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Rockwell International
Atomics International Division

REQUEST FOR TEST

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KEY NOUNS: Pump, Inducer, Sodium LMFBR

TITLE: Minimum Test Series for the Intermediate-Size Inducer Pump in SPTF at ETEC

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T. J. Boardman	731	LB08

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APPROVALS/DATE

G. J. Hallinan 1-9-80

R. Anderson

G. W. Meyers 1-9-80

MASTER

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STATEMENT OF PROBLEM

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

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CONTENTS

TABLES

1.0 INTRODUCTION

This test program will demonstrate the applicability of inducers to large, high-temperature sodium pumps for reactor service. Tests will be performed to provide steady-state head/flow performance data, and to provide cavitation performance data at reduced NPSH. To accomplish these objectives, the FFTF prototype pump, or an FFTF primary 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 design and two-loop flow/speed ratios and at selected sodium temperatures; suction performance determination; and a design point endurance test, up to 2000 hours, based on available time. The endurance test will be run at 100 percent NPSH margin. After testing, the pump will be cleaned of sodium, disassembled, and examined to determine the effects of operation at 100 percent NPSH margin for an extended period of time.

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 the previously available with conventional impeller designs.

Successful testing will provide increased confidence in the use of 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 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 will be measured at various speeds and test loop flow impedances.

Testing will proceed from least severe operating conditions (low flow and low speed) to increasingly severe conditions. At each test temperature, "speed-scan" tests will be run increasing the pump speed from minimum (approximately 500 rpm) to design speed (1110 rpm) in specified increments, while maintaining a constant flow impedance in the test loop. Pump head, flow, and electrical power will be measured at each speed. The sodium temperature will then be increased and the "speed-scan" test repeated at the higher temperature. At minimum and maximum test temperatures (700^{o}F and 950^{o}F), "speed-scan" tests will be run at two separate flow impedances (design and two-loop). Also, limited "flow-scan" tests will be run at these two temperatures, during which the pump will be run at design speed while the flow impedance is varied in increments, from design impedance to two-loop impedance. Pump head, flow, and electrical power will be measured at each impedance condition. The "speed-scan" test at two-loop flow impedance and the "flow-scan" test will not be run at intermediate temperatures.

Following the noncavitating performance tests, the cavitation performance test will be run at 950^{o}F. During this test the pump will be run at design speed and flow while the suction pressure is slowly decreased, to determine the Net Positive Suction Head (NPSH) at which the head across the pump will be reduced by 3 percent due to cavitation.

The final test will be a 2000 hour endurance test to be run at the design condition with a 100% NPSH margin. If the schedule will not permit 2000 hours of operation, the test will be run for whatever lesser length of time is available.

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 similar (but not identical) to that used during Phase B tests of the FFTF Prototype Pump. The number and type of internal instruments may be restricted by permissable modifications to the pump to permit instrument installation. External instrumentation systems are to be provided by ETEC, except signal conditioning equipment which is 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.

5.0 TEST RESULTS

Expected results include obtaining noncavitating performance characteristic data, suction performance data, and data on exposures of the test hardware to extended operation with 100 percent NPSH margin above the value required to limit the pump head drop (due to cavitation) to 3 percent.

The hydraulic test results will be obtained by using standard pump analysis and data reduction procedures, as used for the prototype pump tests. Noncavitating performance characteristic data will show the interrelation of head, capacity, power, and speed. Cavitation performance data will show the critical NPSH value, corresponding to 3 percent head drop at design flow and speed. From this value, the NPSH value for endurance test operation will be determined, and also the suction specific speed at design flow conditions will be calculated.

Data on the exposure of the test hardware to operation with 100 percent NPSH margin 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 power and speed relationship in the region between design and two-loop flow impedance.
2) Establish pump critical NPSH at design speed and flow.
3) Show that the pump has been exposed to extended operation with 100% NPSH margin, 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."

6.0 DESCRIPTION OF TEST

6.1 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 of the prototype pump 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.

6.2 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 the ISIP addendum, N2660MM000001, which covers those changes in the manual necessary for assembling ISIP components.

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.

6.3 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 through the cover gas system and pump seals 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:

TABLE I
RANGE OF TEST VARIABLES

Flow	500-18000	gpm
Sodium Temperature	400-950	^{o}F
Discharge Pressure	0-250	psig
Sodium Level	4-14.5	feet above impeller discharge centerline
Cover Gas Pressure	0.5-24	psia

6.4 TEST SEQUENCE AND LOGIC

This test series is intended to provide data for the evaluation of the performance, particularly suction performance, of an inducer-impeller pump and to provide information related to operating life capabilities under reactor conditions. Because of the similarities of both hardware and test conditions, this program will also provide data for comparison of the inducer pump to the conventional FFTF Prototype Pump. The sodium tests of the ISIP will include most of the test conditions specified for Phase B testing of the prototype pump in Westinghouse Test Request WDTRS 25.14, Revision 18.

The test sequence is as follows:

1) Pump Assembly and Installation
2) Auxiliary Systems Check
3) Preheat to 400°F and Sodium Fill at 400°F
4) Initial Startup at 400°F and Operation During Wetting to 700°F
5) Main Motor Speed Scans at 700°F (R4 and R5)
6) 700°F Limited Flow Scan at 1110 rpm
7) 750°F Checkout and Speed Scan (R4)
8) 800°F Checkout
9) 850°F Checkout and Speed Scan (R4)
10) 900°F Checkout
11) 950°F Checkout and Speed Scans (R4 and R5)
12) 950°F Limited Flow Scan at 1110 rpm
13) Cavitation Performance at 950°F
14) 2000 Hour Design Point Endurance Test at 950°F with 100% NPSH Margin (To be run on a "time available" basis.)
15) Pump Final Disassembly and Inspection

In the foregoing test sequence, R4 and R5 designate design and two-loop flow impedances, respectively (14,500 gpm at 1,110 rpm and 18,000 gpm at 1,110 rpm).

6.5 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			

6.5.1 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.

6.5.2 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.

6.5.3 Preheat and Sodium Fill

Note: Test Requester Hold Point

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

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

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

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

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

Special Post Test Data Reduction - Plot of maximum and minimum temperatures for each zone vs time and 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^{o}F ± 25^{o}F. The rotor torque measurements must be less than 1.25 times the measured room temperature torque values and the measured bearing/journal radial clearance must be within the 75% of the value measured prior to assembly.

6.5.4 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 end-to-end, as close as practical. DAS coefficients shall be entered and performance calculation programs shall be functional in the DAS as required for pony motor operation. Note: This is a hold point. Do not proceed with the test until the instrument checkout is complete.
2) Pony Motor Startup Per Appendix K. (T=400^{O}F)
3) 30-Minute Pony Motor Run. (T=400^{O}F)
4) Main Motor Startup Per Appendix K. (T=400^{O}F)
5) Instrument and Data System Verfication. Note: This is a hold point. Do not proceed with the test until the operational verfication of the instrument and data system is complete for main motor operation.
6) Increase temperature to 500^{O}F at 20^{O}F/hr maximum rate and 600 rpm maximum speed. Stabilize at 500^{O}F for 30 minutes.
7) Perform Bearing Probe System Calibration.
8) Increase temperature to 600^{O}F at 20^{O}F/hr maximum rate and 600 rpm maximum speed. Stabilize at 600^{O}F for 30 minutes.

9) Perform Bearing Probe System Calibration.

10) Increase temperature to 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 700°F temperature for 8 hours; 600 rpm maximum speed.

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.

6.5.5 Initial Low Temperature Checkout at 700°F

Note: Test Requestor Hold Point

6.5.5.1 Main Motor Speed Scan at 700°F

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.

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. Also, prepare plots and tabulations of KW_C (= 750 KW/N^3), H_C (= 750 H/N^3), and Q_C (= 750 Q/N) all vs N; where KW = input electrical power, H = pump head, Q = pump flow rate, and N = pump speed.

6.5.5.2 700°F Limited Flow Scan

With the sodium level at 125 inches above the impeller discharge centerline and the pump speed set at 1,110 rpm, perform a flow scan with five minute stabilization at each of the following flow scan set points: 13,800 gpm, 14,500 gpm, 15,200 gpm, 15,900 gpm, 16,600 gpm, 17,300 gpm, and 18,000 gpm.

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 1,110 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.

6.5.6 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.

6.5.6.1

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

6.5.6.2 800°F Checkout

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

6.5.6.3 850°F Checkout

Note: Test Requestor Hold Point

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

Data Collection - As specified in Table M2.

Special Post Test Data Reduction - Prepare plots and tabulations of actual KW vs Q and of H vs Q, corrected to 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. Also prepare plots of KW_c, H_c and Q_c vs N, as described in 6.5.5.1.

6.5.6.4 900°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)

6.5.7 High-Temperature Checkout at 950°F

6.5.7.1 Main Motor Speed Scan at 950°F

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 instrument system calibrations for cover gas pressure(s), suction pressure, discharge pressure, flow, and speed.
4) 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.
5) 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.

Note: Following instrument calibrations, the speed scans (6.5.7.1), limited flow scans (6.5.7.2), and cavitation performance (6.5.8) should be run without delay to avoid the requirement for recalibration before cavitation performance tests.

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. Also prepare plots of KW_c, H_c and Q_c vs N as described in 6.5.5.1.

6.5.7.2 950°F Limited Flow Scan

Repeat the testing specified in Paragraph 6.5.5.2, with the exception that tests will be performed at 950°F and the cover gas pressure (and lube oil reservoir pressure) will be increased to achieve an NPSH of 60 ± 2 ft.

6.5.8 Cavitation Performance

Purpose - To measure the NPSH which will result in 3 percent pump heat loss due to cavitation, when the pump is operating at design speed and flow.

Note: If more than one week has elapsed since the instrument calibrations of 6.5.7.1, or if the sodium temperature has varied more than ±50°F from 950°F since that time, or if for any other reason the calibration is no longer valid, then recalibrate the instruments and rerun the flow scan test points at 13,800 gpm, 15,200 gpm, and 15,900 gpm before performing this test.

Test Description - The initial flow and Q/N (flow/speed/ratio) values for the cavitation performance test will be calculated, using data from the 13,800 gpm, 14,500 gpm, and 15,200 gpm test points of 3.5.7.1, such that at 3 percent pump head loss due to cavitation, the flow will be 14,500 gpm without changing the flow impedance of the loop during the test. Calculation requirements are given in Appendix B.

The cavitation test will be run in sodium at 950^{o}F, with a pump speed of 1,110 rpm, and with the sodium level 48 inches, or more, above the impeller discharge centerline. The initial conditions will be at the flow rate, Q_s, calculated from Appendix B and with an NPSH of 60 ft, as indicated by the computer calculated parameter summary. The cover gas pressure (and NPSH) will be decreased slowly, in steps or at a slow rate, until the pump head is reduced to the test head drop limit. Data will be taken at specified intervals. The general procedure to be established for this test series is as follows:

1) Establish stable, steady-state operation at:
   a. Flow - Q_s ± 100 gpm (calculated from Appendix B).
   b. Speed - 1,110 ± 5 rpm.
   c. Sodium level - 48 in. (min.) above impeller discharge centerline.
   d. Sodium temperature - 950 ± 10^{o}F
   e. Cover gas pressure - adjusted to obtain 60 ± 2 ft NPSH as indicated by computer calculated summary.
2) 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 for 60 seconds

The nominalized 1110 rpm head output, averaged from the five performance summaries of the 1 hour run, will be used as a baseline head.
Calculate 97.0% 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.

Note: Test requestor hold point

3) Reduce cover gas pressure in approximate 2 psi increments (5 to 6 ft NPSH) until the covergas pressure is equal to atmospheric pressure.
Stabilize for 10 minutes and take a typical data slice at each pressure plateau.
4) Continue reducing the cover gas pressure, taking a typical data slice at each change of approximately 1 psi (2.8 ft NPSH), until the nominalized 1110 rpm head (indicated by the computer calculated parameter summary) is equal to the "head drop limit" (calculated in Step c.). Take one typical data slice at the "head drop limit." During periods when data is being taken, the rate of change of cover gas pressure shall not exceed 0.1 psi per minute.
5) At the "head drop limit" take two additional computer calculated parameter summaries while maintaining the cover gas pressure within 0.2 psi of the value recorded during Step e. at the "head drop limit" point.
6) Raise the cover gas pressure, taking a typical data slice at each change of approximately 1.0 psi (2-8 ft NPSH), until the cover gas pressure reaches atmospheric pressure. During periods when data is being taken, the rate of change of cover gas pressure shall not exceed 0.1 psi per minute.

7) Raise cover gas pressure in approximately 2 psi increments (5-6 ft NPSH increments) until the NPSH, as indicated by the computer calculated summary, is 60 ft. Stabilize for 10 minutes and take a typical data slice at each pressure plateau.

8) 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 - Prepare the calculations, curves, and data tabulations described in Appendix C.

6.5.9 2000 Hour Design Point Endurance Test at 950°F with 100% 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 950°F, with a flow rate of 14,500 gpm and a speed of 1110 rpm. The sodium level and cover gas pressure will be adjusted to achieve an NPSH margin of 100% above the value determined under Paragraph 6.5.8 for a 3 percent head drop (NPSH equal to twice the value calculated in Appendix C). NPSH values to be used for this test are to be referenced to the inducer inlet blade tip elevation only. The sodium level used for this test shall be within the range from the lower end of the induction level probe to 125 in. (±2) above the impeller discharge centerline.

The pump shall be operated continuously under these conditions for 2000 hours, unless operating schedule restrictions dicatatean earlier cessation of testing. Should problems which are unrelated to the pump force a temporary 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	960^{o}F to 940^{o}F	
Pump Speed	1115 rpm to 1105 rpm	
Net Flow	14700 gpm to 14300 gpm	
Sodium Level	+2 in - 2 in	Based on values selected
Cover Gas Pressure	+0.5 psi - 0.5 psi	to achieve 100% NPSH margin

Note: A calculated NPSH variation range from plus 1.53 ft to minus 1.53 ft, about the value corresponding to 100% margin, may be used in lieu of monitoring sodium level and cover gas pressure for qualifying test time.

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. The exceptions to this requirement are low values of sodium level, cover gas pressure, or NPSH, which shall not cause diqualification but must be reported, with the affected time, as a test anomally for each occurrence.

Data Collection and Use - Data recording shall be according to the requirements of Table M2. In addition, the above set point variables shall be monitored, and recorded periodically during the endurance test (at least once each hour). 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.

6.6 DISASSEMBLY AND INSPECTION

6.6.1 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 of the functioning instrumentation.

6.6.2 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.

7.0 DATA

7.1 DATA HANDLING

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

7.2 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.

7.3 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.

7.4 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.

7.5 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.

8.0 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."

9.0 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, August, 1973). Beyond these, no special requirements exist for this particular test specification.

10.0 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 a 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:

	Designee	Alternate
Program Office	R. V. Anderson	G. W. Meyers
Project Engineering	T. J. Boardman	G. J. Hallinan
Site Representative	(Contact ESG Dept. 731-150 if personnel assignments have not been made prior to test operations)	

11.0 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.

TABLE II

SUMMARY OF TEST REQUESTER HOLD POINTS

Paragraph No.	Hold	Action Needed to Remove Hold Point	Approval Needed
1. 6.5.1	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. 6.5.3	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. 6.5.4	Do not initiate powered operation of the pump without prior test requester approval	Preheat satisfactorily completed	Test Requester Site Rep.
4. 6.5.4 (1)	Do not initiate powered operation without prior test requester approval	Pretest instrumentation checkout satisfactorily completed	Test Requester Site Rep.
5. 6.5.4 (5)	Do not initiate main motor operation without prior test requester approval	Pony motor operation satisfactory and operational instrumentation checkout complete	Test Requester Site Rep.
6. 6.5.5	Do not perform low-temperature checkout without prior test requestor approval	Main motor initial operation satisfactorily completed	Test Requester Site Rep.
7. 6.5.6	Do not start mid-temperature check-out without prior test requester approval	Low-temperature checkout satisfactorily completed	Test Requester Site Rep.
8. 6.5.6.3	Do not inititate powered operation at 850°F without prior test requester approval	Heatup to 850°F satisfactorily completed	Test Requester Site Rep.

TABLE II (CONTINUED)

SUMMARY OF TEST REQUESTER HOLD POINTS

Paragraph No.	Hold	Action Needed to Remove Hold Point	Approval Needed
9. 6.5.7.1	Do not initiate 950°F tests without prior test requester approval	Mid-temperature operation and heat-up to 950°F completed satisfactorily	Test Requester Site Rep.
10. 6.5.8(3)	Do not initiate suction pressure reduction without prior test requester approval	950°F Speed Scans and Limited Flow Scan completed satisfactorily. Test requester, Project Engineers, or Site Rep. in control room review of results from Step 10.5.8(2)	Test Requester Site Rep.
11. 6.5.9	Do not initiate 2000-hr endurance test without prior test requester approval	Confirmation by AI that 950°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.
12. 6.8.1	Do not initiate final pump disassembly without prior test requester approval	Test objective satisfied	Test Requester Site Rep.

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 (950°F). Off-design operation may also reduce the running clearance of the hydrostatic bearing. The pump shall not be operated when the bearing clearance is reduced by more than 75% of the clearance determined by the latest proximity probe calibration.

TABLE A1

FLOW RESISTANCE VALUES

Flow Impedances	R-0	R-1	R-2	R-3	R-4	R-5	R-6
K	0	6.576	8.243	9.459	13.063	16.216	22.400

$$K = \frac{Q}{N}$$

where

Q = flow in gpm

N = speed in rpm

Unless otherwise specified, flow scan measurements are to be made at each of the defined loop resistances and at two points in between.

731-V.10/bmg

TABLE A2

SPEED SCAN TEST POINTS

Set Points for

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

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

APPENDIX B

CALCULATION OF INITIAL FLOW FOR CAVITATION PERFORMANCE TEST

I. OBJECT

Calculate the initial flow setting to be used for the cavitation performance test of Paragraph 6.5.8 such that when the 3% head drop limit is reached, the flow rate will be 14,500 gpm.

II. PROCEDURE

The procedure described herein is a graphical solution. Equivalent analytical steps may be used, if convenient. For plotting the curves, it is recommended that head be plotted on a scale of approximately 5 ft per 1/2 in. (or 5 ft per centimeter), and flow be plotted on a scale of approximately 100 gpm per 1/2 in. (or 100 gpm per centimeter), using graph paper.*

Step 1 - Using test results from the 950°F limited flow scan (Paragraph 6.5.7.2), plot the head-flow points, corrected to 1110 rpm, for the test data taken at nominally 13,800 gpm, 14,500 gpm, 15,200 gpm, and 15,900 gpm. Then, draw a smooth curve through the test points.

Note: If instrument recalibration was performed under 6.5.8, use the test data that was rerun after calibration.

Step 2 - Using 97% of the head values used to plot the test curve in Step 1 and the same values, plot a second head vs flow curve (see Figure B-1).

*Use 10 x 10 to the 1/2 in. (or 10 x 10 to the centimeter) graph paper.

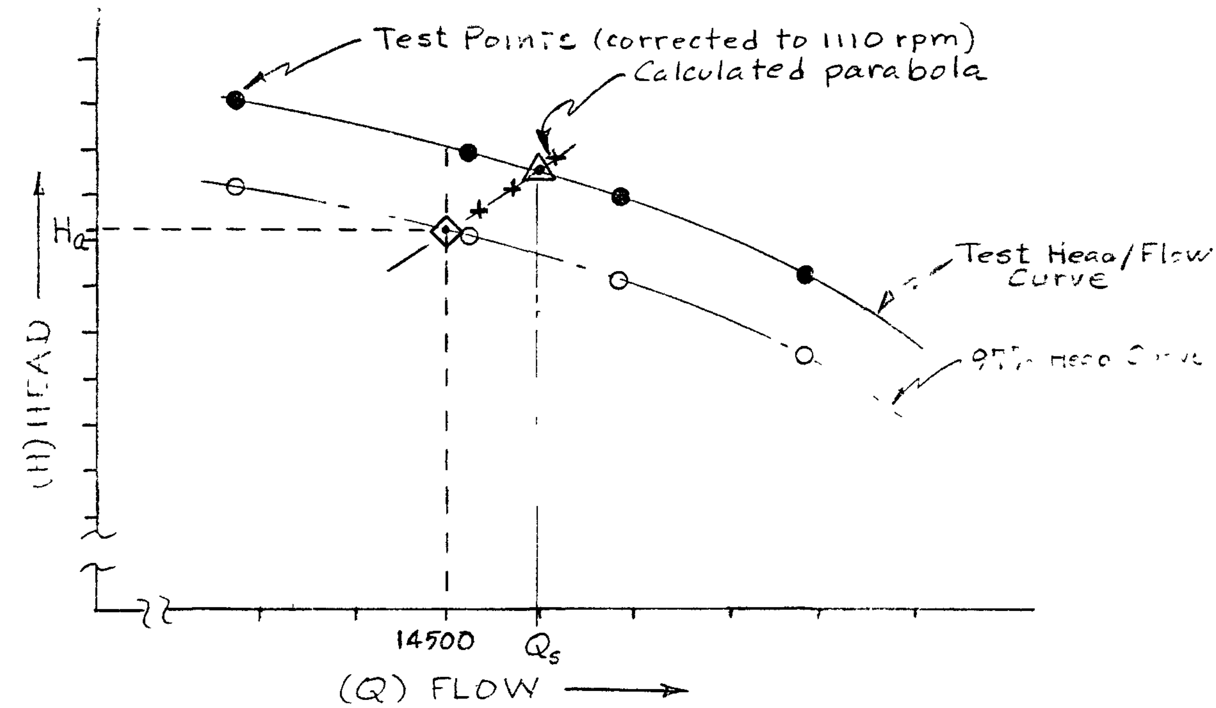

FIGURE B-1 - Graphic method for determining initial flow rate for cavitation performance test.

Step 3 - Record the head value, Ha, where the 97% curve crosses the 14,500 gpm flow line (identified by a diamond,◈, on the 97% curve of Figure B-1.

Step 4 - Using the value, Ha, calculate points for the parabola

$$H = \left[\frac{Ha}{2.1025 \times 10^8}\right] Q^2$$

for values of Q above 14,500.

Step 5 - Plot the calculated points and draw the segment of the parabola which intersects the test curve and the 97% curve.

Step 6 - Record the flow value, Q_s, where the parabola intersects the test head/flow curve (identified by a triangle,△, on the test curve of Figure B-1).

Step 7 - Calculate the flow/speed ratio

$$\left(Q/N\right)_s = Q_s/1110$$

This is the flow/speed ratio which should be used to set the MFL butterfly valves in SPTF for the initial test point. At 1110 rpm, the ratio results in a flow rate equal to Q_s.

APPENDIX C

POST-TEST DATA REDUCTION FOR CAVITATION PERFORMANCE TEST

I. DETERMINATION OF NPSH AND FLOW AT 3 PERCENT HEAD DROP

Step 1 - Correct all measured values of head (H), flow (Q), NPSH (H_{sv}), and input power (KW) from the test speed (N) to 1110 rpm using the affinity laws:

$$H_c = H\left(\frac{1110}{N}\right)^2$$

$$H_{svc} = H_{sv}\left(\frac{1110}{N}\right)^2$$

$$Q_c = Q\left(\frac{1110}{N}\right)$$

$$KW_c = KW\left(\frac{1110}{N}\right)^3$$

where

H_c = corrected head
H_{svc} = corrected NPSH
Q_c = corrected flow
KW_c = corrected power

(Note: The power correction is only approximate due to the wound-rotor motor characteristics, which have not been included.)

<u>Step 2*</u> - Using test results from the 950°F limited flow scan (Paragraph 6.5.7.2), plot the head-flow points (corrected to 1110 rpm, for the test data taken at nominally 13,800 gpm, 14,500 gpm, 15,200 gpm, and 15,900 gpm. Then draw a smooth curve through the test points.

<u>Step 3*</u> - Using 97% of the head values used to plot the test curve in Step 2, and the same flow values, plot a second head vs flow curve.

<u>Step 4</u> - Starting from the test point at the lowest NPSH value, accurately plot each test point (H_c, Q_c) from the cavitation performance test (Paragraph 6.5.8), until the plotted reach the averaged noncavitating head measured in 6.5.8(2)c.

<u>Step 5</u> - Draw a "best-fit" parabola, of the form $H_c = KQ_c^2$ through the plotted test points, crossing the 97% head curve. "Best fit" may be determined analytically by using the average value for K, based on all valid test points (see Figure C-1). Note and record the value of Q_c at which the parabola crosses the 97% head curve.

<u>Step 6</u> - Using a scale of 2 ft per 1/2 in. (or 2 ft per centimeter) and 50 gpm per 1/2 in. (or 50 gpm per centimeter), and starting from the test point at the lowest NPSH value, accurately plot each test point (H_{svc}, Q_c) in the flow regime of Step 4 and draw a "best fit" curve by eye. Note and record the corrected NPSH value (H_{svc}) corresponding to the flow value recorded in Step 5. (See Figure C-2.)

Report the NPSH determined in Step 6 as the "required" NPSH at 1110 rpm and the flow determined in Step 5.

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*Steps 2 and 3 are essentially identical to Steps 1 and 2 in Appendix B and should be plotted to the same scale, using 10 x 10 to the 1/2 in. (or 10 x 10 to the centimeter) graph paper.

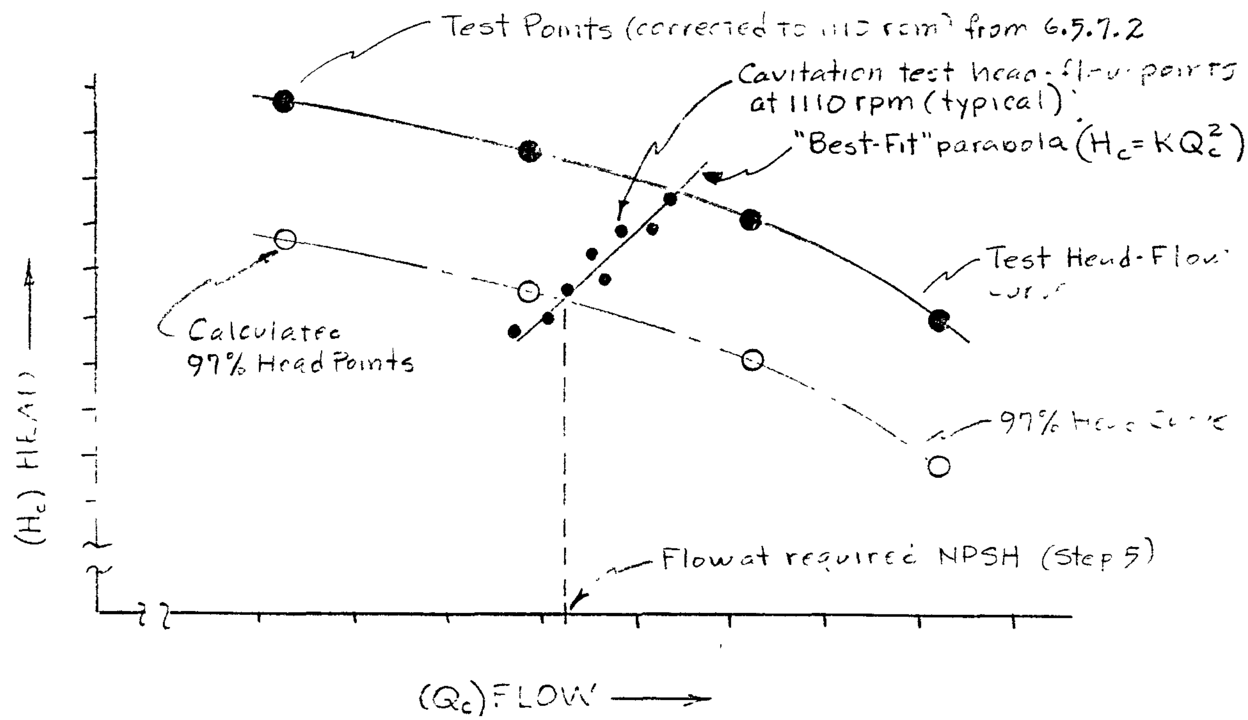

FIGURE C-1 - Graphic method for determining flow at required NPSH

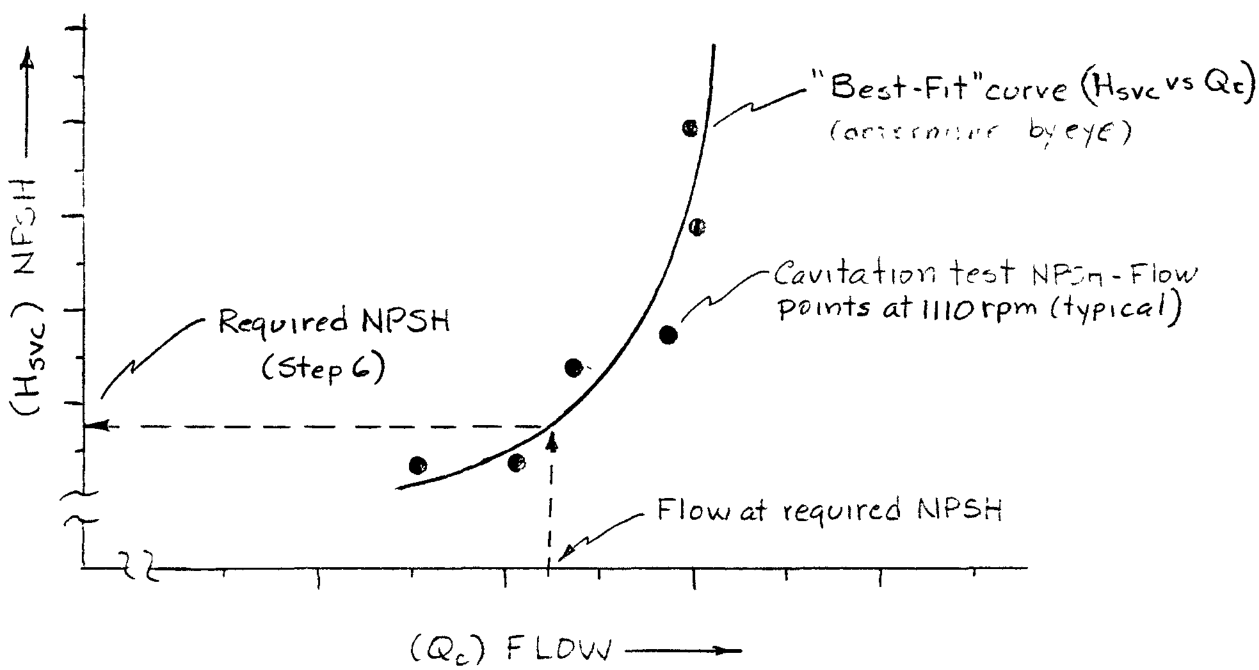

FIGURE C-2 - Graphic method for determining required NPSH

II. TABULATIONS

Submit a tabulation of H, Q, H_{sv}, KW, Eff, H_c, Q_c, H_{svc}, and KWc for all test points, in the sequence in which the points were taken. Also, submit a copy of the performance summary for each test point.

III. CURVES

1) Submit full-size copies of the initial point determination curves of Appendix B, and of the H_c vs Q_c and H_{svc} vs Q_c curves used to determine the required NPSH in this appendix.

2) Submit a curve of H_c vs H_{svc}, showing the plotted points and a "best fit" curve (determined by eye).

APPENDIX D

Facility Electrical Services Required by Test Pump

1. Electrical Services

The facility must provide the following electric service:

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

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

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

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

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

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

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

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

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

2. Main Motor Protection

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

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

b) Instantaneous overcurrent relay ground sensor for stator circuit.

c) Phase sequence and undervoltage relay for stator circuit.

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

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

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

3. Pump Main Motor Starting Interlocks

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

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

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

c) Pony motor is energized.

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

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

4. Pump Main Motor Trip Interlocks

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

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

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

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

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

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

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

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

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

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

APPENDIX E

Deleted

APPENDIX F

DESIGN RESTRICTIVE LIMITS

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

1. Pump Cover Gas Pressure Restricting Design Limit

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

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

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

2. Event No. 6 - Pump Discharge Nozzle Pressure

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

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

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

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

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

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

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

5. Thermal Transient Design Restrictive Limit

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

6. Sodium Fill Parameters

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

Option B - Normal Cover Gas Pressure System Fill

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

APPENDIX G

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APPENDIX H

SPTF/ISIP STEADY-STATE ALARM SETPOINTS AND RESPONSES

SENSOR TAG NO.	PARAMETER	ALARM PANEL AND WINDOW	SETPOINT	TYPE	CORRECTIVE ACTION
E-595	Backup Circulating Oil Pump Run	C201B-15**	(Indicator)		Verify satisfactory operation of backup equipment. Inspect to determine why backup pump started.
E-597	Backup Circulating Oil Cooler Fan Run	C201B-19**	(Indicator)		Verify satisfactory operation of backup equipment. Inspect to determine why backup fan started.
FT-101B	Venturi Flow Low	2DS2VII	500 GPM Below Operating Point - Alarm 1000 GPM Below Operating Point - Trip (during transient mode only)		Check MFL valve positions: check venturi ΔP measurement.
*JAH-75	Main Motor Power		Computer Computed Alarm Computer Computed Trip		A) Reduce to pony motor speed. B) Scan bearing temperature (TE-11, -12), bearing probes (TE-02A, B, C, D) and motor protection data. If any are activated, trip pony motor immediately and perform rotor torque check. If torque is normal, idling operation at pony motor is permissible. Call Cognizant Engineer. C) If alarm does not clear after one minute, terminate test, perform rotor torque check. Call Cognizant Engineer.
JAH-75 (Fixed Point)	Main Motor Power		(Fixed point alarm/trip setpoints to be determined for each test condition and set immediately preceding each test.)		
LSL-04	Lube Oil Supply Reservoir Level - Low	C201B-18	2 Gallons	Low Alarm	Add oil to clear alarm per Procedure 462-OP-308.
LSH-34	Lower Seal Leakage Reservoir - High Level	C201B-13	15 Gallons	High Alarm	Operate lower seal leakage pump.
LSH-36	Upper Seal Leakage Reservoir - High Level	C201B-16	9-1/2 Gallons	High Alarm	Drain reservoir (Valve V-121A) per Procedure 462-OP-308.
LSL-35	Lower Seal Leakage Reservoir - Low Level		2 Gallons	Low Alarm	<u>No Action Required</u>
LSHH-37	Lower Seal Leakage Reservoir - High Level	C201B-14	25 Gallons (+ 6 Gallons Residual)	High Alarm	Record level and drain lower seal oil leakage tank per Procedure 462-OP-308. If LI-16 is decreasing rapidly, shutdown sodium pump. Review data to determine if leakage rate has changed significantly. Call Cognizant Engineer.
LSLL-37	Lower Seal Leakage Reservoir - Low-Low Level	C201B-17	1 Gallon (+ 6 Gallons Residual)	Low Alarm	<u>No Action Required</u>
LAH-40	Pump Tank Level	2DS2IV-1	160 Inches***	High Alarm	Open PV-111 and release sodium until alarm clears.
LAHH-40	Pump Tank Level	2DS3IV-1	206 Inches*** (Dump)	High Alarm	
LAL-40	Pump Tank Level	2DS2V-1	134 Inches***	Low Alarm	Verify HV-432, PV-111, and TV-120 are closed; then adjust HV-420 until proper level attained.
LALL-40	Pump Tank Level	2DS3V-1	115 Inches*** 36 Inches Above Impeller & (62 Inches on LT-42)	Low Alarm Low Trip	
PDIT-17	Lube Oil Seal/Bearing Δ Pressure Low	C201B-25	10 Psid	High Alarm	Shutdown pump and look for leak in supply line, or for flow through relief valve. Check oil temperature and valve settings.
PDSH-05	Oil Filter High Δ Pressure	C201B-20	25 Psid	High Alarm	Switch to clean filter and change Filter 509 according to PMP-533-1.
PDSH-42	Sodium Pump Oil Lift Pump Filter High Δ Press.			High Alarm	Valve-out the filter and replace the element.
PDSH-59	Oil Circulating Pump High Δ Pressure		40 Psid	High Alarm	Determine that flow is normal. Turn off fan on cooler to warm up the oil. If this doesn't help, throttle oil flow to cause oil to heat up.
PAH-105	Sodium Pump Discharge Pressure	2DS2I2	220 Psig	High Alarm	Reduce pump speed until alarm clears. Check covergas pressure at PIC-113, then adjust shaft speed and sodium flow to get within test envelope.
PAHH-105	Sodium Pump Discharge Pressure	2DS3I2	225 Psig	High-High Alarm	
PAH-111	Sodium Pump Suction Pressure	2DS2III2	40 Psia	High Alarm	Decrease pump covergas pressure.

* Starred items are in the Alarm Computer
** Alarm lights also located on local panel (lube oil skid)
*** Different alarm setpoints will be used for transient and cavitation tests

SPTF/ISIP STEADY-STATE ALARM SETPOINTS AND RESPONSES

SENSOR TAG NO.	PARAMETER	ALARM PANEL AND WINDOW	SETPOINT AND TYPE		CORRECTIVE ACTION
PAL-111	Sodium Pump Suction Pressure	2DS2IV2	5 Psia*	Low Alarm	Trip main motor to pony motor. Determine cause and correct. Increase covergas pressure and resume testing.
PAH-113	Sodium Pump Covergas Pressure	2DSII2	35 Psia	High Alarm	Check setting of PIC-113, otherwise, close V-335 and vent through V-334 if pressure too high.
PAL-113	Sodium Pump Covergas Pressure	2DSIII2	10 Psia*	Low Alarm	Trip main motor to pony motor. Determine cause and correct. Increase covergas pressure and resume testing.
	**Difference between hydrostatic bearing metal temperatures (TE-0-1 thru TE-0-4 and TE-02A thru TE-02D) and sodium bearing supply temperature (TE-0-5 and TE-0-6). Under Alarm Panel & Window PANEL MRB-1		Alarm computer will signal when temperature difference between hydrostatic bearing and bulk Na temperature reaches 50°F. If this difference reaches 100°F, the pump will be tripped.		Stop pump and perform torque measurement according to TP-10-PP-006, Step 12.3.2 thru 12.3.12. Dump high rate data from disc to tape. Notify Cognizant Engineer after torque readings are taken.
TE-11	Main Motor Upper Radial Bearing Temperature	C201B-35	205°F	High Alarm	Trip main motor to pony motor and check oil levels. Then stop motor and perform torque check. Call Cognizant Engineer.
TE-12	Main Motor Lower Radial Bearing Temperature	C201B-35	205°F	High Alarm	Trip main motor to pony motor and check oil levels. Then stop motor and perform torque check. Call Cognizant Engineer.
TE-13	Pony Motor Stator Temperature	C201B-34	240°F	High Alarm	Shutdown pony motor -- check thermocouple, motor current draw; if repairs indicated, prepare for removal.
TE-14A	Main Motor Stator Temperature	C201B-36	240°F	High Alarm	Shutdown main motor and check stator thermocouples -- review bearing temperature data and measure shaft breakaway torque. Call Cognizant Engineer.
TE-14B	Main Motor Stator Temperature	C201B-36	240°F	High Alarm	Shutdown main motor and check stator thermocouples -- review bearing temperature data and measure shaft breakaway torque. Call Cognizant Engineer.
TE-14C	Main Motor Stator Temperature	C201B-36	240°F	High Alarm	Shutdown main motor and check stator thermocouples -- review bearing temperature data and measure shaft breakaway torque. Call Cognizant Engineer.
TE-15	Main Motor Thrust Bearing Temperature	C201B-35	205°F	High Alarm	Trip main motor to pony motor and check oil levels. Then stop motor and perform torque check. Call Cognizant Engineer.
TE-18	Sodium Pump Sleeve Bearing Housing Oil Inlet	C201B-27	125°F	High Alarm	Trip main motor to pony motor and determine cause. Turn on alternate oil circulating pump and fan. Call Cognizant Engineer.

* During cavitation tests, the setpoint can be set at 9 ft NPSH (@ 48 in. level, 950°F, 14500 gpm)
** Starred items are in the Alarm Computer

SPTF/ISIP STEADY-STATE ALARM SETPOINTS AND RESPONSES

SENSOR TAG NO.	PARAMETER	ALARM PANEL AND WINDOW	SETPOINT AND TYPE		CORRECTIVE ACTION
TE-19A	Na Pump Bearing Housing Lower Seal Outlet	C201B-29	155°F	High Alarm	Trip main motor to pony motor and determine cause. Turn on alternate circulating pump and fan. Call Cognizant Engineer.
TE-19B	Na Pump Bearing Housing Thrust Bearing Oil	C201B-31	155°F	High Alarm	
TE-19C	Na Pump Bearing Housing Upper Seal Oil Out.	C201B-33	155°F	High Alarm	
TAH-28	Electrolyte HX Cooling Water Outlet Temp.	2DS1V11	95°F	High Alarm	Check cooling tower operation. Correct deficiencies. Increase cooling waterflow, if necessary.
TAH-27	Electrolyte HX Cooling Water Inlet Temp.	2DS1V11	85°F	High Alarm	Check cooling tower operation. Correct deficiencies. Increase cooling waterflow, if necessary.
TAH-119	Sodium Pump Discharge Temperature	2DS1112	975°F	High Alarm	Check sodium cooler operation; otherwise, reduce pump shaft speed.
TAH-120B	Sodium Pump Suction Temperature	2DS2V2	975°F	High Alarm	Check sodium cooler operation; otherwise, reduce pump shaft speed
TI-25	Electrolyte Temperature	C201B-28	135°F	High Alarm	Check cooling water system and electrolyte pump operation, electrolyte level and concentration, correct as necessary Reduce pump shaft speed if temperature rise continues – Increase cooling water flow, if necessary, to resume operation. Select backup electrolyte pump. If TAH-24 alarms, first trip main motor to pony motor.
TAH-24	Electrolyte Temperature	2DS2III1	175°F	High Alarm	
TSH-50 (Also TE-19A)	Na Pump Bearing Housing Lower Seal Oil Out.		155°F	High Alarm	Trip main motor to pony motor and determine cause. Turn on alternate circulating pump and fan. Call Cognizant Engineer.
TSH-53	Na Pump Bearing Housing Thrust Bear. Oil Out.		155°F	High Alarm	
TSH-56	Na Pump Bearing Housing Upper Seal Oil Out.		155°F	High Alarm	
VAH-08X	Seal Oil Bearing Housing - Axis		2 Mils 5 Mils	Alarm SCRAM	Execute spectrum analyzer program for this channel; return to previous test point until alarm clears.
VAH-08Y	Seal Oil Bearing Housing - Axis		2 Mils 5 Mils	Alarm SCRAM	Execute spectrum analyzer program for this channel; return to previous test point until alarm clears.
VAH-08Z	Seal Oil Bearing Housing - Axis		2 Mils 5 Mils	Alarm SCRAM	Execute spectrum analyzer program for this channel; return to previous test point until alarm clears.
ZC-21	Control Signal Fault	C201B-45	1/2" and 57 1/2"	Out-of-Range Alarm	Check C201A fault panel. Switch rheostat control mode to manual and back electrodes out of overtravel.
ZE-84, -85, -85A, -87A, -86B, -87B	*Bearing film thickness, low. Alarm computer will calculate bearing clearance for 3 out of 5 revolutions; give alarm if run out exceeds 75% of available clearance.		Orbits of bearing motion are to be such that bearing clearance is not to be less than 25% of radial clearance as determined during most recent bearing probe calibration.		Return to previous test point or lower pump shaft speed to level where bearing orbit is reduced to clear alarm. Call Cognizant Engineer.

*Starred items are in the Alarm Computer

SPTF/ISIP STEADY-STATE ALARM SETPOINTS AND RESPONSES

SENSOR TAG NO.	PARAMETER	ALARM PANEL AND WINDOW	SETPOINT AND TYPE	CORRECTIVE ACTION
ZS-39	Lower Leakage Reservoir Pump Relief		Relief Valve Opened (1 GPM)	Check to see that drain valve is open.
ZS-43	Sodium Pump Oil Lift Pump Relief		Relief Valve Opened (845 Psig)	Check pressure at thrust bearing supply connection. If high, verify filter to be cleaned.
ZS-61	No. 1 Oil Circulating Pump Relief		Relief Valve Opened (130-140 Psig)	Switch to alternate pump. Isolate pump and check relief valve.
ZE-62	No. 2 Oil Circulating Pump Relief	C201B-24	Relief Valve Opened (130-170 Psig)	Switch to alternate pump. Isolate pump and check relief valve.
ZE-64	Sodium Pump Bearing Housing Pressure Relief		Relief Valve Opened (70 Psig)	Verify that outlet valves are opened.
TE-14-1 to -14-8 TE-26-1 to -26-8 TE-44-1 to -44-8 TE-62-1 to -62-8 TE-72-1 to -72-8	Pump Tank Thermal Gradient, Unheated Zone		At no time shall the side-to-side temperature gradient (DDIM column on L-ΔT printout) exceed 100°F. DDIM is printed out for five elevations in the unheated zone and four elevations in the heated zone.	The deviations should only occur during temperature changes. If they occur, discontinue heatup until internal temperatures equilibrate. If pump motor is off, perform torque checks prior to turning motor on.
TE-901-62, -65, -66, -71, -952A, -953A, -954A, -955A TE-1-2-3, -2-7, -3-3, -3-7, -4-3, -4-7, -5-3, and TE1-5-7	Pump Tank Thermal Gradient, Heated Zone		At no time shall the integrated L-ΔT (Total L-Δ-T EW and SN in L-ΔT printout) exceed 2775°F-in. Prior to sodium fill operations, the "HEATED L-DELTA-T," south and west, shall not exceed 6100°F-in.	

NOTE: ALL ALARMS ARE TO BE RECORDED AND BROUGHT TO THE ATTENTION OF THE NEXT OPERATIONS ENGINEER AND COGNIZANT ENGINEER. IF ANY ALARM OCCURS AS A RESULT OF CHANGING OPERATING POINT, RETURN TO PREVIOUS POINT UNLESS OTHER CORRECTIVE ACTION SPECIFIED. FOLLOWING ALL PUMP TRIPS, THE HIGH RATE DISC DATA IS TO BE DUMPED ONTO TAPE.

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, ETEC must bring the pump back to the last safe operating point and avoid any test points in the unsafe operating region. The AI ESG representative at ETEC 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^{o}F Minimum 104^{o}F, for 1110 rpm 121^{o}F, maximum
Electrode Position (For starting Main Drive Motor)	Top of Normal Travel (Maximum Resistance)
Control Mode (For Starting Main Drive Motor)	Set up for "Automatic" or "Manual"

d) Pony Motor Starting

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

e) Pump Startup Restrictions

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

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

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

2. Running Limits

a) Main Motor

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

Parameter	Range/Limit
Stator Winding (RTD @2A)	90°C Rise (based on 40°C ambient)
Upper Guide Bearing	Minimum of 55°C Rise or 95°C
Lower Guide Bearing	Minimum of 55°C Rise or 95°C
Thrust Bearing	Minimum of 55°C Rise or 95°C
Voltage	3785 - 4530

b) Rheostat

Parameter	Range/Limit
Electrolyte Temperature	68°F to 135°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°C Rise
Voltage	435 - 520

d) Pump Structure

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

e) Hydrostatic Bearing

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

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

f) Motor Power

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

g) Tank Gradient Requirements

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

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

3. Tank Gradient Criteria for Sodium Fill

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

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

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

TABLE J-1

REQUIRED OPERATOR ACTION TO SELECTED ALARMS

<table>
<tr><th>ALARM</th><th>STEADY STATE (NOTE 2)</th><th>THERMAL TRANSIENT (NOTE 3)</th></tr>
<tr><td>High Main Motor Power

(See Note 1)</td><td>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.</td><td rowspan="2">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.</td></tr>
<tr><td>High Sodium Bearing Temp.

(See Note 1)</td><td>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.</td></tr>
<tr><td>Low Operating Clearance in Sodium Brg.</td><td>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.</td><td>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.</td></tr>
</table>

NOTE 1 - A second level alarm will automatically trip main motor if condition worsens.

NOTE 2 - Includes pump operation at stable or slowly changing speed, flow and temp conditions; no operator action is required for a power alarm during pump startup and/or controlled speed changes.

NOTE 3 - Includes pump operation during transient application period and post transient thermal soak.

NOTE 4 - Perform rotor torque check. If torque is normal, idling operation on pony motor is permissible while waiting for special engineering instructions.

APPENDIX K

Initial Powered Operation of the Prototype Pump

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

1. Initial Powered Pump Operation on Pony Motor

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

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

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

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

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

Repeat the post-run checks.

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

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

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

Check pump rotational torque and record the reading.

This completes the initial pony motor checkout of the pump.

2. Initial Powered Pump Operation on Main Motor

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

APPENDIX L

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

TABLE M1

INSTRUMENTATION RECORDING SUMMARY

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

N266RFT00002
Page 73

T. LE M1

INSTRUMENTATION RECORDING SUMMARY

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

TABLE M1

INSTRUMENTATION RECORDING SUMMARY

Item	Instr.	Description	Recording System DAS	FM 3.75 IPS	FM 15 IPS	Man.	Alarm	Trip	Comment
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			X						
411	FT-101AM	Venturi Flow (Low) gpm	X						Reduced from It. 422
412	FT-101BM	Venturi Flow (High) gpm	X						
413	NE-23	Airborne Noise			X				
414	PDT-26	Pump Delta Press.	X						
415	PT-105	Discharge Pressure	X	X			X	X	
416	PT-111	Suction Pressure	X	X					
417	PT-113	Cover Gas Pressure	X				X		
418	PT-115	Cover Gas Pressure	X						
419	TE-119	Discharge Temp	X					X	
420	TE-120	Suction Temp	X				X		
421	--	Pump Deck Temp				X			
422	FT-101A	Venturi Flow (Low) (in H_2O)	X						

TABLE M1

INSTRUMENTATION RECORDING SUMMARY

Item	Instr.	Description	Recording System DAS	FM 3.75 IPS	FM 15 IPS	Man.	Alarm	Trip	Comment
501	LT-40	Tank Level - Induc.	X				X	X	See Appendix F for Set point
502	LT-42	Tank Level - Delta P	X				X	X	See Appendix F for Set point
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									
514									
515									
516									
517									
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524									
525	TE-0-19								

TABLE M1

INSTRUMENTATION RECORDING SUMMARY

Item	Instr.	Description	Recording System			Man.	Alarm	Trip	Comment
			DAS	FM 3.75 IPS	FM 15 IPS				
526									
527									
528									
529									
530									
531									
532									
533									
534									
535									
536									
537									
538									
539									
540	TE-0-34	Brg. Feed Up Mix - 158ccW	X						
541									
542									
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	DAS	FM 3.75 IPS	FM 15 IPS	Man.	Alarm	Trip	Comment
			Recording System						
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						

INSTRUMENTATION RECORDING SUMMARY

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

TABLE M1

INSTRUMENTATION RECORDING SUMMARY

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

TABLE M1
INSTRUMENTATION RECORDING SUMMARY

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

TABLE M2

DATA COLLECTION REQUIREMENTS

PARA.		DESCRIPTION	DIGITAL TAPE SCAN RATE	STANDARD DATA SLICE (NOTE 1) FREQUENCY	OTHER
1.	6.5.1	Assembly	-	-	As Specified in Test Descr. Text
2.	6.5.2	Aux. System C/O	-	-	As Specified in Test Descr. Text
3.	6.5.3	Preheat & Sodium Fill	12 Scans/hr	-	As Specified in Test Descr. Text
4.	6.5.4 (2)	Pony Jogs	1 Per Sec	-	L-Delta-T at Test Start
5.	6.5.4 (3)	Pony Run In	2 Per Min	2 Per Hour	
6.	6.5.4 (4)	Main Motor Jogs	1 Per Sec	-	
7.	6.5.4 (6)	Heatup to 500^{o}F	2 Per Min	2 Per Hour	L-Delta-T Once Per Hour
8.	6.5.4 (7)	Probe Calibration	-	-	Calibration Record
9.	6.5.4 (8)	Heatup to 600^{o}F	2 Per Min	2 Per Hour	L-Delta-T Once Per Hour
10.	6.5.4 (9)	Probe Calibration	-	-	Calibration Record
11.	6.5.4 (10)	Heatup to 700^{o}F	2 Per Min	2 Per Hour	L-Delta-T Once Per Hour
12.	6.5.4 (11)	Probe Calibration	-	-	Calibration Record
13.	6.5.4 (12)	Wetting	2 Per Min	2 Per Hour	L-Delta-T at 4-Hour Intervals
14.					

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
15.	6.5.5.1	700°F Speed Scans	12 Scans/Min	Note 2	--
16.	6.5.5.2	700°F Flow Scan	12 Scans/min	Note 3	
17.	6.5.6.1 (1)	Temp Up to 750°F	2 Scans/Min	2 Per Hour	L-Delta-T Once Per Hour
18.	6.5.6.1 (2)	Probe Cal.	-	-	Calibration Record
19.	6.5.6.1 (3)	750°F R4 Speed Scan	12 Scans/Min	Note 2	--
20.	6.5.6.2 (1)	Temp Up to 800°F	2 Scans/Min	2 Per Hour	L-Delta-T Once Per Hour
21.	6.5.6.2 (2)	Probe Calibration	-	-	Calibration Record
22.	6.5.6.3 (1)	Temp Up to 850°F	2 Scans/Min	2 Per Hour	L-Delta-T Once Per Hour
23.	6.5.6.3 (2)	Probe, Level, Cal.	-	-	Calibration Record
24.	6.5.6.3 (3)	850°F R4 Speed Scan	12 Scans/Min	Note 2	
25.	6.5.6.4 (1)	Temp Up to 900°F	2 Scans/Min	1 Per Hour	L-Delta-T Once Per Hour
26.	6.5.6.4 (2)	Probe Calibration	-	-	Calibration Record

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
27.	6.5.7.1 (1)	Temp Up to 950^{o}F	2 Scans/Min	2 Per Hour	L-Delta-T Once Per Hour
28.	6.5.7.1 (2)	Probe, Level, Cal.	-	-	Calibration Record
29.	6.5.7.1 (3)	Pres., Flow & Speed Calibrations	-	-	Calibration Record
30.	6.5.7.1 (4)	950^{o}F R4 Speed Scan	12 Scans/Min	Note 2	
31.	6.5.7.1 (5)	950^{o}F R5 Speed Scan	12 Scans/Min	Note 2	--
32.	6.5.7.2	950^{o}F Flow Scan	12 Scans/Min	Note 3	
33.	6.5.8	Cavitation Tests	-	-	As Specified in Test Description
34.	6.5.9	2000-Hr Endurance	1 Scan/Min	1 Per Hour	L-Delta-T at 8-Hr Intervals

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.