PREPARED BY	Rockwell International Corporation Atomics International Division	NUMBER N266ST310001
D.R. Paradise System Performance Engr.	CODE IDENT NO. 09974	TYPE Design
		DATE 21 April 1978
CONCURRENCE 4/20/78 E. Andrews Quality Assurance	**SPECIFICATION**	SUPERSEDES SPEC DATED REV LTR. / PAGE 1 OF TOTAL PAGES 36

TITLE

PUMP, SODIUM, INDUCER, INTERMEDIATE SIZE (ISIP)
(Impeller/Inducer/Diffuser Retrofit)

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DOE/SF/76026--T23

AT03-76SF76026

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TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

SPECIFICATION FOR PUMP, SODIUM, INDUCER, INTERMEDIATE SIZE (ISIP)

1. SCOPE This specification defines the requirements for the Intermediate-Size Inducer Pump, (also referred to herein as the ISIP) which is to be made by replacing the impeller of the FFTF Prototype Pump with a new inducer, impeller, diffuser, seal, and necessary adapter hardware. Subsequent testing requirements of the complete pump assembly are included.

2. DOCUMENTS

2.1 Applicable Documents

American Society of Mechanical Engineers (ASME)

ASME Boiler and Pressure Vessel Code, 1977 Edition, including Summer 1977 Addenda

ANSI/ASME BPV-III-NCA	Division 1 and Division 2 Nuclear Power Plant Components; General Requirements
ANSI/ASME BPV-III-1-NB	Class 1 Components
ASME SA-182	Specification for Forged or Rolled Alloy-Steel Pipe Flanges, Forged Fittings, and Valves and Parts for High Temperature Service
ASME SA-351	Specification for Austenitic Steel Castings For High-Temperature Service
ASME SA-453	Specification For Bolting Materials, High Temperature, 50 to 85 KSI Yield Strength, with Expansion Coefficients Comparable to Austenitic Steel
ASME SA-637	Specification For Precipitation Hardening Nickel Alloy Bars, Forging Stock For High-Temperature Service
ASME SA-638	Specification For Precipitation Hardening Iron Base Superalloy Bars, Forgings, and Forging Stock for High-Temperature Service

Rockwell International Corporation, Atomics International Division

Drawing

N266E000002	Interface Control Drawing (ICD), "Intermediate-Size Inducer Pump"

Specification

N001A0110001	Cleaning and Cleanness
N001A0116001	Packaging and Packing for Shipping and Storage; dated 27 April 1977
N266RFT000001	Sodium Testing of Intermediate Size Inducer Pump in SPTF at LMEC

Department of Energy, Nuclear Power Development Division

RDT Standards

RDT F 2-2	Quality Assurance Program Requirements, August 1973, including Amendments 1 through 4
RDT F 8-6T	Hoisting and Rigging of Critical Components and Related Equipment with Amendments 1 through 3

Argonne National Laboratory (ANL)

ANL-7273	Thermophysical Properties of Sodium

International Conference of Building Officials

UBC-1976 Edition	Uniform Building Code

Westinghouse Electric Corporation

HWS-1551	LMFBR Low Capacity Prototype Pump -- FFTF Primary Pump, Rev. 1, January 1974, including addendum 1P (June 1977)
WDTRS 25.14, Rev. 18	Sodium Testing of the FFTF Prototype Pump
WEMD 114E829, Rev. 12	General Assembly, Prototype Sodium Pump

American National Standards

ANSI B46.1-1962 (R1971) Surface Texture

2.2 Other Documents (See 6.3).

3. REQUIREMENTS

3.1 Item_Definition The FFTF Prototype Pump's original construction requirements are defined in document HWS-1551. The basic pump frame for the ISIP is from the FFTF Prototype Pump. This specification defines the design, fabrication, assembly and test for utilizing this pump frame with a new inducer/impeller/diffuser and necessary adapter hardware in place of the original impeller. For a complete description of the FFTF Prototype Pump, refer to referenced Document a., (OMM-051-00-005, hereinafter referred to as OMM).

3.1.1 Interface_Definition The physical interface of the ISIP components are defined by ICD N266E000002. Changes in the interface shall be minimized wherein the pump shall be capable of being restored to its original configuration.

3.1.1.1 Impeller_Mounting Mounting of the inducer/impeller on the existing taper at the lower end of the pump shaft shall be designed for controlled advance onto the taper such that the stress criteria of Table 3-III are not exceeded.

3.1.1.2 Axial_Clearance At least one-half inch axial clearance shall be provided by the design above and below all rotating members.

3.1.1.3 Radial_Clearance Radial clearance at the wear rings and at the inducer vane tips shall be based on assembly stackup of tolerances for the parts determining the clearance, but in no case shall the radial clearance be less than 0.050 inch using the most adverse tolerance stackup.

3.1.1.4 Tool_Interfaces

a. The inducer, impeller, adapter diffuser, and other new parts (weighing in excess of 10 pounds) designated for installation into the existing pump frame, shall be designed to permit lifting and handling in accordance with the requirements of RDT F 8-6. In addition, the parts shall be designed to interface with the special assembly tools as part of the assembly procedure described in the specially addended version of the OMM.

b. Tool interface requirements shall be met by designing the parts to interface with existing, modified, or new special assembly tools (Refer to 3.4.6).

c. The bearing support flange (approximate weight 10,000 pounds) shall be positioned and supported

from the impeller (or shaft) during upending and installation of the shield plug/support cylinder (SP/SC) over the shaft. During installation, the shaft assembly shall be supported from the lower end.

3.2 Performance

3.2.1 Hydrodynamic Design Point The hydraulic design conditions for which the pump shall be designed shall be in accordance with Table 3-I.

3.2.2 Range of Operation The range of operation for which the inducer and impeller and associated components shall be designed is presented in Table 3-II, which also includes the design point, and is depicted in Figures 3-1A and 3-1B.

3.2.2.1 Operating Life The inducer and impeller shall be designed for testing over the operating ranges depicted in Figures 3-1A, 3-1B and under the suction conditions (NPSHA) given in 3.2.2.3. The test time shall be 2,000 hours, of which 1,000 hours will be at design temperature (1050F). The second 1,000 hours (equally distributed) shall be at temperatures of 400, 600, and 800F. In addition, the test will include a four-point, full-speed cavitation performance test at 1050F. The suction pressure will be reduced to the point of 3.5 percent reduction in head across the pump at 14,000, 14,500, 16,000 and 18,000 gpm.

After performance testing, a 2,000 hour endurance test at 14,500 gpm shall be conducted with a 200 percent NPSH margin over the value determined for a 3 percent reduction in head. Verification of design shall be by usual inspection of the impeller and inducer after testing. The criteria for success shall be the absence of visual evidence of pitting or other material damage (which can be attributed to cavitation) when reviewed with the unaided eye.

3.2.2.2 System Resistance The specific speed (NS) curves shown on Figure 3-1A represent coincident system resistance curves for a particular head-capacity characteristic. In order to determine the corresponding system resistance characteristics, parabolic system resistance curves ($H = KQ^2$) shall be assumed through the origin and each of the following head-capacity points:

NS	H(ft)	Q(gpm)	EQUATION
755	608	7,300	$H = 1.1409 \times 10^{-5}Q^2$
1050	574	10,500	$H = 5.2063 \times 10^{-6}Q^2$
1930	357	20,470	$H = 8.5199 \times 10^{-6}Q^2$
3000	90	15,680	$H = 3.6606 \times 10^{-7}Q^2$

3.2.2.3 Net Positive Suction Head Available The net positive suction head available (NPSHA) to the pump varies with output flow rate at 1050F in accordance with the following relationship:

$$NPSHA = 56.5126 - 1.125 \times 10^{-8}Q^2 \quad \text{(ft)}$$

Where: NPSHA = Net Positive Suction Head at pump inlet nozzle, minus the elevation difference, in feet, from the inducer inlet elevation down to the inlet nozzle centerline. (ft)

Q = Output volumetric flow rate (gpm)

(NOTE: Inducer inlet flow may be slightly higher than pump outlet flow due to internal leakage.)

3.2.3 Suction Performance

3.2.3.1 Net Positive Suction Head Required (NPSHR) The principal criteria to be used in evaluating the inducer/impeller relative to the conventional impeller, shall be the suction performance. Suction performance shall be evaluated on the basis of the NPSHR to limit the pump head loss due to cavitation to 3 percent of the initial noncavitating head in a fixed throttle valve, constant speed test. The NPSHR shall be reported at the flow at which the 3 percent limit was reached. For this evaluation, the parameter NPSHR shall be calculated in the same manner as used for sodium testing of the FFTF Prototype Pump, i.e., NPSH at the pump inlet centerline; refer to reference Document b..

The design target values for NPSHR are shown in Figure 3-2, as a function of actual-to-design flow ratio. The volumetric flow rate, corresponding to the unity value for actual-to-design flow ratio, shall be selected to provide maximum margin against cavitation damage over the life of the pump when the pump is operated in accordance with 3.2.2.

3.2.3.2 Suction Demonstration Capability Requirement The pump shall be capable of demonstrating operation at design speed (1,110 rpm) and runout flow (18,000 gpm) with full temperature (1050F) and suction conditions corresponding to minimum submergence (4 ft above impeller discharge centerline) and minimum gas pressure (36 ft abs of sodium at 1050F) with less than 3 percent decrease in head due to cavitation.

Equivalent submergence and cover gas pressure combinations may be used for this demonstration.

3.3 Design Requirements

3.3.1 Stress Criteria All parts (except instrumentation) shall be designed and analysed to meet the structural design criteria of Table 3-III.

3.3.1.1 Steady-State Conditions A reduction of the structural design criteria in Table 3-III shall be determined and the reduced criteria used for design under steady-state temperature conditions.

3.3.1.2 Thermal Transients The design shall be analyzed to identify which of the test thermal transients described in Table 4-II may be run without exceeding the structural design criteria of Table 3-III. The pump shall be analyzed subsequently to determine which thermal transients, listed in HWS-1551, the pump could withstand without exceeding the structural design criteria of Table 3-III.

The foregoing analysis shall be limited to use of elastic and simplified inelastic methods. Those areas where inelastic analysis would be required shall be identified.

3.3.2 Mechanical Load Criteria

3.3.2.1 Unbalanced Rotating Loads The impeller and inducer design shall include provisions to permit dynamic balancing of the inducer-impeller assembly within 3.5 inch-ounces at each balance plane when mounted on a balance spindle.

3.3.2.2 Radial Thrust Loads Design of the inducer, impeller, and diffuser adapter shall be such that polar symmetry is maintained.

3.3.2.3 Axial Thrust Loads The wear ring diameters shall be designed to maintain axial thrust between the limits of 70,000 pounds upward and 40,000 pounds downward over the operating range of the pump. Axial thrust calculations shall consider the possibility of at least ten percent difference between the static head at the tip of the lower (front) shroud and static head at the tip of the upper (back) shroud. Balance piston arrangements based on variation of axial clearances shall not be used to balance axial thrust.

3.3.3 Design for Recirculating Flows The design shall include internal passageways to permit ducting flow from the lower end of the hydrostatic bearing and recirculating flow from the back wear ring of the impeller, to a low pressure

region of the inducer/impeller assembly. Flow from the bearing will be 100 gpm at design conditions. To minimize distortion under thermal transient conditions, passageways shall be symmetrical about the pump axis. At design operating conditions, passageways shall be sized to maintain the static pressure below the hydrostatic bearing to less than 18 psi above the inducer inlet pressure.

3.3.4 Drainability and Venting All internal parts shall be designed for self draining and venting. The use of drain holes and vent holes at specific locations shall be acceptable providing flow through these holes is considered in the hydrodynamic design. Concurrent draining and venting through the same holes shall not be permitted.

3.3.5 Threaded Fasteners All internal threaded fasteners shall be positively locked to prevent loosening (friction locks are not acceptable), and the head of the fastener shall be trapped to prevent entry into the fluid stream in the event of failure of the fastener shank. Unless otherwise specifically required, threads shall be the coarse thread series (UNC) and shall have a nominal diameter of one-half inch or greater.

3.3.6 Special Tool Design Special tools, or equipment to permit adapting existing special tools to the ISIP, shall be provided as required to permit handling and assembly of the pump internals. The design, fabrication, and proof testing of all lifting tools shall conform to the requirements of RDT F 8-6 for tackle. Support stands and similar static equipment shall meet the requirements of the Uniform Building Code for this region. Tool surfaces designed to contact the stainless steel pump parts shall be corrosion resistant. Stainless steel, nickel plate, chrome plate or nylon are chemically suitable contact surface materials. The design of the special tools shall permit assembly of the ISIP as described in the OMM (Refer to 6.3a).

3.3.7 Critical Speed The calculated critical speed of the rotating assembly, including the ISIP inducer and impeller, shall not be more than 5 percent below the calculated critical speed for the FFTF Prototype Pump.

3.3.8 Direction of Rotation The inducer and impeller shall be designed to rotate counterclockwise when viewed from the pump drive end (top).

3.4 Identification and Marking Identification and marking of parts shall be according to applicable detail design drawings.

3.5. Materials, Processes and Parts

3.5.1 Material Specification Material for the major parts shall conform to the following material specifications:

Part	Material Specification
1. Inducer 2. Diffuser 3. Diffuser Adapter	Forging, Grade F 304 Austenitic Stainless Steel, conforming to requirements of ASME SA-182; to the requirements of ANSI/ASME BPV-III-1-NB, Article NB-2000, and supplemental requirements to be specified by AI.
4. Impeller	Casting, Grade CF8 Austenitic Stainless Steel, conforming to the requirements of ASME SA-351; to the requirements of ANSI/ASME BPV-III-1-NB, Article NB-2000, and to the supplemental requirements to be specified by AI.
5. Bellows Seal	Nickel Alloy, Grade 718, percipitation hardened condition, made from double vacuum melted ingot.
6. Bolting Stock (Threaded fasteners, shaft keys, etc.)	(A286 Bolting Stock) Conforming to ASME SA-638, Grade 660, Type 2 or ASME SA-453, Grade 660 Class B.

3.5.2 Fluid Properties The thermophysical properties of sodium to be used for this design and subsequent test evaluation shall be according to ANL-7323.

3.5.3 Fabrication Procedures

a. Equipment Protection Extreme care shall be exercised to protect all surfaces from contamination during fabrication, handling, testing, and storage. Precautions necessary to ensure such protection shall be incorporated in the detailed component or fabrication procedure. Detailed procedures for cleanliness control, in-

process cleaning, and final cleaning of all parts, components, and assemblies shall be utilized.

b. Sensitization After rough machining and prior to final machining, the inducer, impeller, diffuser, and adapter shall be given a supplemental heat treatment in order to develop maximum dimensional stability. These heat treated parts shall be subsequently protected from moisture which can promote intergrannular attach or stress corrosion. Contaminates to be avoided include oxidizing agents (such as nitric acid), halide environments (such as salt air or fluorides from weld fluxes or smoke) and caustic solutions (such as hydroxides).

c. Fabrication and Assembly Interchangeability Marking The designer shall identify and mark on the component drawings the reference surfaces used during fabrication to achieve or maintain perpendicularities or concentricities.

Identification marks shall be shown on drawings and on the articles themselves.

d. Surface Finish The definitions, measurement and designation of surface finishes shall be in accordance with ANSI B46.1.

e. Welding All weld joints (except lock welds) in contact with sodium shall be full penetration welds, designed to permit radiographic examination and shall be in accordance with Subarticle NB-4400 of the Code. Lock welds shall be visually examined under 5X magnification.

f. Special Processes Any nonstandard fabrication processes employed shall be identified and a procedure for their application specified. Examples of nonstandard processes are electro-discharge or electrochemical machining and electron beam welding.

g. Cleaning All cleaning shall be in accordance with the requirements of AI Specification N001A0110001. Final cleaned surfaces shall meet the requirements for cleanness Level 3. All cleaning procedures shall be submitted and approved by AI.

h. Lubricant/Coolant A lubricant/coolant may be employed during machining operations provided it does not contaminate any crevice or inacessible

area that cannot be subsequently cleaned, and provided the lubricant is removed after completion of all operations. Lubricants used on austenitic stainless steel shall have a sulfur or chloride content of less than 5,000 ppm.

TABLE 3-I

HYDRODYNAMIC DESIGN POINT

Flow Rate	14,500 gpm
Total Head Across Pump	500 ft
Shaft Speed	1,110 rpm
*Minimum Submergence (above impeller discharge centerline)	4 ft
**Minimum Cover Gas Pressure (at minimum submergence)	36 ft Na absolute (at 1050F)
Fluid	Sodium
Fluid Inlet Temperature	1050F
Fluid Density	50.97 lb/ft^3

*Refer to 3.2.2 for normal operating conditions.

**Resulting NPSH is approximately 41.3 ft, referred to inducer inlet elevation. This value includes pump inlet velocity head, but does not include internal suction elbow losses.

TABLE 3-II

PERFORMANCE REQUIREMENTS

1	Design flow rate, gpm	14500
2	Total head at design flow rate, ft.	500
3	Design speed, rpm	1110
4	Minimum sodium level above impeller discharge centerline, ft.	4
5	Minimum cover gas pressure at minimum sodium level, ft of sodium absolute, 1050F	36
6	Maximum required NPSH at design flow rate, ft.	Note 1
7	Maximum required NPSH at runout flow rate, ft.	Note 1
8	Flow rate, at pony motor speed, gpm (maximum	1400
9	Total head at shutoff, ft. (maximum)	Note 2
10	Total head (at pony motor speed) ft. (see Note 3)	5 (max)
11	Runout flow rate, gpm	18000
12	Runout head, ft. (minimum)	375
13	Maximum inlet temperature, F (See Note 4)	1050
14	Minimum inlet temperature, F	350
15	Allowable change of free-surface level, ft.	11
16	Performance rangeability N	Note 5

NOTES:

1. The minimum available NPSH at a flow of 18,000 gpm shall be that corresponding to minimum cover gas pressure occuring concurrently with minimum sodium level. The pump shall not cavitate at any specified operating flow up to 18,000 gpm at the design speed under this level and cover gas pressure. Cavitation shall not be considered to exist until the total head

drops 3 percent from the noncavitating head at the specified flow and design speed.

2. A stable (negative slope) head-capacity curve between flows of 7,000 to 18,000 gpm at design speed shall be a design objective. A shutoff head (at design speed) not less than the head developed at a flow of 7,000 gpm shall also be a design objective. A runout head of greater than 375 ft. is specified to assure smooth, stable operation at runout.

3. At pony motor operation, the maximum allowable head shall be 5 ft. A design objective at pony motor speed is to meet 4 ft. head at a low of 1,100 to 1,450 gpm.

4. For the maximum outlet temperature, the heat input from the pump shall be taken into account.

5. The pump shall be capable of continuous operation between the boundaries shown on Figure 3-1A.

TABLE 3-III

STRUCTURAL DESIGN CRITERIA STRESS LIMITS FOR DESIGN OF THE ISIP INDUCER, IMPELLER, AND DIFFUSER

A. HIGH TEMPERATURE CRITERIA (≥800°F)

Use Code Case 1592-10 (as guidance)

A.1 Primary Stress Limits

A.1.1 Design Condition

Design Pressure + Dead Load + Design Mechanical Load (includes seismic)

$$P_M \leq S$$

$$P_M + P_b \leq 1.5S_o$$

A.1.2 Normal Operating Conditions

Pressure + Thermal + Mechanical Loads + Dead Weight

$$P_M \leq S_{Mt}$$

$$P_L + P_b \leq kS_{Mt}$$

$$P_L + \frac{P_b}{K_t} \leq S_t$$

A.2 Secondary Stress Limits

A.2.1 Strain Accumulation Limits

Average Inelastic Strain ≤ 0.5% weld
1.0% base material

or

$$X + Y \leq S_a/S_y$$

$S_a = 1.25\ S_t$ (maximum temperature for 10^4 hours)

S_y = Yield at average temperature of cycle $\frac{T_{MAX} + T_{MIN}}{2}$

or

TABLE 3-III

STRUCTURAL DESIGN CRITERIA STRESS LIMITS FOR DESIGN OF THE ISIP INDUCER, IMPELLER, AND DIFFUSER (continued)

$$X + Y \leq 1$$

$T_{MIN} \leq$ temperature at which $S_M = S_t$ at 10^5 hours

A.2.2 Creep Fatigue Limits

$$\frac{\Sigma b}{Na} + \frac{\Sigma t}{Td} \leq 0.6$$

Figure 3-3 shall be used as the design fatigue curve for pressure or other high-cycle oscillations.

B. LOW TEMPERATURE CRITERIA (≤800°F)

Section III, Subsection NB (as guidance)

B.1 Primary + Secondary Stress Limits

B.1.1 Design Condition

Design Pressure + Design Dead Weight + Design Mechanical Load (include seismic)

$$P_M \leq S_M$$

$$P_L + P_b \leq 1.5S_M$$

B.1.2 Normal Operating Condition

Pressure + Thermal + Mechanical Load + Dead Weight

$$P_L + P_b + Q \leq 3S_M$$

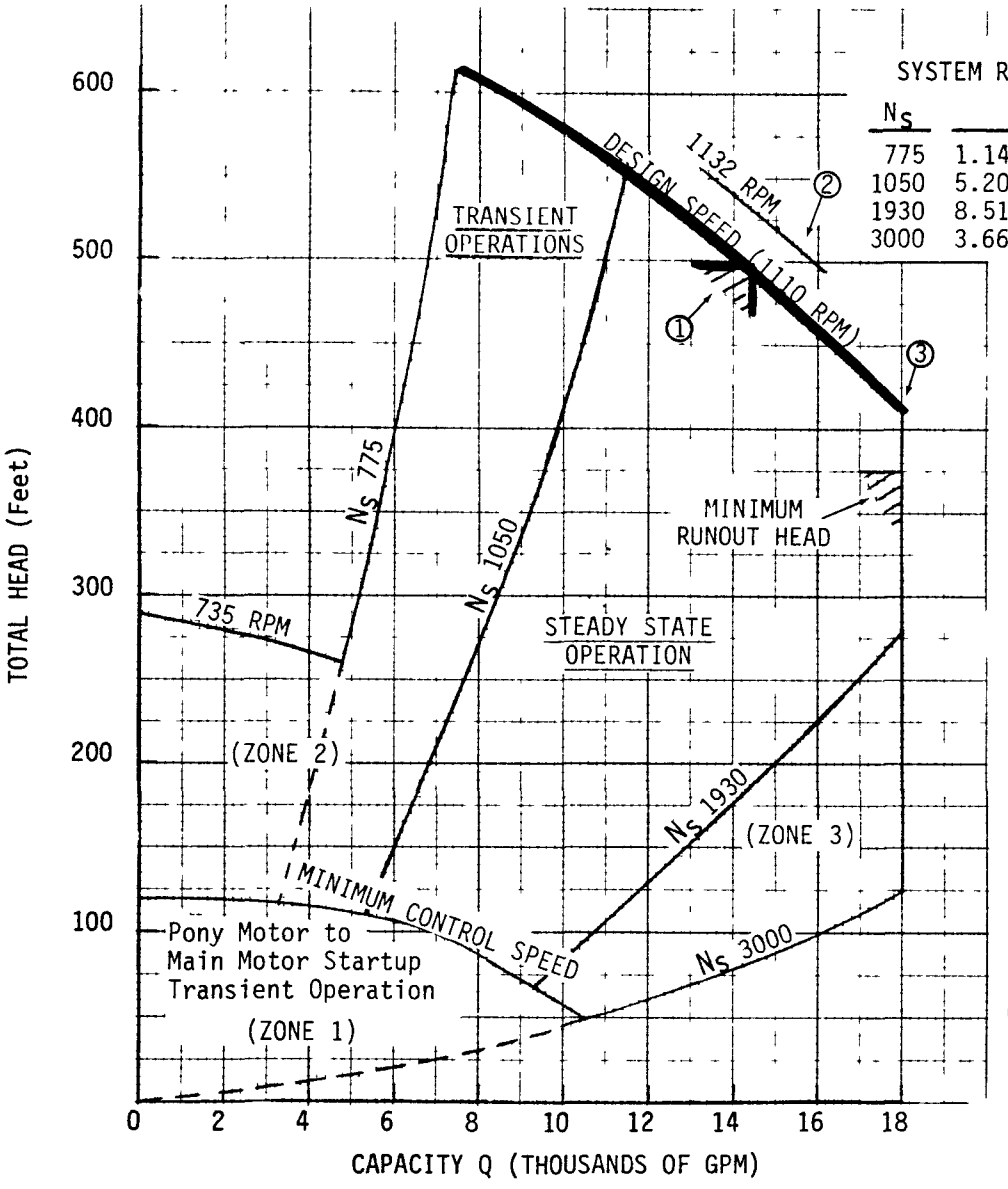


Figure 3-1A
Pump Main Motor
Operation Envelope

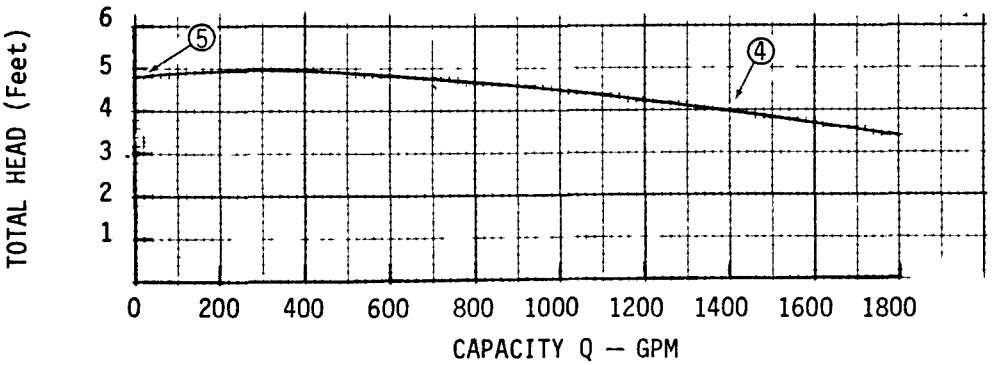


Figure 3-1B
Pump Pony Motor
Operation Envelope

Refer: HWS-1551, Fig. 2

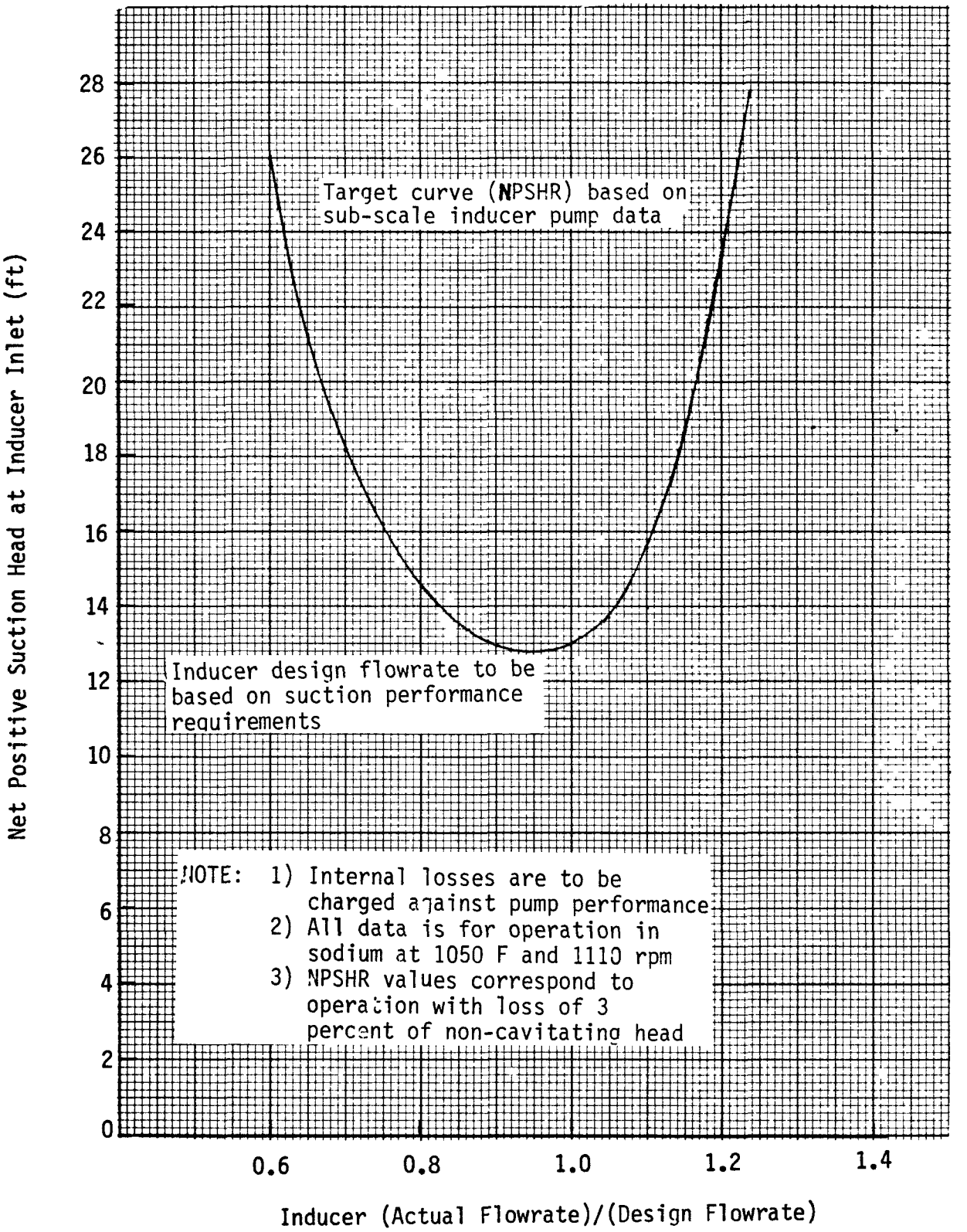
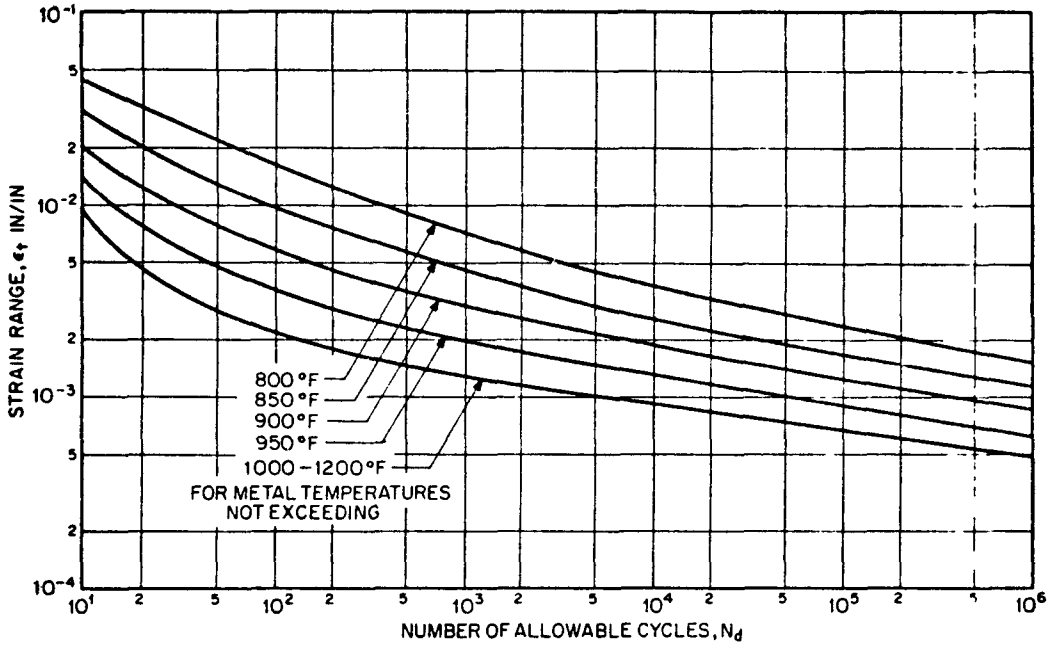


Figure 3-2. Suction Performance NPSHR Target Values for Intermediate Size Inducer Pump (ISIP)



Design fatigue strain range, ϵ_t, 304 SS and 316 SS — elastic analysis

Design Fatigue Strain Range, ϵ_t, for 304 SS and 316 SS (Elastic Analysis)

N_d Number of Cycles	ϵ_t, Strain Range (in./in.) at Temperature				
	800 F	850 F	900 F	950 F	1000-1200 F
10^1	.0448	.0303	.0201	.0107	.00915
2×10^1	.0318	.020	.0124	.0078	.00472
4×10^1	.0231	.0145	.00867	.0051	.00322
10^2	.0168	.00982	.00587	.00355	.00212
2×10^2	.0125	.00772	.00469	.0028	.00174
4×10^2	.00956	.00612	.00387	.0024	.00152
10^3	.00711	.00462	.00304	.00198	.00129
2×10^3	.00576	.00382	.00257	.00173	.00114
4×10^3	.00476	.00322	.00222	.00153	.00104
10^4	.00376	.00261	.00186	.0013	.000922
2×10^4	.00316	.00222	.00164	.00116	.000842
4×10^4	.00269	.00202	.00144	.00106	.000762
10^5	.00224	.00162	.00122	.000899	.000662
2×10^5	.00196	.00147	.00108	.000799	.000602
4×10^5	.00176	.00131	.000966	.000719	.000544
10^6	.00151	.00112	.000826	.000619	.000482

Reference ASME Code Case N-47 (1592-10), Fig . T-1430-1A,1B and Table 1430-1A,1B

Figure 3-3

4. QUALITY ASSURANCE PROVISIONS

4.1 Quality Assurance Program A quality assurance program shall be established and maintained meeting the requirements of RDT F 2-2, Section 1, Section 2 (except 2.5.1), Section 3 (except 3.3.5 and 3.9), Section 4 (except 4.12), and Section 5 (except 5.3, 5.9 and 5.14).

4.2 Design Verification Compliance with the design requirements of Section 3 of this specification, shall be demonstrated by analysis and accepted procedures (See Table, Appendix 20) and verified by an independent formal design review.

4.3 Quality Examination

4.3.1 Visual and Dimensional Examination All fabricated parts shall be subjected to a visual examination and a dimensional check to verify compliance with drawings and applicable specifications.

4.4. Test Requirements

4.4.1 Test Scope Testing is considered to start with the recording of the receipt of inspection data and to continue through assembly, installation, performance testing, removal, cleaning, and post-test inspection. All information regarding the condition or performance of the pump and its auxiliaries, whether or not the information concerns the inducer, shall be considered as test data.

4.4.2 Assembly and Installation Pump parts shall be received, inspected, and assembled in accordance with the addended OMM by the testing organization. Follcwing assembly of the internals, the internal subassembly shall be installed in the pump tank, then installation of the motor and connection of auxiliaries completed. Assembly and installation shall be performed in accordance with specific procedures in accordance with OMM requirements.

4.4.2.1 Special Tools In addition to the operating equipment, there is a set of special tools used for assembly and disassembly of the pump. These tools are "pump peculiar," designed specifically to meet pump requirements. Other general purpose and "facility peculiar" tools are not included.

For complete description of the special tools, refer to the OMM.

4.4.3 Instrumentation and Controls Instrumentation to be used for sodium testing of the ISIP shall be the same, or equivalent to, instrumentation used for testing the prototype FFTF pump during Phase B tests, with the exception of the mid-shaft bearing probes which will be deleted. The complete list of instrumentation is described in N266RFT000001.

4.4.3.1 Internal Instrumentation Internal instrumentation, consisting of thermocouples, accelerometers, and proximity probes, and including necessary clips and penetration seals, will be supplied by AI for installation by the LMEC testing organization.

4.4.3.2 External Instrumentation Controls and Equipment External instrumentation, controls and auxiliary equipment (4.4) shall be supplied by the LMEC testing organization.

4.4.4 Auxiliary Equipment Auxiliary equipment requirements, in addition to the liquid rheostat shall include:

a. The liquid rheostat control cabinet (C201A).

b. An alarm/monitor control cabinet (C999 - sometimes referred to as (C201B) which includes an annunciator panel, lube oil and motor temperature indicators and which functions as an interface junction between the pump and the facility control system.

c. An oil lubrication system to provide oil circulation, cooling and filtration for the upper, oil lubricated bearings. Includes indicators of temperature, pressure, and level to monitor performance of the oil lubrication system.

4.4.5 Performance Testing After all equipment has been installed and preoperational checkouts completed per the OMM, pump performance tests shall be performed. The performance test shall repeat those selected tests performed during Phase B testing of the prototype pump (refer to WDTRS 25.14) in accordance with the Request for Test (Refer 6.2.2) and detail test procedures to be prepared by the LMEC test organization. The sequence of the previous Phase B tests shown in Table 4-I shall be used. Temperature ranges and rates for thermal transient testing shall be as listed in Table 4-II. In addition, a 2,000 hour endurance test shall be run at design speed, flow and temperature with a 200 percent NPSH margin over the 3 percent head reduction requirement.

4.4.6 Cleaning and Disassembly Removal from the pump tank, cleaning and disassembly of the ISIP shall be performed in

accordance with the addended OMM using detail procedures prepared by the test organization. During removal, the pump internals shall be maintained in an inert atmosphere until cleaned. The alcohol cleaning process shall be used. Following general cleaning, disassembly and spot cleaning (as required) shall be completed. All disassembled parts shall be inspected and inspection data recorded on special data forms provided in the addended OMM.

TABLE 4-I

TEST SEQUENCE

Sequence Number	Test Identification (WDTRS 25.14)	Test Description
1.	7.2.1	Pump Assembly and Installation
2.	7.2.2	Auxiliary System Check
3.	7.2.3	Preheat and Sodium Fill
4.	7.2.4	Initial Startup and Operation During Wetting
5.	7.2.5.4	Pony Motor Flow Scan
6.	7.2.5.5	Main Motor (R4) Speed Scan
7.	-	500 rpm Flow Scan(1)
8.	7.2.7.1	700 F Checkout
9.	7.2.7.2	750 F Checkout and Speed Scan & Endurance Test
10.	7.2.7.4	800 F Checkout
11.	7.2.7.5	850 F Checkout and Speed Scan
12.	7.2.7.8	900 F Checkout
13.	7.2.8.1	950 F Checkout and Speed Scans & Endurance Test
14.	7.2.9(a)	1000 F Checkout
15.	7.2.9(c)	1050 F Checkout
16.	7.2.10.1	1050 F Speed Scans & Endurance Test
17.	7.2.11.A	Minimum NPSHA Demonstration
18.	7.2.11.B	Cavitation Performance
19.	7.2.12	Post-Cavitation Checkout
20.	7.2.7.3	Low-Temperature Thermal Transients 201, 202, & 203
21.	7.2.7.6	Mid-Temperature Thermal Transients 204 & 205
22.	7.2.7.6	High-Temperature Thermal Transients 206, 207, 208, & 210
23.	7.2.10.3	Design Point Endurance Test

(1) Test needs to be based on results of Pony Motor Flow Scan.

TABLE 4-II

TEST THERMAL TRANSIENTS(1)

Event	Initial(2)(3) Speed/Flow (rpm/gpm)	Initial Temp. (F)	Final Temp. (F)	Temp. Change (F)	Trans Rate (F/sec)	Main Drive Trip	Soak Time (hr)
201	1,110/14,500	750	600	-150	-0.4	No	6
202	1,110/14,500	750	600	-150	-1.5	No	6
203	1,110/14,500	500	650	+150	+1.5	No	6
204	1,110/14,500	850	650	-200	-2.0	No	8
205	1,110/14,500	700	850	+150	+1.5	No	6
206	500/12,000	1050	720	-330	-0.4	Yes	12
207	1,110/14,500	1050	720	-330	-1.2	No	12
208	1,110/14,500	1050	825	-225	-2.0	No	9
210	1,110/14,500	1050	900	-150	-3.0	No	6

(1) Reference WDTRS 25.14.

(2) Initial speed and flow is shown at the beginning of the thermal transient.

(3) All thermal transient events shall be run with constant speed and discharge throttle valve settings, and with a constant sodium level within facility level control limits.

5. PACKAGING AND PACKING Finished component castings, forgings and machined parts shall be packaged and packed in accordance with the requirements of AI Specification N001A0116001. Packaging to Level A shall be required to maintain a dry argon purge gas environment during shipment and storage. Packing to Level B applies using wood packing crates.

6. DOCUMENTS, DATA, AND REPORTS

6.1 Drawings Drawing requirements for the ISIP shall include the following:

a. General Assembly Drawing

b. Engineering Layout Drawing

c. "Spot" Layout Drawings (as required)

d. Detail Drawings

e. Interface Control Drawing

6.1.1 General Assembly Drawing The general assembly drawing shall be the top level drawing for the ISIP, through which access to all other drawings can be attained. This drawing shall be a modified or addended version of the existing Westinghouse drawing 114E829 for the FFTF Prototype Pump.

6.1.2 Engineering Layout Drawing The engineering layout drawing shall be a cross-section assembly drawing showing assembled dimensions, tolerances, and clearances for the inducer/impeller and its hydrodynamic surroundings. This drawing shall have sufficient dimensional data and auxiliary views to permit engineering stress and thermal analysis. The layout drawing shall be maintained in an up-to-date status as new or revised dimensional data is received.

6.1.3 Spot Layout Drawings Spot layout drawings shall be prepared as required to show assembled dimensional information in local regions. These drawings shall be for temporary use in providing up-to-date engineering information as the design develops and as supplements to the overall layout drawing between update periods.

6.1.4 Detail Drawings Detail drawings shall be prepared for each new part showing all the requirements for fabricating and inspecting the part.

6.1.5 Interface Control Drawing An interface control drawing shall show all dimensional and functional interface data required for the design of new parts. The source of all data shall be referenced on the drawing.

6.2 Documentation

6.2.1 Reports The following reports shall be prepared to record and support the design, analysis, and test effort:

a. Hydrodynamic design report

b. Steady-state stress analysis report

c. Final design report, including thermal transient analysis

d. Interim test reports

e. Final test report, including post-test inspection

f. Status reports, weekly and monthly, to report project status with relation to established milestones, recent accomplishments, and problem areas.

6.2.2 Request for Test A Request for Test shall be prepared in accordance with requirements of the test facility, describing all those tests to be run and the sequence of testing to be used. In addition, the Request for Test shall define restrictive limits, non-test operation of the pump, and data recording and reporting requirements. The Request for Test shall contain sufficient detail to permit preparation of test procedures by the testing organization.

6.2.3 Operations and Maintenance Manual (OMM) Addendum An addendum shall be prepared for the existing OMM (refer document a.) to cover assembly, disassembly, and inspection of those new parts used to construct the ISIP from the existing prototype pump. The addendum shall include graphic material and detail instructions for the use of special tools at least to the extent presently provided in the existing manual.

6.3 Reference Documents

a. OMM-051-00-005, Rev. 2, Westinghouse Electric Corporation Electro-Mechanical Division (WARD), "Operation and Maintenance Manual, Liquid Metal Coolant Pump, Model LMP-1, for the Fast Flux Test Facility (Prototype and Primary) Contract E(45-1)-2170."

b. 77 LMEC-DRF-2476, letter from R.E. Fenton (LMEC) to T.A. Mangelsdorf (HEDL), "FFTF Prototype Pump - Phase B - Minimum NPSH Demonstration at Runout Flow and Pump Cavitation Performance at Selected Flowrates," July 19, 1977.

c. Engineering Memorandum 4438, Westinghouse Electric Corporation, E-M Division, "Stress Analysis of the

FFTF Impeller, FFTF Primary Pump," S.O. U360, August 31, 1972, by R.J. Oleyar.

d. FRA-152-3, Draft for RDT F 9-1, "Interim Supplementary Structural Criteria for Elevated Temperature," A.L. Snow, November 6, 1970.

6.4 Data Submittal Data on subcontract purchase items (i.e., castings, forgings, and other machined parts), shall be submitted as defined in Appendix 10 and as specified in the applicable Procurement specification and purchase order. A supplier data list (SDRL) shall be prepared, as applicable, for each procurement specification.

APPENDIX 10
DATA SUBMITTAL REQUIREMENTS

10.1 INTRODUCTION This appendix establishes the requirement for data to be submitted to AI. It is comprised of two major elements: a set of general requirements which apply to all data items; a Supplier Data Requirements List (SDRL)* which lists all of the data items required and provides the schedule and submittal requirements.

10.2 GENERAL REQUIREMENTS

10.2.1 Document Identification Requirements

10.2.1.1 Title Each document submitted shall bear a title which is descriptive of the contents and which distinguishes it from other similar documents.

10.2.1.2 Numbering All documents shall be numbered. The Supplier's document numbering system may be used provided that it prohibits the use of the same number on more than one document. The document number shall appear on each page of the document. The Supplier's drawing numbering system shall meet the following minimum requirements:

a. The document number shall not exceed 15 characters. These characters may include numbers, letters, and dashes, with the following limitations:

(1) Letters I, O, and Q shall not be used.

(2) Letters shall be upper case (capitals).

(3) Numbers shall be whole Arabic (1, 2, 3, etc.) numerals. Fractional, decimal, and Roman numerals shall not be used.

(4) Blank spaces are not permitted.

Each page of multisheet documents shall be numbered. The first page shall indicate the total number of pages.

10.2.1.3 Revisions The supplier's document revision system shall include a requirement for advancing the revision letter or number each time the document is revised and reissued.

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*SDRL to be provided in applicable procurement document.

10.2.1.4 Identification The first page of the document shall show the supplier's name and address (city and state are required, street address is optional), the document title, document number, current revision letter or number, and date.

10.2.2 Document Legibility and Reproducibility

10.2.2.1 Clarity All documents submitted shall be of sufficient clarity such that, when reproduced, lines, numbers, letters, and characters of the reproductions will be clearly legible and readable.

10.2.2.2 Reproducible Copies When reproducible copies of drawings are ordered, they shall be direct reading black-on-white translucents. Sepias are not acceptable. Reproducibles shall be of such quality that when microfilmed, copies made from the microfilm meet the requirements of Paragraph 10.2.2.1.

10.2.2.3 Subtier Documents All documents forwarded from subtier suppliers shall comply with these same requirements.

10.2.3 Contractual Due Dates When the due date specified in the SDRL occurs on Saturday, Sunday, or a holiday, the due date becomes the subsequent working day. Unless otherwise specified, all schedules are expressed in calendar days.

20.2.4 Preparation for Shipment

10.2.4.1 Transmittal Letter The supplier shall submit all data under a transmittal letter (or equivalent) which includes the following:

a. AI Purchase Order number

b. Purchase Order line item number

c. SDRL line item number. (If the document satisfies more than one item number, then all applicable line item numbers will be listed.)

d. Supplier document identification number, title, and revision or date

e. Quantity and type (reproducible or nonreproducible) of data transmitted

f. Action required (e.g., AI approval, review, or for information)

10.2.4.2 Method of Transmittal All reproducibles of "B" (11 in. by 17 in.) and larger sized drawings shall be shipped rolled (unfolded) inside mailing tubes. All prints of "B" and larger size drawings shall be folded to 8-1/2 in. by 11 in. and shipped flat. All "A" (8-1/2 in. by 11 in.) size documents shall be shipped flat.

APPENDIX 20

TABLE 20-I DESIGN VERIFICATION METHOD

Paragraph	Requirement	Verification Method					Comment
		Analysis	Drawing Review	Checking	Tolerance Stackup	Test	
3.1.1.1	Impeller Mounting						Procedure in OMM Addendum (6)
3.1.1.2	Axial Clearance			X	X		
3.1.1.3	Radial Clearance			X	X		
3.1.1.4(a)	Tool Interfaces		X	X			RDT F 8-6 Stress Signoff
(b)			X	X			
(c)			X	X			
3.2.1	Hydrodynamic Design Point	X					Analysis (1)
3.2.2	Range of Operation	X					Analysis (1)
3.2.2.1	Operating Life					X	Test (4.4.5)(4)
3.2.3.1	Net Positive Suction Head Required	X				X	Analysis (1) Test (4.4.5)(4)
3.2.3.2	Suction Demonstration Capability					X	Test (4.4.5)(4)
3.3.1	Stress Criteria	X					Analysis (3)
3.3.1.1	Steady State Conditions	X					Analysis (3)
3.3.1.2	Thermal Transients	X					Analysis (5)
3.3.2.1	Unbalanced Rotating Loads		X	X			
3.3.2.2	Radial Thrust Loads	X	X	X			(a) Analysis (1) (b) Test Org & Insp
3.3.2.3	Axial Thrust Loads	X	X	X			Analysis (1,3)
3.3.3	Design for Recirculating Flows	X	X	X			Report (2)
3.3.4	Drainability and Venting	X	X	X			
3.3.5	Threaded Fasteners		X	X			
3.3.6	Special Tool Design		X	X			OMM Addendum (6)
3.4	Identification and Marking		X	X			Procurement Spec's
3.5.1	Material Specification		X	X			Procurement Spec's
3.5.2	Fluid Properties	X					Analysis, Reports (1,4)
3.5.3	Fabrication Procedures		X				Procurement Spec's

Reference Documents

(1) Hydrodynamic Analysis Report (Est. Complete 4/7/78) by Rocketdyne
(2) Design Report (Est. Complete Dec. by AI
(3) Structural Analysis Report (Est. Complete 4/7/78) by Rocketdyne
(4) Final Test Report (Est. Complete Dec. 1980) by AI
(5) Test Transient Identification, TI (Est. Complete Sept. 1978) by AI
(6) OMM Addendum (Est. Complete JUL 10, 1978) by AI