMMARY OF TEST REQUESTER HOLD POINTS

Paragraph No.	Hold	Action Needed to Remove Hold Point	Approval Needed
27. 7.7.8.3	Do not initiate Thermal Transient Test No. 210	Review of data from Transient No. 208	Test Requester Site Rep.
28. 7.8.1	Do not initiate final pump disassembly without prior test requester approval	Test objective satisfied	Test Requester Site Rep.

TABLE IV

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TABLE V

THERMAL TRANSIENT TEST PARAMETERS

	A	B	C	D	E	F	G	H
Event	Tank Level	Starting Speed/Flow rpm/gpm	Starting Temp °F	Final Temp	Delta-T °F	Transient Rate °F/Second	Main (1) Drive Trip	Soak Times Hrs. (2)
201	125 in.	1110/14500	750	600	150	-0.4	NO	6.
202	"	"	750	600	160	-1.5	NO	6.
203	"	"	500	650	150	+1.5	NO	6.
204	"	"	850	650	200	-1.5	NO	8.
205	"	"	700	850	150	+1.5	NO	6.
206	"	500/12000 (5)	1050	720	330 (3)	-0.4	YES (4)	12.
207	"	1110/14500	1050	720	330 (3)	-1.2	NO	12.
208	"	"	1050	825	225	-2.0	NO	9.
210	"	"	1050	900	150	-3.0	NO	6.

(1) Operation on pony motor will be continued after main drive trip.

(2) Soak is defined as holding pump at final transient cycle temperature within facility limitation. It is noted that the SPTF can't hold constant temperature with pump on pony motor at temperature in excess of 700°F; therefore, a slow temperature down ramp during the soak period is anticipated and considered acceptable.

(3) Test goal, facility may be limiting.

(4) Raise sodium level to 174 inches immediately after main motor trip.

(5) Use maximum obtainable flow if 12,000 gpm cannot be achieved.

APPENDIX A

Details of Hydraulic Testing at SPTF

The test request requires speed scans at several loop resistances as well as constant speed operation over a large flow range. The loop resistances referenced in this test specification are defined in Table A1. The formal speed scans at various loop resistances will be performed as specified in Table A3 of this Appendix.

It should be noted that at low flow, high speed conditions, it is possible for the pump discharge pressure to exceed the design pressure (225 psi) for the discharge nozzle. Under no circumstances should the discharge pressure be allowed to exceed 225 psig at design temperature (1050^{o}F). Off-design operation may also reduce the running clearance of the hydrostatic bearing. The pump shall not be operated when the bearing clearance is reduced by more than 75% of the clearance determined by the latest proximity probe calibration.

TABLE A1

FLOW RESISTANCE VALUES

Loop Resistances	R-0	R-1	R-2	R-3	R-4	R-5
K	0	296	383	438	648	874

$$K = \frac{Q}{\sqrt{H}}$$

where

Q = flow in gpm

H = head in feet

For flow scans, measurements are to be made at each of the defined loop resistances and at two points in between. There must be five evenly distributed flow points between R-0 and R-1. Specifically, this note applies to Paragraphs 7.5.5.1 and 7.5.5.3.

TABLE A2

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TABLE A3

SPEED SCAN TEST POINTS

Set Points for

	rpm: Set Points for Decreasing Speed (All Resistance Values)	Set Points for Increasing Speed: rpm: Increasing Speed	Design Resistance R4	R1	R3.3	R5	R6(1)	Stabilization Hold Period (Min)
Pony Motor	94	94						30
Main Motor		Min. Spd.	X					30
	500	500	X	X	X	X	X	30
	600	600	X	X				30
	700	700	X	X	X			30
		800	X	X				30
		830					X	30
	900	900	X	X	X	X		30
		950	X	X				30
	1000	1000	X	X				60
		1025	X	X				60
	1050	1050	X	X	X	X		60
		1075	X	X				60
	1110	1110	X	X	X	X		60
		1120	X					180
Max. Control Speed		1132	X					180

(1) 10 psig cover gas pressure must be used during the R6 speed scan. MFL valves to be full open if R6 condition cannot be reached.

APPENDIX B

Deleted

APPENDIX C

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APPENDIX D

Facility Electrical Services Required
by Test Pump

1. Electrical Services

The facility must provide the following electric service:

a) 4160 VAC three-phase to power the main drive motor (2500 hp).

b) 480 VAC three-phase to power the pony motor (25 hp).

c) 480 VAC, 6-1/2 KVA feeder to lube oil system to power: Lube oil pump No. 1 (3 hp), oil cooler fan No. 1 (2 hp), and lower leakage tank pump (1/2 hp), and associated instrumentation and control.

d) 480 VAC, 6 KVA feeder to lube oil system to power: lube oil pump No. 2 (3 hp), and oil cooler fan No. 2 (2 hp), and associated instrumentation and control.

e) 480 VAC, 7 KVA feeder to lube oil system to power: oil lift pump (pump) (3 hp) and oil lift pump (motor) (3 hp), and associated instrumentation and control.

Items c) and e) above can be supplied in parallel from the same source. Item d) should be supplied from a source as independent from the source supplying c) and e) as practical to provide the most insurance that at least one source is available at all times.

f) 120 VAC, 60 Hz, 1.0 KVA feeder for Panel C201B. This source should be a well regulated instrument supply. Regulation is to be equal to or better than ±2% of nominal voltage (120 VAC) and ±2% of nominal frequency (60 Hz).

g) 480 V, 3 ph, 60 Hz, 20 KVa feeder to the liquid rheostat controller C201A for powering the 7-1/2 hp electrolyte pump motors and the 9 kW heaters in the electrolyte storage tank.

h) 120 V, 1 ph, 60 Hz, 2 KVA feeder to the liquid rheostat controller C201A for instrumentation and control purposes. Source for this power should be regulated within the limits specified in f).

2. Main Motor Protection

The facility must provide the following relay protection for the pump main motor:

a) Induction over current relay with instantaneous unit for stator circuit.

b) Instantaneous overcurrent relay ground sensor for stator circuit.

c) Phase sequence and undervoltage relay for stator circuit.

d) Motor slip ring flashover/ground protection relay for rotor circuit.

e) Current balance relay with current transformers accurate to 5 Hz for rotor circuit.

Dual function relays may be utilized to combine the above protective features where such relay types are available.

3. Pump Main Motor Starting Interlocks

The facility must provide interlocking to prevent starting the main pump motor until the following conditions are satisfied:

a) Lube oil pressure across the pump seal/bearing housing established. A contact closure is provided from the lube oil system for this purpose (PDSL 21157).

b) Liquid rheostat in maximum resistant position and electrolyte pump is running. A single contact closure for both functions is provided from the liquid rheostat for this purpose (ZSH 21121).

c) Pony motor is energized.

Interlocks are not required for pony motor operation. Attempts to start the pony motor prior to starting the oil lift pumps may result in breaker trip on overcurrent since the pony motor is not sized to overcome the required starting torque. No equipment damage will result, however.

The foregoing conditions, b) and c), should be required only for starting the main motor but should not be required for continued operation.

4. Pump Main Motor Trip Interlocks

The following pump main motor trip interlocks will be effective during operational testing. These are in addition to those protective relaying functions listed in Item 2 of Appendix D.

a) The main motor will be tripped when upper bearing housing vibration equals or exceeds 5 mils. The vibration will be based on electronic double integration of the VE-08 accelerometer output.

b) The main motor will be tripped when the hydrostatic bearing structure temperature exceeds the bearing fluid feed temperature by 100^{o}F.

c) The main motor will be tripped when the main motor power consumption exceeds a predetermined power standard by 20%. The trip criterion will be established during the test program.

In addition to the above automatic main motor trip conditions, manual main motor trips will be initiated for the following conditions:

a) Loss of lube oil pressure across pump seal/bearing housing (PDSL 21157 and PDSL 21117). Available time is approximately 5 minutes. Available as a retransmitted alarm from C201B and as a direct alarm from the oil system to the main facility annunciator.

b) High lube oil temperature (TSH 21119C, TSH 21119B, TSH 21119A or TSH 21118). The time available is dependent on the rate of temperature rise but in no case will it be less than 5 minutes. Available as a retransmitted alarm from C201B.

c) Liquid rheostat high temperature (TISH 21124) (175^{o}F). Approximately 1 minute is available until boiling occurs with possible rotor current unbalance. Available as a direct alarm from the liquid rheostat to the main facility annunciator. (A previous alarm at 135^{o}F provides time for operator corrective action; the 175^{o}F alarm requires pump motor shutdown.)

Motor protective relaying listed in 2 above should provide automatic tripping of motor power to minimize damage to the pump motor.

Other alarms from the pump system are indicative of malfunctions and must be answered in a timely manner. In many cases, they will lead to one of the conditions described above.

APPENDIX E

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APPENDIX F

DESIGN RESTRICTIVE LIMITS

Restricting design limits for the specific SPTF casualty events are as follows:

1. Pump Cover Gas Pressure Restricting Design Limit

a) The cover gas pressure for the oil circulation system shall be maintained at at least 4 psig. For normal operation, this should be 4 to 6 psig. There is no requirement for a pressure regulator to maintain a fixed pressure difference above the pump tank cover gas pressure.

b) The postulated failure in the pump cover gas control system that would increase the pump tank cover gas to 25 psig will not damage the pump hardware.

c) Provision should be made to manually increase the Oil Circulation System cover gas pressure to a level greater than 25 psig. This would allow continued operation of the pump in the event the pump tank cover gas increases for any reason during some critical test that should not be interrupted.

2. Event No. 6 - Pump Discharge Nozzle Pressure

Restricting Design Limit: 225 psig at 1050^{o}F
253 psig at 1025^{o}F and below

3. Event No. 15 - Low Pump Tank Sodium Level

a) Design Limit - The restrictive design limit is that the level shall not be allowed to go below 3 feet above the impeller centerline with power to the pump motors. Also, during a shutdown and drain operation, the bearing will not be allowed to run dry (sodium level below the upper level of the suction nozzle) before the pump stops rotating. (Two minutes must be allotted from when the pump motor is tripped until the sodium level reaches the top of the suction nozzle.)

b) Alarm Point - The alarm point will be set at 6 inches above the trip point.

4. Event No. 16 - High Pump Tank Sodium Level

a) Design Limit - The restrictive design is at 180 inches above the centerline (the maximum sodium level) of the impeller. The high level trip must be set to preclude exceeding this limit under any circumstances.

b) Alarm Point - A high level alarm will be set 2 inches below the trip point.

5. Thermal Transient Design Restrictive Limit

The definition of an alarm set point in the thermal transient control system would be very difficult. The thermal transient control must be self-limiting to preclude thermal transient events that exceed the limits of the U2 or E10X event as defined in Reference 3.

6. Sodium Fill Parameters

a)	Temperature	400 ±10°F (Pump tank must be within ±40°F of sodium temperature during fill.)
b)	Fill Rate	Normal max. rate of 80 gpm and slower as necessary to allow controllability as completion of fill is nearer.
c)	Instrumentation	The pump level probes will be used to determine when final fill is achieved or how much additional Na is necessary to complete the fill. Notice will also be taken of T/C fluctuation to indicate Na presence.
d)	Atmosphere Condition	The atmosphere will be argon with the required purity levels. Two options are available: Option A - Vacuum Fill The loop will be evacuated to 0.1 psia and filled. The PSP seal oil system will be drained, purged (to remove as much oil vapor as possible) and blankoff flanges reinstalled over all openings.

Option B - Normal Cover Gas Pressure System Fill

The main flow loop will be filled with the cover-gas system at nominal covergas operating pressure (10 in. water gage).

APPENDIX G

Deleted.

APPENDIX H

TABLE OF ALARM REACTIONS

ALARM	PROBABLE CAUSE	WHAT TO CHECK	REACTION	CORRECTION CRITERIA	COMMENT
ZL-67 TE-11 TE-12 TE-14 A,B,C TE-15	A) Low oil supply in motor bearing supply pots. B) Motor power supply inbalance.	A) Oil pots located on drive motor. B) Motor parameters EE-73, IE-74, JE-75B	A) Add oil to low pots. B) If excessive shut down drive, notify ESG	A) High temp returns to limits of para 3.4.1 of Ref 11. B) Correction of power supply problem.	If not corrected, shut down.
TE-13	Motor power supply problem.	Motor parameters EE-71, IE-72, JE-75A.	If excessive shut down drive, notify ESG	Correction of power supply problem.	
TE-18	A) Heat exchanger malfunction. B) Low oil flow. C) Low oil flow.	A) Heat exchanger fan operation, louvers open. B) Check throttle valve settings. C) Pump/motor failed.	A) Select alternate fan, manually open louvers. B) Adjust valve settings per O&M Manual C) Select alternate motor/pump.	A) Temp drops below 125°F on TI-46 on oil circ skid. B) Temp drops below 125°F on TI-46 on oil circ skid. C) Temp drops below 125°F on TI-46 on oil circ skid.	Greer Manual paragraph 3.5.3.3 TE-13, A,B,C PI-45
TE-19 A,B,C	A) Heat exchanger malfunction.	A) Heat exchanger fan operation, louvers open.	A) Select alternate fan, manually open louvers.	A) Temp drops below 155°F on TI-49, TI-52 or TE-55..	Greer Manual paragraphs 3.5.3.13, 3.5.3.14, 3.5.3.16 TE-18, PI-43, PI-51, PI-54
LSH-04	Reservoir level low.	Level LIT-16 on reservoir.	Fill reservoir with oil. NOTE: Drain upper & lower seal leakage reservoirs prior to filling. This is for inventory control.	Level (LIT-16) indicates normal level (more than 2 gallons).	Greer Manual paragraph 3.5.3.1
LSH-34 LSH-37	Reservoir full.	-	Drain oil per Greer Manual, paragraphs 3.4.6.2 and 3.4.6.3.	Pump will shut off automatically.	Greer Manual paragraphs 3.5.3.5, 3.5.3.6, 3.5.3.7 LSH-34, LSH-36

Table of Alarm Reactions

ALARM	PROBABLE CAUSE	WHAT TO CHECK	REACTION	CORRECTION CRITERIA	COMMENT
LSH-36	Reservoir full.	Check level with dipstick.	Drain oil per Greer Manual para 3.4.5.3.	Level drops below 9-1/4 gallons.	Greer Manual paragraph 3.5.3.4
PDSH-05	Filter element is dirty.	-	Select alternate filter (see Greer Manual para 4.1.3).	Alarm goes off.	Greer Manual paragraph 3.5.3.2
PD-17 PDSL-57	A) Leak in supply line.	A) Visually examine oil circ system for evidence of leak.	A) Shutdown. Repair leak.	A) Leak repaired. System capable of maintaining at least 10 psid.	Greer Manual paragraph 3.5.3.9
	B) Flow diverted through relief valve.	B) Alarm ZS-64.	B) Shutdown. Determine cause of relief valve opening.	B) System capable of maintaining at least 10 psid.	Greer Manual paragraphs 3.5.3.9 and 3.5.3.17
	C) Low flow.	C) Flow FI-10, throttle valve settings pump motor.	C) Shutdown until cause of low flow is corrected.	C) System capable of maintaining at least 10 psid.	Greer Manual paragraphs 3.5.3.9 and 3.5.3.17 and B) & C) under TE-18 above.
PDSH-42	Filter element is dirty.	-	Stop oil lift pump and replace filter element.	Alarm does not come on when lift pump restarted.	Greer Manual paragraph 3.5.3.18
PDSH-59	A) Both circ pumps off.	A) Visually check skid for pump operation.	A) Terminate sodium pump operation until oil pumps are operational.	A) Oil circ pumps are operational and alarm off (greater than 40 psid).	Greer Manual paragraph 3.5.3.8
	B) Oil pump isolation valve closed.	B) Verify that Greer valve numbers 539, 540, 541, 542 are open.	B) Standby pump should automatically start. Otherwise terminate sodium pump operation until situation corrected.	B) Valves opened, pumps sustain PD greater than 40 psid and alarm goes off.	
	C) System PD drops.	C) Check PD-17, react as there.	C) See PD-17 above.	C) See PD-17 above.	

Table of Alarm Reactions

ALARM	PROBABLE CAUSE	WHAT TO CHECK	REACTION	CORRECTION CRITERIA	COMMENT
ZS-39	Solenoid fails to open.	The lower leakage reservoir drain pump must be running, otherwise, false signal.	Open solenoid bypass valve on the lower leakage reservoir.	Alarm goes off when relief flow stops.	Greer Manual paragraph 3.5.3.15
ZS-43	A) Downstream isolation valve closed.	A) Valve position on oil circ skid.	A) Open isolation valve.	A) Alarm goes off when relief flow stops.	Greer Manual paragraph 3.5.3.12
	B) Lift filter PD high.	B) Check PDSH-42, react as there.	B) See PDSH-42.	B) Alarm goes off when relief flow stops.	
ZS-61 ZS-62	A) Downstream isolation valve closed.	A) Valve position on oil circ skid.	A) Open isolation valve.	A) Alarm goes off when relief flow stops.	Greer Manual paragraphs 3.5.3.10 and 3.5.3.11
	B) Filter PD high.	B) Check PDSH-05, react as there.	B) See PDSH-05.	B) Alarm goes off when relief flow stops.	
Back-Up Oil Circ Pump Running	A) Loss of Buss A (or B).	A) Facility power supply.	A) Find/repair fault.	A) Power available to the pump. Manually select the primary. Will hold if corrected.	Greer Manual paragraph 3.5.3.19
	B) Pump PD low.	B) Check PD-17.	B) React as in PD-17.	B) Manually select the primary. Will hold if corrected.	
Back-Up Oil Cooler Fan Running	No air flow.	Check fan operation and louver position. Check TE-18A.	React as in TE-18A.	Manually select the primary. Will hold if corrected.	Greer Manual paragraph 3.5.3.21
ZS-21 ZC-21	Electrode position limit switch fail.	Visually verify electrode position at rheostat.	Switch rheostat control mode to manual and back electrodes out of over-travel.	Alarm off and rheostat functioning normally.	

Table of Alarm Reactions

ALARM	PROBABLE CAUSE	WHAT TO CHECK	REACTION	CORRECTION CRITERIA	COMMENT
TISH-24	A) Electrolyte coolant pump malfunction.	A) Electrolyte coolant pump operation.	A) Verify coolant pump operation.	A) Electrolyte temp drops below 135°F on TE-25.	TE-26, TE-27, TE-28, TE-31, TE-32, LSL-29, CE-22, TE-25
	B) Heat exchanger malfunction.	B) Cooling water supply malfunction.	B) Verify cooling water malfunction.	B) Electrolyte temp drops below 135°F on TE-25.	
LSH-29	Electrolyte level low.	Electrolyte level.	Add water and adjust solution.	Level (LIT-16) indicates normal level.	TISH-24, LI-23, ZS-21

APPENDIX I

Deleted

APPENDIX J

Operation Restrictive Limits

GENERAL: The limits defined here must never intentionally be exceeded. Should during execution of the test program defined herein an operation restrictive limit be inadvertently be exceeded, LMEC must bring the pump back to the last safe operating point and avoid any test points in the unsafe operating region. AI representative at LMEC must be advised about this condition immediately.

1. Start/Stop Limits

   a) Except when otherwise required for a test, loop throttling is to be set at R4 for all pony motor and main motor startups and stops.

   b) Main Motor (Startup)

Parameter	Range/Limit
Line Voltage (4160 V nominal)	3855 - 4485 volts
Startups Per Hour	At minimum control speed, not limited; do not exceed winding or bearing temperature rise limits. Do not exceed rheostat limits.
Startup Speed	Minimum control speed (maximum rheostat resistance)
Oil Lift System	On for at least 60 seconds unless the Pony Motor is running. Then, do not use Oil Lift.
Insulation Resistance (terminal to ground)	25 Megohms (250 megohms without leads)

   c) Rheostat (Startup of Main Motor)

Parameter	Range/Limit
Electrolyte Temperature (For starting Main Drive Motor)	68°F Minimum 104°F, for 1110 rpm 121°F, maximum
Electrode Position (For starting Main Drive Motor)	Top of Normal Travel (Maximum Resistance)
Control Mode (For Starting Main Drive Motor)	Set up for "Automatic" or "Manual"

d) Pony Motor Starting

Parameter	Range/Limit
Multiple Startups	Three consecutive stratups with full coastdown between starts. Then, 20 minutes running, (30 minutes stopped) before fourth start.
Oil Lift System	On for at least 60 seconds UNLESS the Main Motor is running. Then, do not use Oil Lift.
Insulation Resistance (terminal to ground)	5 Megohms

e) Pump Startup Restrictions

1) Powered Pump Operation will not be initiated unless shaft hand rotation torque values are less than 1.25 times the room temperature hand rotation torque values.

2) Powered pump operation will not be initiated unless at least 75% of the bearing clearance measured at pump assembly is still present. This requirement assumes that the bearing proximity probe instrumentation package includes provisions for making at temperature bearing clearance measurements.

3) For a period of twelve (12) hours prior to initiating powered operation, a more frequent shaft rotation is required to preclude thermal distortion in the shaft assembly. An approximate schedule of 90^{o} rotation every half hour is recommended.

2. Running Limits

a) Main Motor

Minimum permissible steady state main motr speed 400 rpm.
Maximum permissible steady state main motr speed 1132 rpm.

Parameter	Range/Limit
Stator Winding (RTD @2A)	90^{o}C Rise
Upper Guide Bearing	55^{o}C Rise or 95^{o}C
Lower Guide Bearing	55^{o}C Rise or 95^{o}C
Thrust Bearing	55^{o}C Rise or 95^{o}C
Voltage	3785 - 4530

b) Rheostat

Parameter	Range/Limit
Electrolyte Temperature	68^{o}F to 135^{o}F
Electrolyte Solution	(Limits deleted for Testing)
Electrolyte Level	0 ± 5 in.
Electrode Position	.5 in. - 57.5 in. (Normal)

c) Pony Motor

Parameter	Range/Limit
Temperature (By Detector)	90^{o}C Rise
Voltage	435 - 520

d) Pump Structure

Parameter	Range/Limit
Shaft Position in Lower Bearing	75% of total radial clearance determined by latest bearing probe calibration
Tank Discharge Nozzle Vibration Inches (Peak to Peak)	Above 20 Hz - .002 max. 5-20 Hz - .010 max. 0.5 Hz or Composite - .030 max.
Seal Housing Vibration	0-20 Hz - .005 max. A pump trip will be initiated if this maximum vibration limit is reached.

e) Hydrostatic Bearing

1) The minimum operating film thickness in the sodium lubricated hydrostatic bearing, except for start/stop situations, will be at least 25% of the available clearance at this bearing as determined by measurement at pump assembly or by at temperature calibration measurements provided this capability exists as part of the bearing proximity probe instrumentation package. An operating alarm will be activated when this condition is reached. Required actions to alarms are specified in Table J-1.

2) The hydrostatic bearing structure temperature will be limited to 50^{O}F in excess of the bearing fluid feed temperature. An operating alarm will be activated when this condition is reached. Required actions to alarms are specified in Table J-1.

f) Motor Power

An operating alarm will be activated when the power consumption exceeds an allowable standard that will be established during the test program. Required actions to alarms are specified in Table J-1.

g) Tank Gradient Requirements

1) The integration of side-to-side temperature gradient over the entire pump length (or algebraic summation of Delta-T X length) in any axial pump plane shall not exceed 2775^{O}F-in.

2) At no point shall the side-to-side temperature gradient, at a constant elevation, exceed 100^{O}F.

3. Tank Gradient Criteria for Sodium Fill

a) The integration of side-to-side temperature gradient over the pump length above the maximum sodium level in any axial pump plane shall not exceed 2775°F-in. The integration may be alternately described as the algebraic summation of Delta-T X length in a given pump plane.

b) The integration of side-to-side temperature gradient over the pump length (or algebraic summation of Delta-T X length) below the maximum sodium level in any axial pump plane shall not exceed 6100°F-in.

c) At no point shall the side-to-side temperature gradient, at a constant elevation, exceed 100°F.

REQUIRED OPERATOR ACTION TO SELECTED ALARMS

ALARM	STEADY STATE (NOTE 2)	THERMAL TRANSIENT (NOTE 3)
High Main Motor Power (See Note 1)	a) Maintain All Operating Parameters Constant b) Scan Bearing Temp, Bearing Probes, and motor protection alarms. If any are activated, trip both main and pony motors immediately; See Note 4. c) If alarm does not clear after one minute, terminate test; See Note 4.	a) Immediately close transient feed tank valve. b) After transient feed system is secure, immediately trip main motor. c) Operate on pony motor for one minute; See Note 4.
High Sodium Bearing Temp. (See Note 1)	a) Maintain all operating parameters constant. b) Scan Brg. probe, motor power, and motor protection alarms, If any are activated, immediately trip both main and pony motors; See Note 4. c) If alarms does not clear after one minute, terminate test; See Note 4.	
Low Operating Clearance in Sodium Brg.	a) If more than one probe set alarms, terminate test in controlled manner; See Note 4. b) If any probe alarm is coupled with a bearing temp. or motor power alarm, immediately cut main and pony motors; See Note 4.	a) If more than one probe set alarms, immediately secure transient feed system. b) Trip Main Motor. c) Continue to operate on pony motor and maintain vigil on brg. temp alarm and pony motor protection alarms.

NOTE 1 - A second level alarm will automatically trip main motor if condition worsens.
NOTE 2 - Includes pump operation at stable or slowly changing speed, flow and temp conditions; no operator action is required for a power alarm during pump startup and/or controlled speed changes.
NOTE 3 - Includes pump operation during transient application period and post transient thermal soak.
NOTE 4 - Perform rotor torque check. If torque is normal, idling operation on pony motor is permissible while waiting for special engineering instructions.

APPENDIX K

Initial Powered Operation of the Prototype Pump

The initial startup procedure as described below is to be used for initiation of powered pump operation after a complete or partial pump disassembly and reassembly. Sodium level shall be 125 inches above impeller centerline, and loop resistance R4 for initial powered operation.

1. Initial Powered Pump Operation on Pony Motor

Prior to initiation of Pony Motor jog, acceptable pump shaft rotational breakaway torque readings must be obtained and recorded. "JOG" the Pony Motor for one second. Observe operation and listen during coastdown. Turn the Selector Switch to "OFF" and examine the shaft coupling and seal-bearing connections. Check the Lube Oil Systems to ascertain that they are still operating normally.

Confirm that the pump and its auxiliary equipment are functioning correctly.

"JOG" the Pony Motor for five seconds, monitoring input voltage and current, indicated rpm, and pump coastdown time when the "JOG" is terminated. Record all values.

Examine the coupling, the seal-bearing connections, the oil circulation and lift systems, and visually inspect the seal housing and motor mount studs and nuts.

Check pump rotational torque and record the reading and proceed if the readings are acceptable. "JOG" the Pony Motor for 30 seconds.

Repeat the post-run checks.

"START" the Pony Motor and run for 5 minutes. During this run measure flow and measure head. Adjust flow until flow is 1225 ± 100 gpm. Measure and record head, temperature, level, voltage and current.

When the 5-minute run is completed, terminate the run and measure pump coastdown time.

Examine the coupling, the seal-bearing connections, the oil circulation and lift systems, and visually inspect the seal housing, and motor mount nuts and studs.

Check pump rotational torque and record the reading.

This completes the initial pony motor checkout of the pump.

2. Initial Powered Pump Operation on Main Motor

Check the Motor Support Stand and shaft coupling areas to be sure that no hoses, tools, wiring, or other material is near the shaft or cluttering the area. There must be no tools or parts of any kind (pencils, washers, etc.) lying about inside the motor support stand.

Check the Liquid Rheostat and Speed Control cubicle. Besides being fully operational, the electrodes should be checked to assure they are fully withdrawn (up), and the Speed Control should be set at minimum speed.

Start the Pony Motor. Observe operation of the pump at least 5 minutes. During this time period, shut off the oil lift systems (motor and pump) and check to be sure that pony operation is normal in all respects.

Verify that the pump and its auxiliary equipment are functioning correctly.

"JOG" the Main Drive Motor until it reaches a constant speed and has run at that speed for five seconds. During this 5-second run, monitor main motor input (stator) voltage, current, kW, and indicated rpm. When terminating the JOG, measure coastdown time to 200 rpm. Record all values.

Terminate the Pony Motor operation and measure coastdown time to zero speed (for comparison with previously obtained values).

Examine the coupling, the seal-bearing connections, the oil circulation system, and visually inspect seal housing and motor mount nuts and studs.

Start up the Oil Lift Systems and the Oil Circulation System.

Start the Pony Motor, shut down the Oil Lift Systems.

Check that the Liquid Rheostat and Speed Control System are set for minimum speed (manual mode).

Start the Main Drive Motor. When the pump reaches Minimum Control Speed, record data as follows:

> Pony Motor voltage; current, Main Motor input voltage, current, kW; Test Loop Head, Flow Temperature.

Every fifteen minutes, record Main Motor input voltage, current, and kW, and loop head, flow, and temperature.

After 45 minutes of operation, record vibration and bearing proximity probe data.

After running for 1 hour, terminate the test. Record coastdown to Pony Motor speed. Subsequently, turn the Pony Motor OFF and record the coast down.

Conduct a complete post test inspection of the data and the pump (as previously specified). Check pump rotational torque and record the readings.

APPENDIX L

Deleted

APPENDIX M

Instrumentation Requirements

This appendix summarizes the instrumentation requirements for the Pump Test in sodium. Tables M1 and M2, enclosed, define the applicable test instrumentation, identify the instrument/recorder matchup, and finally the recording requirements for each test which comprise the Test series. In addition to the above specific requirements, the following general guidelines apply:

1) The disc recorder scan rate for all tests will be 1 scan/sec.

2) All measurements in Table M2 recorded on the DAS (Data Acquisition System) will be inputted to both the digital tape and disc units with the exception of tank skin thermocouples. The tank skin T/C's need only be recorded on digital tape.

3) The FM recorders will be operated continuously during all operational changes in pump speed or flow.

4) A "typical data slice" is defined as 60 sec of FM recording and a Performance Calculated Summary (ISIP).

The numbers in parenthesis under the "Comment" column pertain to the following comments:

1) Sensor to be provided by ESG.
2) Signal conditioning equipment to be provided by ESG.
3) Signal conditioning equipment, excepting charge amplifiers, to be provided by ESG.

TABLE M1

INSTRUMENTATION RECORDING SUMMARY

Item	Instr.	Description	Recording System DAS	FM 3.75 IPS	FM 15 IPS	Man.	Alarm	Trip	Comment
101	PSH-70	Oil Lift Press. Switch					X		
102	SE-47	Tach. Gen. (rpm)	X						
103	TE-11	Upper Rad. Brg. Temp				X	X		
104	TE-12	Lower Rad. Brg. Temp				X	X		
105	TE-13	Pony Stator Temp				X	X		
106	TE-14A	Main Stator Temp				X	X		
107	TE-14B	Main Stator Temp				X	X		
108	TE-14C	Main Stator Temp				X	X		
109	TE-15	Thrust Brg. Temp				X	X		

TABLE M1

INSTRUMENTATION RECORDING SUMMARY

Item	Instr.	Description	Recording System DAS	FM 3.75 IPS	FM 15 IPS	Man.	Alarm	Trip	Comment
201	CE-22	Elec. Conductivity	X						
202	LI-23	Sump Tank Level	X						
203	LSL-29	Elec. Level Alarm					X		
204	TISH-24	Elec. Temp Alarm					X		(135°F)
205	TISH-24	Elec. Temp Alarm					X		(135°F)
206	TE-25	Elec. Temp	X						
207	TE-26	Elec. Temp Controller							
208	TE-27	HX Cooling In Temp				X			
209	TE-28	HX Cooling Out Temp				X			
210	TE-31	HX Elec. Out Temp							
211	TE-32	HX Elec. In Temp							
212	ZT-21	Electrode Position	X				X		
213	ZC-21	Control Signal Fault					X		

TABLE M1

INSTRUMENTATION RECORDING SUMMARY

Item	Instr.	Description	Recording System: DAS	Recording System: FM 3.75 IPS	Recording System: FM 15 IPS	Man.	Alarm	Trip	Comment
300	FI-10	HSG. Oil Flow							
301	FI-33	Purge Gas In				X			
302	FI-920	Purge Gas Out							
303	LSL-04	Supply Reserv. Level					X		
304	LIT-16	Supply Reserv. Level							
305	LSH-34	Lwr. Seal Leak Level					X		(High)
306	LSL-35	Lwr. Seal Leak Level					X		(Low)
307	LSH-36	Up Seal Leak Level					X		(High)
308	LIT-37	Lwr. Seal Leak Level							
309	LSHH-37	Lwr. Seal Leak Level					X		(High/High)
310	LSLL-37	Lwr. Seal Leak Level					X		(Low/Low)
311	PDSH-59	Circ. Pump Delta Press					X		(Low)
312	PI-60	Circ. Pump Press. In				X			
313	PI-63	Fill Reserv. Press.				X			
314	PI-03	Supply Resv. Press.				X			
315	PDSH-05	Filter Delta Press.					X		(High)
316	PD-17	HSG. Delta Press.				X	X		(Low)
317	PI-40	Oil Lift Pressure				X			
318	PS-41	Oil Lift Press. Switch							
319	PDSH-42	Lift Filter Press. Delta					X		(High)
320	PI-45	HSG. Inlet Pressure				X			
321	PI-48	Low Seal Out Press.				X			
322	PI-51	T. Brg. Out Press.				X			
323	PI-54	Up Seal Out Press.							
324	PDSL-57	HSG. Delta Press.					X		(Low)

1. ⌞E M1

INSTRUMENTATION RECORDING SUMMARY

Item	Instr.	Description	Recording System DAS	FM 3.75 IPS	FM 15 IPS	Man.	Alarm	Trip	Comment
325	PI-58	Circ. Pump Out Press.				X			
326	TE-18	Hsg. In Temp.	X				X		(High)
327	TE-19A	Low Seal Out Temp.	X				X		(High)
328	TE-19B	T Brg. Out Temp	X				X		(High)
329	TE-19C	Up Seal Out Temp	X				X		(High)
330	TI-46	Hsg. In Temp				X			
331	TSH-47	Hsg. In Temp Alarm					X		(High)
332	TI-49	Low Seal Out Temp				X			
333	TE-49	Low Seal Out Temp							
334	TSH-50	Low Seal Out Temp Alarm					X		(High)
335	TI-52	T Brg. Out Temp				X			
336	TSH-53	T Brg. Out Temp Alarm					X		(High)
337	TE-55	Up Seal Out Temp				X			
338	TSH-56	Up Seal Out Temp Alarm					X		(High)
339	ZS-39	Low Leak Relief Alarm					X		
340	ZS-43	Oil Lift Relief Alarm					X		
341	ZS-61	No. 1 Circ Pump Relief					X		
342	ZS-62	No. 2 Circ Pump Relief					X		
343	ZS-63	Hsg. Relief Alarm					X		
344	E-595	Backup Circ Pump Run					X		
345	E-597	Backup Fan Run					X		

TABLE M1

INSTRUMENTATION RECORDING SUMMARY

Item	Instr.	Description	Recording System				Alarm	Trip	Comment
			DAS	FM 3.75 IPS	FM 15 IPS	Man.			
401	EE-71	Pony Motor Voltage				X			
402	IE-72	Pony Motor Current	X						
403	EE-73A	Main Motor Voltage				X			
404	EE-73B	Main Motor Voltage				X			
405	EE-73C	Main Motor Voltage				X			
406	IE-74A	Main Motor Current	X						
407	IE-74B	Main Motor Current	X						
408	IE-74C	Main Motor Current	X						
409	JE-75B	Main Motor Power	X				X	X	See App. J for Trip Setpoint
410	FE-104D	PM Flowmeter (Low)	X						
411	FT-101AM	Venturi Flow (Low) gpm	X						Reduced from It. 422
412	FT-101BM	Venturi Flow (High) gpm	X						
413	NE-23	Airborne Noise			X				
414	PDT-26	Pump Delta Press.	X						
415	PT-105	Discharge Pressure	X	X			X	X	
416	PT-111	Suction Pressure	X	X					
417	PT-113	Cover Gas Pressure	X				X		
418	PT-115	Cover Gas Pressure	X						
419	TE-119	Discharge Temp	X					X	
420	TE-120	Suction Temp	X				X		
421	--	Pump Deck Temp				X			
422	FT-101A	Venturi Flow (Low) (in H_2O)	X						

TABLE M1

INSTRUMENTATION RECORDING SUMMARY

Item	Instr.	Description	Recording System DAS	FM 3.75 IPS	FM 15 IPS	Man.	Alarm	Trip	Comment
501	LT-40	Tank Level - Induc.	X				X	X	See Appendix F for Setpoint
502	LT-42	Tank Level - Delta P	X				X	X	" " " " "
503	TE-02A	Top Brg. Temp - W	X				X	X (1)	See Appendix J for
504	TE-02B	Top Brg. Temp - E	X				X	X (1)	Alarm and Trip Setpoints
505	TE-02C	Top Brg. Temp - N	X				X	X (1)	" " " "
506	TE-02D	Top Brg. Temp - S	X				X	X (1)	" " " "
507	TE-0-1	Bot. Brg. Temp - N	X				X	X (1)	" " " "
508	TE-0-2	Bot. Brg. Temp - S	X				X	X (1)	" " " "
509	TE-0-3	Bot. Brg. Temp - E	X				X	X (1)	" " " "
510	TE-0-4	Bot. Brg. Temp - W	X				X	X (1)	" " " "
511	TE-0-5	Brg. Feed Temp In - E	X					X (1)	" " " "
512	TE-0-6	Brg. Feed Temp In - W	X					X (1)	" " " "
513	TE-0-7	Brg. Top Out Temp - W	X					(1)	
514	TE-0-8	Brg. Top Out Temp - E	X					(1)	
515	TE-0-9	Vortex Chamb. Temp - W15R	X					(1)	
516	TE-0-10	Vortex Chamb. Temp - W27R	X					(1)	
517	TE-0-11	Brg. Return Temp - 120ccW	X					(1)	
518	TE-0-12	Brg Return Temp Up -300ccW	X					(1)	
519	TE-0-13	Brg Return Temp Up -30ccW	X					(1)	
520	TE-0-14	Brg Return Temp Up -210ccW	X					(1)	
521	TE-0-15	Mid-Tank Na Temp - N	X					(1)	
522	TE-0-16	Mid-Tank Na Temp - S	X					(1)	
523	TE-0-17	Mid-Tank Na Temp - E	X					(1)	
524	TE-0-18	Mid-Tank Na Temp - W	X					(1)	
525	TE-0-19	Brg. Bot. Out Temp -E10.5R	X					(1)	

TABLE M1

INSTRUMENTATION RECORDING SUMMARY

Item	Instr.	Description	Recording System						
			DAS	FM 3.75 IPS	FM 15 IPS	Man.	Alarm	Trip	Comment
526	TE-0-20	Brg. Bot Out Temp -W10.5K	X					(1)	
527	TE-0-21	Brg. Bot Out Temp -E7.8R	X					(1)	
528	TE-0-22	Brg. Bot Out Temp -W7.8K	X					(1)	
529	TE-0-23	Brg. Feed Out Temp - N	X					(1)	
530	TE-0-24	Brg. Feed Out Temp - S	X					(1)	
531	TE-0-25	Brg. Feed Out Temp - E	X					(1)	
532	TE-0-26	Brg. Feed Out Temp - W	X					(1)	
533	TE-0-27	Up Impl. Leak Temp -W15R	X					(1)	
534	TE-0-28	Up Impl. Leak Temp -W21R	X					(1)	
535	TE-0-29	Brg. Return - Low - N	X					(1)	
536	TE-0-30	Brg. Return - Low - S	X					(1)	
537	TE-0-31	Brg. Return - Low - E	X					(1)	
538	TE-0-32	Brg. Return - Low - W	X					(1)	
539	TE-0-33	Brg. Feed Up Mix - 338ccW	X					(1)	
540	TE-0-34	Brg. Feed Up Mix - 158ccW	X					(1)	
541	TE-035	Brg. Feed Mid Mix - 38ccW	X					(1)	
542	TE-0-36	Brg. Feed Bot Mix - N	X						
545	TE039	T. Brg. Oil Temp - Top E							Record locally
546	TE-0-40	T. Brg. Oil Temp - Bot E							if req'd for
547	TE-0-41	T. Brg. Oil Temp - Top W							special testing
548	TE-0-42	T. Brg. Oil Temp - Bot W							
549	TE-14-1	Tank Skin El. 14 - N	X						
550	TE-26-1	Tank Skin El. 26 - N	X						

TABLE M1

INSTRUMENTATION RECORDING SUMMARY

Item	Instr.	Description	Recording System DAS	FM 3.75 IPS	FM 15 IPS	Man.	Alarm	Trip	Comment
551	TE-44-1	Tank Skin - El. 44 - N	X						Used for L-Delta-T
552	TE-62-1	Tank Skin - El. 62 - N	X						Calculation in
553	TE-72-1	Tank Skin - El. 74 - N	X						Unheated Region
554	TE-14-2	Tank Skin - El. 14 - NE	X						Recorded on Tape Only
555	TE-26-2	Tank Skin - El. 26 - NE	X						When Calculations are
556	TE-44-2	Tank Skin - El. 44 - NE	X						Required
557	TE-62-2	Tank Skin - El. 62 - NE	X						
558	TE-72-2	Tank Skin - El. 74 - NE	X						
559	TE-14-3	Tank Skin - El. 14 - E	X						
560	TE-26-3	Tank Skin - El. 26 - E	X						
561	TE-44-3	Tank Skin - El. 44 - E	X						
562	TE-62-3	Tank Skin - El. 62 - E	X						
563	TE-72-3	Tank Skin - El. 74 - E	X						
564	TE-14-4	Tank Skin - El. 14 - SE	X						
565	TE-26-4	Tank Skin - El. 26 - SE	X						
566	TE-44-4	Tank Skin - El. 44 - SE	X						
567	TE-62-4	Tank Skin - El. 62 - SE	X						
568	TE-72-4	Tank Skin - El. 74 - SE	X						
569	TE-14-5	Tank Skin - El. 14 - S	X						
570	TE-26-5	Tank Skin - El. 26 - S	X						
571	TE-44-5	Tank Skin - El. 44 - S	X						
572	TE-62-5	Tank Skin - El. 62 - S	X						
573	TE-72-5	Tank Skin - El. 74 - S	X						
574	TE-14-6	Tank Skin - El. 14 - SW	X						
575	TE-26-6	Tank Skin - El. 26 - SW	X						

TABLE M1

INSTRUMENTATION RECORDING SUMMARY

Item	Instr.	Description	Recording System DAS	FM 3.75 IPS	FM 15 IPS	Man.	Alarm	Trip	Comment
576	TE-44-6	Tank Skin - El. 44 - SW	X						Used for L-Delta-T
577	TE-62-6	Tank Skin - El. 62 - SW	X						Calculation in
578	TE-72-6	Tank Skin - El. 74 - SW	X						Unheated Region
579	TE-14-7	Tank Skin - El. 14 - W	X						Recorded on Tape Only
580	TE-26-7	Tank Skin - El. 26 - W	X						When Calculations are
581	TE-44-7	Tank Skin - El. 44 - W	X						Required
582	TE-62-7	Tank Skin - El. 62 - W	X						
583	TE-72-7	Tank Skin - El. 74 - W	X						
584	TE-14-8	Tank Skin - El. 14 - NW	X						
585	TE-26-8	Tank Skin - El. 26 - NW	X						
586	TE-44-8	Tank Skin - EL. 44 - NW	X						
587	TE-62-8	Tank Skin - El. 62 - NW	X						
588	TE-72-8	Tank Skin - El. 74 - NW	X						
589	TE-901-71	Tank Skin ZN. 5 - N	X						
590	TE-954A	Tank Skin ZN. 4 - N	X						
591	TE-901-65	Tank Skin ZN. 3 - N	X						
592	TE-952A	Tank Skin ZN. 2 - N	X						
593	TE-955A	Tank Skin ZN. 5 - S	X						
594	TE-901-66	Tank Skin ZN. 4 - S	X						
595	TE-593A	Tank Skin ZN. 3 - S	X						
596	TE-901-62	Tank Skin ZN. 2 - S	X						
597	TE-1-5-3	Tank Skin ZN. 5 - E	X						
598	TE-1-4-3	Tank Skin ZN. 4 - E	X						
599	TE-1-3-3	Tank Skin ZN. 3 - E	X						
600	TE-1-2-3	Tank Skin ZN. 2 - E	X						

TABLE M1

INSTRUMENTATION RECORDING SUMMARY

Item	Instr.	Description	Recording System DAS	FM 3.75 IPS	FM 15 IPS	Man.	Alarm	Trip	Comment
601	TE-1-5-7	Tank Skin ZN. 5 - W	X						
602	TE-1-4-7	Tank Skin ZN. 4 - W	X						
603	TE-1-3-7	Tank Skin ZN. 3 - W	X						
604	TE-1-2-7	Tank Skin ZN. 2 - W	X						
609	ZE-82AB	T Brg. Probe - In line suc.	X	X			X		(1) (2)
610	ZE-83AB	T Brg. Probe - 90 Deg Suc	X	X			X		(1) (2)
611									
612									
613	ZE-86A	M Brg. Probe - 90 Deg Suc	X		X		X		(1) (2)
614	ZE-87A	M Brg. Probe - Inline Suc	X		X		X		(1) (2)
615	ZE-86B	B Brg. Probe - 270 Deg Suc	X	X			X		(1) (2)
616	ZE-87B	B Brg. Probe - 180 Deg Suc	X	X			X		(1) (2)
617	VE-06Z	Motor Vib - Inline Suc			X				30 Mil P-P Trip Setpoint
618	VE-06X	Motor Vib - 90 Deg Suc			X				30 Mil P-P Trip Setpoint
619	VE-06Y	Motor Vib - Vertical			X				30 Mil P-P Trip Setpoint
620	VE-07Z	Tank Vib - Inline Suc			X				
621	VE-07X	Tank Vib - 90 Deg Suc			X				
622	VE-07Y	Tank Vib - Vertical			X				
623	VE-08Z	Oil Brg. Vib. Inline Suc			X			X	
624	VE-08X	Oil Brg. Vib - 90 Deg Suc			X			X	
625	VE-08Y	Oil Brg. Vib - Vertical			X			X	

TABLE M1

INSTRUMENTATION RECORDING SUMMARY

Item	Instr.	Description	Recording System DAS	FM 3.75 IPS	FM 15 IPS	Man.	Alarm	Trip	Comment
628	VE-09B	NA Brg Vib - 195 Deg Cow Radial			X				(1) (3)
629	VE-09A	NA Brg Vib - 195 Deg Cow Axial			X				(1) (2)
635	NE-24	ANL Hydrophone							Special High Tape Speed
636	PI-114	Shot Cavity Vacuum				X			Recording Required
637	SE-20	Shaft Revolution Counter	X	X					

TABLE M2

DATA COLLECTION REQUIREMENTS

PARA.		DESCRIPTION	DIGITAL TAPE SCAN RATE	STANDARD DATA SLICE (NOTE 1) FREQUENCY	OTHER
1.	7.5.1	Assembly	-	-	As Specified in Test Descr. Text
2.	7.5.2	Aux. System C/O	-	-	As Specified in Test Descr. Text
3.	7.5.3	Preheat & Sodium Fill	12 Scans/hr	-	As Specified in Test Descr. Text
4.	7.5.4 (a)	Pony Jogs	1 Per Sec	-	L-Delta-T at Test Start
5.	7.5.4 (b)	Pony Run In	2 Per Min	2 Per Hour	
6.	7.5.4 (c)	Main Motor Jogs	1 Per Sec	-	
7.	7.5.4 (c)	Main Motor Run In	2 Per Min	2 Per Hour	
8.	7.5.4 (e)	Heatup to 500°F	2 Per Min	2 Per Hour	L-Delta-T Once Per Hour
9.	7.5.4 (f)	Probe Calibration	-	-	Calibration Record
10.	7.5.4 (g)	Heatup to 600°F	2 Per Min	2 Per Hour	L-Delta-T Once Per Hour
11.	7.5.4 (h)	Probe Calibration	-	-	Calibration Record
12.	7.5.4 (i)	Heatup to 680°F	2 Per Min	2 Per Hour	L-Delta-T Once Per Hour
13.	7.5.4 (j)	Probe Calibration	-	-	Calibration Record
14.	7.5.4 (k)	Wetting	2 Per Min	2 Per Hour	L-Delta-T at 4-Hour Intervals
15.	7.5.4 (l)	Probe Calibration	-	-	Calibration Record
16.	7.5.4 (m)	Cooldown to 600°F	2 Per Min	1 Per Hour	L-Delta-T at 4-Hour Intervals
17.	7.5.4 (n)	Probe & Level Calibration	-	-	Calibration Record
18.	7.5.5.1	Pony Flow Scan	12 Per Min	Note 3	

NOTE 1 - Standard Data Slice consists of 60 second of FM Recorders and Performance Calculation Summary (ISIP).

NOTE 2 - Once near end of each speed plateau stabilization point.

NOTE 3 - At each flow setpoint.

TABLE M2

DATA COLLECTION REQUIREMENTS

PARA.		DESCRIPTION	DIGITAL TAPE SCAN RATE	STANDARD DATA SLICE (NOTE 1) FREQUENCY	OTHER
19.	7.5.5.2 (a)	Speed Scans	12 Scans/Min	Note 2	--
20.	7.5.5.2 (b)	600^{o}F 8-hr Endurance	2 Scans/Min	2 per hour	L-Delta-T at Test Start & Finish
21.	7.5.5.3	Main Flow Scan	12 Scans/min	Note 3	
22.	7.5.6.1 (a)	Temp Up to 700^{o}F	2 Scans/Min	2 Per Hour	L-Delta-T Once Per Hour
23.	7.5.6.1 (b)	Probe Calibration	-	-	Calibration Record
24.	7.5.6.2 (a)	Temp Up to 750^{o}F	2 Scans/Min	2 Per Hour	L-Delta-T Once Per Hour
25.	7.5.6.2 (b)	Probe & Level Cal.	-	-	Calibration Record
26.	7.5.6.2 (c)	750^{o}F R4 Speed Scan	12 Scans/Min	Note 2	--
27.	7.5.6.2 (d)	750^{o}F 8-hr Endurance	2 Scans/Min	2 Per Hour	L-Delta-T at Test Start & Finish
28.	7.5.6.3 (a)	Temp Up to 800^{o}F	2 Scans/Min	2 Per Hour	L-Delta-T Once Per Hour
29.	7.5.6.3 (b)	Probe Calibration	-	-	Calibration Record
30.	7.5.6.4 (a)	Temp Up to 850^{o}F	2 Scans/Min	2 Per Hour	L-Delta-T Once Per Hour
31.	7.5.6.4 (b)	Probe, Level, Cal.	-	-	Calibration Record
32.	7.5.6.4 (c)	850^{o}F R4 Speed Scan	12 Scans/Min	Note 2	
33.	7.5.6.5	Temp Up to 900^{o}F	2 Scans/Min	1 Per Hour	L-Delta-T Once Per Hour

NOTE 1 - Standard data slice consists of 60 seconds of FM records and performance calculation summary (ISIP).

NOTE 2 - Once near end of each speed plateau stabilization point.

NOTE 3 - At each flow setpoint.

TABLE M2

DATA COLLECTION REQUIREMENTS

PARA.		DESCRIPTION	DIGITAL TAPE SCAN RATE	STANDARD DATA SLICE (NOTE 1) FREQUENCY	OTHER
34.	7.5.7.1 (a)	Temp Up to 950°F	2 Scans/Min	2 Per Hour	L-Delta-T Once Per Hour
35.	7.5.7.1 (b)	Probe, Level, Cal.	-	-	Calibration Record
36.	7.5.7.1 (c)	950°F R4 Speed Scan	12 Scans/Min	Note 2	
37.	7.5.7.1 (d)	950°F R5 Speed Scan	12 Scans/Min	Note 2	--
38.	7.5.7.1 (e)	950°F R3.3 Speed Scan	12 Scans/Min	Note 2	--
39.	7.5.7.1 (f)	950°F 8-hr Endarance	2 Scans/Min	2 Per Hour	L-Delta-T at Test Start & Finish
40.	7.5.8 (a)	Temp Up to 1000°F	2 Scans/Min	2 Per Hour	L-Delta-T Once Per Hour
41.	7.5.8 (b)	Probe Calibration	-	-	Calibration Record
42.	7.5.8 (c)	Temp Up to 1050°F	2 Scans/Min	2 Per Hour	L-Delta-T Once Per Hour
43.	7.5.8 (d)	Probe, Level, Cal.	-	-	Calibration Record
44.	7.5.9.1	1050°F R4 Speed Scan	12 Scans/Min	Note 2	--
45.	7.5.9.1	1050°F R5 Speed Scan	12 Scans/Min	Note 2	--
46.	7.5.9.1	1050°F R3.3 Speed Scan	12 Scans/Min	Note 2	--
47.	7.5.9.1	1050°F 8-hr Endurance	2 Scans/Min	2 Per Hour	L-Delta-T at Test Start & Finish
48.	7.5.10	Cavitation Tests	-	-	As Specified in Test Description
49.	7.5.11	Post Cavitation C/O	1 Scan/Min	1 Per Hour	L-Delta-T at Test Start & Finish
50.	7.7.3	Preheat and Refill	Same as 7.5.3		
51.	7.7.4	Restart and Rewet	Same as 7.5.4		
52.	7.7.5.1	Main Motor Speed Scans	Same as 7.5.5.2		
53.	7.7.5.2	Main Motor Flow Scan	Same as 7.5.5.3		
54.	7.7.6.1	800°F Recheck	Same as 7.5.6.2 (a), (b) and (c)		

NOTE 1 - Standard data slice consists of 60 seconds of FM recorders and performance calculation summary (ISIP).

NOTE 2 - Once near end of each speed plateau stabilization point.

TABLE M2

DATA COLLECTION REQUIREMENTS

PARA.		DESCRIPTION	DIGITAL TAPE SCAN RATE	STANDARD DATA SLICE (NOTE 1) FREQUENCY	OTHER
55.	7.7.6.2	900°F Recheck	Same as 7.5.6.4 (a), (b) and (c)		
56.	7.5.6.3	1050°F Speed Scans Repeat	Same as 7.5.8 (c) and (d), and 7.5.9.1		
57.	7.7.1	2000-Hr Endurance	1 Scan/Min	1 Per Hour	L-Delta-T at 8-Hr Intervals
58.	7.7.2	Pre Trans. Stability	2 Scans/Min	Once	L-Delta-T Computation
59.	7.7.2	Trans. Applic.	1 Scan/Sec	-	FM Recorders Continuous
60.	7.7.2	Soak	1 Scan/Sec	12 Per Hour	FM Recorders Continuous
61.	7.7.2	Upramp	12 Scans/Min	Note 2	--
62.	7.7.2	Post Trans Endurance	2 Scans/Min	1 Per Hour	--

NOTE 1 - Standard data slice consists of 60 seconds of FM recorders and performance calculation summary (ISIP).

NOTE 2 - Once near end of each speed plateau stabilization point.