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Rockwell International
Atomics International Division

REQUEST FOR TEST

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Sodium Testing of Intermediate-Size Inducer Pump in SPTF at ETEC		N266RFT000001	B SEE SUMMARY OF CHG
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<p>The applicability of inducers to large, high-temperature sodium pumps for reactor service needs to be demonstrated.</p> <p><i>DOE/SF/76026--T64</i></p> <p><i>A T03 - 76SF76026</i></p>				

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REV	SUMMARY OF CHANGE	APPROVALS AND DATE
A	<p>Incorporated comments in accordance with the following:</p> <p>(1) DOE Letter RRT:EC:330 dated August 10, 1978, J. J. Morabito to J. B. LaGrone, "AI Intermediate Inducer Test Request; RRT Comments"</p> <p>(2) ETEC Letter 78ETEC-DRF-2543 dated September 18, 1978, R. E. Fenton to R. V. Anderson, "ETEC Comments to ISIP Test Request"</p> <p>(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"</p> <p>Changes indicated by black line on right border</p>	<p><i>L. Stabinsky</i> 12/18/78 <i>J. O. Pfloutz</i> 12/18/78 <i>L.S.</i></p> <p><i>R.E. Schumacher</i> 12/18/78 <i>T.J. Boardman</i> 12/18/78 <i>fva R.L.</i> 12/18/78</p> <p>Rel. Date: 12-19-78 BK</p>
B	<p>Incorporated comments in accordance with the following:</p> <p>(1) ESG, Rockwell International IL TJB:006 dated March 1, 1979, T. J. Boardman to R. V. Anderson, "ISIP, RFT N266RFT000001, Rev. A"</p> <p>(2) ESG, Rockwell International IL, TJB:008, dated March 5, 1979, T. J. Boardman to R. V. Anderson, "ISIP-RFT, Thermal Transients"</p> <p>Changes are indicated by black lines on right border</p>	<p><i>R.E. Schumacher</i> 3-15-79 <i>T.J. Boardman</i> 3/21/79</p> <p><i>R.V. Anderson</i> 3-22-79</p> <p><i>R.E. Schumacher</i> 3/26/79 <i>T.J. Boardman</i> 3/26/79 <i>E. Anderson</i> 3/26/79</p> <p>Rel. Date: 3-26-79 BK</p>



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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 (Deleted)



5.0 TEST METHODS

Sodium tests of the ISIP will be 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.

The next series of tests 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 selected thermal transients run for Phase B testing of the FFTF Prototype Pump are planned to be repeated.

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	400-950	°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	3°F/sec
	Max Δt	330°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 many of the test conditions specified for Phase B testing of the prototype pump in Westinghouse Test Request WDTRS 25.14, Revision 18.

The test sequence is as follows:

- 1) Pump Assembly and Installation
- 2) Auxiliary Systems Check
- 3) Preheat to 400⁰F and Sodium Fill at 400⁰F
- 4) Initial Startup at 400⁰F and Operation During Wetting to 680⁰F
- 5) Pony Motor Flow Scan at 600⁰F
- 6) Main Motor Speed Scans at 600⁰F
- 7) 500 rpm Flow Scan at 600⁰F
- 8) 700⁰F Checkout
- 9) 750⁰F Checkout and Speed Scan and Endurance Test
- 10) 800⁰F Checkout
- 11) 850⁰F Checkout
- 12) 900⁰F Checkout
- 13) 950⁰F Checkout and Speed Scan and Endurance Test
- 14) Deleted
- 15) Deleted
- 16) Deleted
- 17) Cavitation Performance at 950⁰F



- 18) Post Cavitation Checkout at 950⁰F
- 19) Deleted
- 20) Deleted
- 21) Deleted
- 22) Deleted
- 23) Deleted
- 24) Deleted
- 25) Deleted
- 26) Deleted
- 27) Deleted
- 28) 2000 Hour Design Point Endurance Test at 950⁰F with 200% NPSH Margin
- 29) 300 Hour Off-Design Endurance Test at 950⁰F 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. In addition to specific test data, the facility shall maintain historical data recording operating conditions to which the pump has been exposed permitting maintaining the following tabulation form up to date:



OPERATING CONDITION HISTORY
(Hours)

Speed (rpm)	Temp. (°F)	376- 575	576- 775	776- 975
0				
Pony Motor				
401-500				
501-800				
801-1000				
Above 1000				

7.5.1 Initial Pump Assembly & Installation

Note: Test Requester Hold Point

Purpose - to assemble the pump in preparation for testing.

Test Description - 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.

Data Collection and Use - 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 Auxiliary System Check

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

Test Description - 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.

Data Collection and Use - 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.

Expected Results and Completion Criteria - 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 400⁰F, to fill the pump, and to wet the surfaces of the redesigned pump components and proximity probes at 680⁰F.



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 10⁰F/hr for a dry pump and 20⁰F/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 + 25⁰F) at a maximum rate of 10⁰F/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 $\pm 40^0\text{F}$. 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 400⁰F.

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 400⁰F. 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 plots 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 $400^{\circ}\text{F} \pm 25^{\circ}\text{F}$. 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. ($T=400^{\circ}\text{F}$)
- 3) 30-Minute Pony Motor Run. ($T=400^{\circ}\text{F}$)



- 4) Main Motor Startup Per Appendix K. (T=400°F)
- 5) Instrument and Data System Verification. Note: This is a hold point. Do not proceed with the test until the operational verification of the instrument and data system is complete for main motor operation.
- 6) Increase temperature to 500°F at 20°F/hr maximum rate and 600 rpm maximum speed. Stabilize at 500°F for 30 minutes.
- 7) Perform Bearing Probe System Calibration.
- 8) Increase temperature to 600°F at 20°F/hr maximum rate and 600 rpm maximum speed. Stabilize at 600°F for 30 minutes.
- 9) Perform Bearing Probe System Calibration.
- 10) Increase temperature to 680/700°F at 20°F/hr maximum rate and 600 rpm maximum speed. Stabilize for 30 minutes.
- 11) Perform Bearing Probe System Calibration.
- 12) Hold 680/700°F temperature for 8 hours; 600 rpm maximum speed.
- 13) Cool Pump to 600°F at 400 to 600 rpm at -20°F/hr maximum rate.
- 14) Perform Bearing Probe and Fluid Level Instrument Calibration at 600°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°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.



- a) Data Collection - As specified in Table M2.
- b) Special Post-Test Data Reduction - Prepare plots of head vs flow plus plots of bearing orbit diameter, offset azimuth, offset radius and minimum film thickness vs flow for each proximity probe set.

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 the specified test speeds; plots of bearing orbit diameter, orbit offset azimuth, orbit offset radius and minimum film thickness, for each bearing probe set, vs speed, for each loop resistance.

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 700⁰F at 20⁰F/hr maximum rate and 750 rpm maximum speed. Stabilize at 700⁰F for 1/2 hour.
- 2) Perform bearing probe system calibration. (T = 700⁰F)

7.5.6.2

- 1) Increase temperature to 750⁰F at 20⁰F/hr maximum rate and 750 rpm maximum speed. Stabilize at 750⁰F for 1/2 hour.
- 2) Perform bearing probe system calibration. (T = 750⁰F)
- 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 800⁰F Checkout

Note: Test Requestor Hold Point

- 1) Increase temperature to 800⁰F at 20⁰F/hr maximum rate and 750 rpm maximum speed. Stabilize at 800⁰F for 1/2 hour.
- 2) Perform bearing probe system calibration. (T = 800⁰F)

7.5.6.4 850⁰F Checkout

- 1) Increase temperature to 850⁰F at 20⁰F/hr maximum rate and 750 rpm maximum speed. Stabilize at 850⁰F 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 the specified test speeds. Prepare plots of bearing orbit diameter, orbit offset azimuth, offset radius and minimum film thickness vs speed, for each probe set, for 800 and 850°F.

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. 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 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 the specified test speeds. Prepare plots of bearing orbit diameter, orbit offset azimuth, orbit offset radius and minimum film thickness vs speed, for each probe set, for each loop resistance.

7.5.8 Deleted

7.5.9 Deleted

7.5.10 Deleted

7.5.10.1 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 950°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 $\frac{+3}{-0}$ 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:

- 1) Establish stable steady-state operation at defined initial temperature, speed, and flow conditions.
- 2) Adjust cover gas pressure to obtain at least 60 ft NPSH as indicated by computer calculated parameter summary.
- 3) Operate for at least 1 hour at 60 ft NPSHA conditions to establish baseline parameters. Take a typical data slice once every fifteen minutes. Typical data is as follows:
 - a. Computer calculated performance summary
 - b. 60 sec FM recorder slice at 15 IPS (ANL hydrophone should be recorded at 60 IPS)
 - c. Digital tape slice at 1 sec scan rate

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.
- 4) Reduce cover gas pressure in approximate 2 psi increments (5.56 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.



- 5) 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 3) is indicated by the computer calculated parameter summary. Stabilize for 10 minutes and take a typical data slice at each pressure plateau.
- 6) As an alternative to Step 5 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.
- 7) 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 3 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.
- 8) As an alternative to Step 7 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.



- 9) 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.
- 10) 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. Prepare plots of bearing orbit diameter, orbit offset azimuth, orbit offset radius and minimum film thickness vs NPSH, for each probe set, for each flow rate.

7.5.11 Post Cavitation Checkout (Deleted)



7.6 ENDURANCE TESTS

7.6.1 2000 Hour Design Point Endurance Test at 950⁰F 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 950⁰F, 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 7.5.10.1 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	+10F	-10F
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.

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, pump power, sodium bearing temperature difference (average outlet structural temperatures minus average inlet sodium temperature to the bearing), bearing orbit diameter and minimum film thickness 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.



7.6.2 300 Hour Off-Design Endurance Test at 950°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, 950°F, 200% NPSH margin), the pump speed will be reduced to 894 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% margin at design conditions in Paragraph 7.6.1.

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

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. (-0.0/+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	$\pm 10^{\circ}\text{F}$
Speed	$\pm 5 \text{ rpm}$
Flow	$\pm 200 \text{ gpm}$
Sodium Level	$\pm 2 \text{ in.}$ (excepting $+3.0/-0.0$ at 48 in.)
Cover Gas Pressure	$\pm 0.5 \text{ psi.}$

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, sodium bearing temperature difference (average outlet structural temperature difference minus average inlet sodium temperature to the bearing), and bearing orbit diameter and minimum film thickness 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 THERMAL TRANSIENT TESTS

7.7.1 Low Temperature Transients

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

The pump shall be exposed to Events 202 and 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.

7.7.2. Mid-Range Thermal Transient

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

The pump shall be exposed to Event 204 described in Table V. The transient event will consist of the events described in Paragraph 7.7.1.

7.7.3 High Temperature Thermal Transients

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

Test Description - Performed thermal transient events 207, 208, and 210 described in Table V. Basic test elements and data collection will be identical to Paragraph 7.7.1 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 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 all functioning instrumentation.

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 ESG; 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 by the test performer.



8.5 FINAL REPORT

The ETEC final report should include descriptions of:

- 1) Test Facility
- 2) Instrumentation
- 3) Test Article Installation
- 4) Testing
- 5) Test Article Removal and Cleaning
- 6) 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 final reports.
- 7) Responsible test requester personnel are:

	<u>Designee</u>	<u>Alternate</u>
Program Office	R.V.Anderson	R.E.Schnurstein
Project Engineering	T.J.Boardman	G.J.Hallinan
Site Representative	H.Strahl	J.Armstrong



12.0 REFERENCES

1. Westinghouse Document WDTRS 25.14, "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.

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TABLE I

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TABLE II
PUMP INSTRUMENTATION

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



TABLE II
PUMP INSTRUMENTATION
(Continued)

Number	Description	Readout Location	Range	Accuracy
TI 46	Seal/Bearing Housing	Oil Circ Skid	0-200°F	± 2%
TSH 47	Inlet Oil Temperature			
TI 49	Lower Seal Outlet Oil	Oil Circ Skid	0-200°F	± 2%
TE 49	Temperature			
TSH 50				
TI 52	Thrust Bearing Oil	Oil Circ Skid	0-200°F	± 2%
TSH 53	Outlet Temperature			
TE 55	Upper Seal Oil	Oil Circ Skid	0-200°F	± 2%
TSH 56	Outlet Temperature			
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	Lower Seal Leakage	C283	0-100%	± 4%
LSLL37	Reservoir Oil Level			
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 ₂ O	± 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	\pm 2%
EE 73ABC	Main Motor Voltage(3-Phase)	"	0-4160 volts	\pm 2%
IE 74ABC	Main Motor Current(3-Phase)	"	0-328 amps	\pm 2%
JE 75B	Main Motor Power	"	0-2000 kW	\pm 2%
SE 47	Speed	C201A	0-1200 rpm	\pm 2%
FI 10	Seal/Bearing Housing Oil Flow	Oil Circ Skid	0-30 gpm	\pm 2%
FI 33	Purge Gas In	Control Console	0-0.5 cfm	\pm 10%
FT 101A	Sodium Flow - Venturi - Low Range	Control Console	0-4000 gpm	\pm 7.5%
FT 101B	Sodium Flow - Venturi - High Range	Control Console	0-20000 gpm	\pm 7.5%
FE 104	Sodium Flow	Operator's Console	0-20000 gpm	\pm 7.5%
FI 920	Purge Gas Out	Local	0-0.5 cfm	\pm 10%
CE 22	Electrolyte Conductivity	C201A	0-5%	\pm 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 ⁰ F	Review of 600 ⁰ F test data and pump operation	Test Requester Site Rep.
8. 7.5.6.3	Do not initiate powered operation at 800 ⁰ F	Review of lower temp test data	Test Requester Site Rep.
9. 7.5.7.1	Do not initiate 950 ⁰ F baseline tests	Review heatup performance data	Test Requester Site Rep.
10. Deleted			
11. Deleted			
12. Deleted			

TABLE III (CONTINUED)
SUMMARY OF TEST REQUESTER HOLD POINTS

Paragraph No.	Hold	Action Needed to Remove Hold Point	Approval Needed
13. Deleted			
14. Deleted			
15. Deleted			
16. Deleted			
17. Deleted			
18. 7.6.1	Do not initiate 2000-hr endurance test without prior test requester approval	Confirmation by AI that 950 ⁰ F speed scan data has been reviewed, that NPSH test data is complete, and that no unacceptable anomalies have been left unresolved	Test Requester Site Rep.
19. 7.6.2	Do not initiate 300-hr off-design endurance test without prior test requester approval	Confirmation of 2000-hr endurance test data	Test Requester Site Rep.
20. 7.7.1	Do not initiate Thermal Transient Test No. 202	Review of data from the completed testing	Test Requester Site Rep.
21. 7.7.1	Do not initiate Thermal Transient Test No. 203	Review of data from Transient No. 202	Test Requester Site Rep.
22. 7.7.2	Do not initiate Thermal Transient Test No. 204	Review of data from the completed testing	Test Requester Site Rep.
23. Deleted			
24. Deleted			
25. 7.7.3	Do not initiate Thermal Transient Test No. 207	Review of data from Transient No. 204	Test Requester Site Rep.
26. 7.7.3	Do not initiate Thermal Transient Test No. 208	Review of data from Transient No. 207	Test Requester Site Rep.

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TABLE III (CONTINUED)
SUMMARY OF TEST REQUESTER HOLD POINTS

Paragraph No.	Hold	Action Needed to Remove Hold Point	Approval Needed
27. 7.7.3	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.

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TABLE IV

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TABLE V
THERMAL TRANSIENT TEST PARAMETERS

Event	A Tank Level	B Starting Speed/Flow rpm/gpm	C Starting Temp °F	D Final Temp	E Delta-T °F	F Transient Rate °F/Second	G Main (1) Drive Trip	H Soak Times Hrs. (2)
201 Deleted								
202	125 in.	1110/14500	750	600	150	-1.5	NO	6.
203	"	"	500	650	150	+1.5	NO	6.
204	"	"	850	650	200	-1.5	NO	8.
205 Deleted								
206 Deleted								
207	"	"	950	620	330 (3)	-1.2	NO	12.
208	"	"	950	725	225	-2.0	NO	9.
210	"	"	950	800	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.

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 Drive Trip (1)	Soak Times Hrs. (2)
201 Deleted								
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203	"	"	500	650	150	+1.5	NO	6.
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208	"	"	950	725	225	-2.0	NO	9.
210	"	"	950	800	150	-3.0	NO	6.

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(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 (950⁰F). 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

	Set Points for		Set Points for Increasing Speed					Stabilization Hold Period (Min)	
	rpm: Decreasing Speed (All Resistance Values)	rpm: Increasing Speed	Design Resistance	R4	R1	R3.3	R5	R6(1)	
<u>Pony Motor</u>	94	94							30
<u>Main Motor</u>		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
<u>Max. Control Speed</u>		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.

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APPENDIX B

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APPENDIX C

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APPENDIX D

Facility Electrical Services Required
by Test Pump1. 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 $\pm 2\%$ of nominal voltage (120 VAC) and $\pm 2\%$ 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 100⁰F.
- 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) (175⁰F). 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 135⁰F provides time for operator corrective action; the 175⁰F 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.

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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 1050⁰F
253 psig at 1025⁰F 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 $400 \pm 10^{\circ}\text{F}$ (Pump tank must be within $\pm 40^{\circ}\text{F}$ 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

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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 imbalance.	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-19, 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 TE-18 3.5.3.14 PI-43 3.5.3.16 PI-51 PI-54
LSH-04	Reservoir level low.	Level LIT-15 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 LSH-34 3.5.3.6 LSH-36 3.5.3.7 LSH-37

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
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. B) Oil pump isolation valve closed. C) System PD drops.	A) Visually check skid for pump operation. B) Verify that Greer valve numbers 539, 540, 541, 542 are open. C) Check PD-17, react as there.	A) Terminate sodium pump operation until oil pumps are operational. B) Standby pump should automatically start. Otherwise terminate sodium pump operation until situation corrected. C) See PD-17 above.	A) Oil circ pumps are operational and alarm off (greater than 40 psid). B) Valves opened, pumps sustain PD greater than 40 psid and alarm goes off. C) See PD-17 above.	Greer Manual paragraph 3.5.3.8

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. B) Lift filter PD high.	A) Valve position on oil circ skid. B) Check PDSH-42, react as there.	A) Open isolation valve. B) See PDSH-42.	A) Alarm goes off when relief flow stops. B) Alarm goes off when relief flow stops.	Greer Manual paragraph 3.5.3.12
ZS-61 ZS-62	A) Downstream isolation valve closed. B) Filter PD high.	A) Valve position on oil circ skid. B) Check PDSH-05, react as there.	A) Open isolation valve. B) See PDSH-05.	A) Alarm goes off when relief flow stops. B) Alarm goes off when relief flow stops.	Greer Manual paragraphs 3.5.3.10 and 3.5.3.11
Back-Up Oil Circ Pump Running	A) Loss of Buss A (or B). B) Pump PD low.	A) Facility power supply. B) Check PD-17.	A) Find/repair fault. B) React as in PD-17.	A) Power available to the pump. Manually select the primary. Will hold if corrected. B) Manually select the primary. Will hold if corrected.	Greer Manual paragraph 3.5.3.19
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. B) Heat exchanger malfunction.	A) Electrolyte coolant pump operation. B) Cooling water supply malfunction.	A) Verify coolant pump operation. B) Verify cooling water malfunction.	A) Electrolyte temp drops below 135°F on TE-25. B) 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
LSH-29	Electrolyte level low.	Electrolyte level.	Add water and adjust solution.	Level (LIT-16) indicates normal level.	TISH-24, LI-23, ZS-21

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APPENDIX I

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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 startups 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° rotation every half hour is recommended.

2. Running Limitsa) 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 02A)	90 ⁰ C Rise
Upper Guide Bearing	55 ⁰ C Rise or 95 ⁰ C
Lower Guide Bearing	55 ⁰ C Rise or 95 ⁰ C
Thrust Bearing	55 ⁰ C Rise or 95 ⁰ C
Voltage	3785 - 4530

b) Rheostat

Parameter	Range/Limit
Electrolyte Temperature	68 ⁰ F to 135 ⁰ 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 ⁰ 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	Above 20 Hz - .002 max.
Nozzle Vibration	5-20 Hz - .010 max.
Inches (Peak to Peak)	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 50⁰F 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 2775⁰F-in.
- 2) At no point shall the side-to-side temperature gradient, at a constant elevation, exceed 100⁰F.

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 2775⁰F-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 6100⁰F-in.
- c) At no point shall the side-to-side temperature gradient, at a constant elevation, exceed 100⁰F.

REQUIRED OPERATOR ACTION TO SELECTED ALARMS

ALARM	STEADY STATE (NOTE 2)	THERMAL TRANSIENT (NOTE 3)
High Main Motor Power (See Note 1)	<ul style="list-style-type: none"> 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. 	<ul style="list-style-type: none"> 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)	<ul style="list-style-type: none"> 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.	<ul style="list-style-type: none"> 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. 	<ul style="list-style-type: none"> 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.

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APPENDIX L

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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			Man.	Alarm	Trip	Comment
			DAS	FM 3.75 IPS	FM 15 IPS				
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				Comment
			DAS	FM 3.75 IPS	FM 15 IPS	Man.	
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 ⁰ F)
205	TISH-24	Elec. Temp Alarm				X	(135 ⁰ 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			Man.	Alarm	Trip	Comment
			DAS	FM 3.75 IPS	FM 15 IPS				
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. LE M1
INSTRUMENTATION RECORDING SUMMARY

Item	Instr.	Description	Recording System					Comment
			DAS	FM 3.75 IPS	FM 15 IPS	Man.	Alarm	
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			Man.	Alarm	Trip	Comment
			DAS	FM 3.75 IPS	FM 15 IPS				
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 ₂ O)	X						

TABLE M1
INSTRUMENTATION RECORDING SUMMARY

Item	Instr.	Description	Recording System						Comment
			DAS	FM 3.75 IPS	FM 15 IPS	Man.	Alarm	Trip	
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					Comment
			DAS	FM 3.75 IPS	FM 15 IPS	Man.	Alarm	
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				Man.	Alarm	Trip	Comment
			DAS	FM 3.75 IPS	FM 15 IPS					
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			Man.	Alarm	Trip	Comment
			DAS	FM 3.75 IPS	FM 15 IPS				
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						Comment
			DAS	FM 3.75 IPS	FM 15 IPS	Man.	Alarm	Trip	
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

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	L-Delta-T Once Per Hour
8. 7.5.4 (e)	Heatup to 500 ⁰ F	2 Per Min	2 Per Hour	Calibration Record
9. 7.5.4 (f)	Probe Calibration	-	-	L-Delta-T Once Per Hour
10. 7.5.4 (g)	Heatup to 600 ⁰ F	2 Per Min	2 Per Hour	
11. 7.5.4 (h)	Probe Calibration	-	-	Calibration Record
12. 7.5.4 (i)	Heatup to 680 ⁰ 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 ⁰ 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 ⁰ 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 ⁰ 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 ⁰ 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 ⁰ F R4 Speed Scan	12 Scans/Min	Note 2	--
27. 7.5.6.2 (d)	750 ⁰ 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 ⁰ 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 ⁰ 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 ⁰ F R4 Speed Scan	12 Scans/Min	Note 2	
33. 7.5.6.5	Temp Up to 900 ⁰ 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 ⁰ 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 ⁰ F R4 Speed Scan	12 Scans/Min	Note 2	
37.	7.5.7.1 (d) 950 ⁰ F R5 Speed Scan	12 Scans/Min	Note 2	--
38.	7.5.7.1 (e) 950 ⁰ F R3.3 Speed Scan	12 Scans/Min	Note 2	--
39.	7.5.7.1 (f) 950 ⁰ 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
57.	7.6.1 2000-Hr Endurance	1 Scan/Min	1 Per Hour	L-Delta-T at 8-Hr Intervals
	7.6.2 300-Hr Off-Des. End.	1 Scan/Min	1 Per Hour	L-Delta-T at 8-Hr Intervals
58.	7.7.1 (1) Pre Trans. Stability	2 Scans/Min	Once	L-Delta-T Computation
59.	7.7.1 (2) Trans. Applic.	1 Scan/Sec	-	FM Recorders Continuous
60.	7.7.1 (3) Soak	1 Scan/Sec	12 Per Hour	FM Recorders Continuous
61.	7.7.1 (4) Upramp	12 Scans/Min	Note 2	--
62.	7.7.1 (5) Post Trans Endurance	2 Scans/Min	1 Per Hour	--

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

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