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# Fast Flux Test Facility Sodium Pump Operating Experience - Mechanical

**MASTER**

Prepared for the U.S. Department of Energy  
Assistant Secretary for Nuclear Energy

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**Westinghouse  
Hanford Company** Richland, Washington

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U.S. Department of Energy under Contract DE-AC06-87RL10930

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# Fast Flux Test Facility Sodium Pump Operating Experience - Mechanical

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## ABSTRACT

The Heat Transport System (HTS) pumps were designed, fabricated, tested, and installed in the Fast Flux Test Facility (FFTF) Plant during the period from September 1970 through July 1977. Since completion of the installation and sodium fill in December 1978, the FFTF Plant pumps have undergone extensive testing and operation with HTS testing and reactor operation. Steady-state hydraulic and mechanical performances have been and are excellent. In all, FFTF primary and secondary pumps have operated in sodium for approximately 75,000 hours and 79,000 hours, respectively, to August 24, 1987.

## PUMP DESCRIPTION

The Reactor Heat Transport System incorporates six large centrifugal pumps, three primary and three secondary pumps. The primary and secondary pumps are essentially identical in design, the main difference being that the secondary pumps are 14 feet shorter. Figures 1 and 2 show the primary and secondary pump arrangement, respectively.

The pumps are a free-surface, shaft-sealed, vertical, single-stage, centrifugal, single-suction pump with variable speed drive. They are designed to pump 566°C (1050°F) sodium at 3293m<sup>3</sup>/h (14,500 gpm) and 152.4 meters (500 ft) head for the primary pump and 121.9 meters (400 ft) head for the secondary pump. The drive mechanism for each pump is a 2500-hp air-cooled, wound-rotor induction motor with speed controlled by a liquid rheostat. A pony motor is mounted on top of the main drive motor for low-speed and low-flow operation of the pump. The pump shaft is joined to the motor shaft through a flexible coupling that transmits motor torque to the pump shaft while allowing for some misalignment of the two units without imposing excessive side loads or movements to either.

There are three bearings on the pump shaft. The lower one is a hydrostatic bearing supplied with liquid sodium from the pump discharge. The radial and thrust bearings are located at the upper end of the shaft. The seals are mechanical, oil lubricated, rubbing-face type. The radial and thrust bearing assemblies and seals share the common lubricant which is circulated, filtered and cooled by the oil circulation system.

Each of the primary pumps is located in a sealed and inerted equipment cell within the containment building. Secondary pumps are located in separate buildings outside the containment building.

## PUMP OPERATIONAL HISTORY

The operational performance of the HTS pumps has been satisfactory since the installation and sodium fill completion in December 1978. In all, FFTF primary and secondary pumps have operated in sodium for approximately 75,000 hours and 79,000 hours, respectively, up to August 24, 1987.

The operational history of primary P-1 pump (Loop-1) was essentially identical to that of the other primary pumps until June 19, 1979, when the P-1 pump sodium level was inadvertently raised to about six feet above the normal maximum operating sodium level. This introduced sodium into the annular space between the shaft and the shield plug.

Attempts to start the P-1 pump were unsuccessful after this event. Application of approximately 1220 NM (900 ft-lb) of torque was required to free the P-1 pump and to re-establish pump operation; however, pump vibration levels were observed to be about ten times their original values as indicated in Figure 3. The excessive vibration levels were attributed to a slightly bent shaft, but the damaged P-1 pump performed satisfactorily until it was replaced with a spare pump in March and April 1980.

The hydraulic performance of the primary and secondary sodium pumps is normal and remains unchanged since initial pump operation. The hydraulic characteristics are determined every three months to provide comparison of operating pump data with design and original test data. The pump discharge pressures are used as an acceptance criteria. An example of the comparison between the calculated pressure (Pc) for a particular pump operation condition and the measured discharge pressure (Pm) is shown in Table 1.

TABLE 1  
Comparison Between Design and Measured Discharge Pressures

<u>Primary Pumps</u>	<u>Pc</u>	<u>Pm</u>	<u>Secondary Pumps</u>	<u>Pc</u>	<u>Pm</u>
P-1	135 psi	139 psi	P-4	174 psi	173 psi
P-2	134 psi	138 psi	P-5	181 psi	173 psi
P-3	134 psi	136 psi	P-6	178 psi	170 psi

The mechanical performance of the HTS pumps is very satisfactory and consistent. The mechanical characteristics are monitored and evaluated by vibration, torque, and coastdown data. The vibrational peak-to-peak displacements are well within the specified value of 5 mils peak-to-peak. The pump breakaway torques are within the engineering specified limit of 102 NM (75 ft-lb). The coastdown times from both main motor to pony motor operation and from pony motor to zero speed have remained essentially unchanged throughout the pump operational time.

## SEAL OPERATING EXPERIENCE

The HTS pump seals have generally performed satisfactorily even though excessive leakages have occurred on four pumps and leakage rates are higher than the original design goal. The combined nominal leakage rate for the pumps' upper and lower seals is approximately 100 cc/h compared to the design goal of 20 cc/h. Ten upper seals and three lower seals have been replaced in the FFTF sodium pumps since their initial operation (1978 to present). The number of seal changes performed on each pump to date is shown in Table 2.

TABLE 2  
Seal Replacements

Pump	<u>P-1*</u>	<u>P-2</u>	<u>P-3</u>	<u>P-4</u>	<u>P-5</u>	<u>P-6</u>
Upper Seal	1	2	3	1	0	4
Lower Seal	1	1	0	0	0	2

\*Seal replaced in conjunction with pump replacement of April 1980.

The majority of seal changes were necessitated by high leakage rates which were attributed to the seal hanging open.

The total operating hours as of August 24, 1987, for each seal presently installed in the pumps are shown in Table 3.

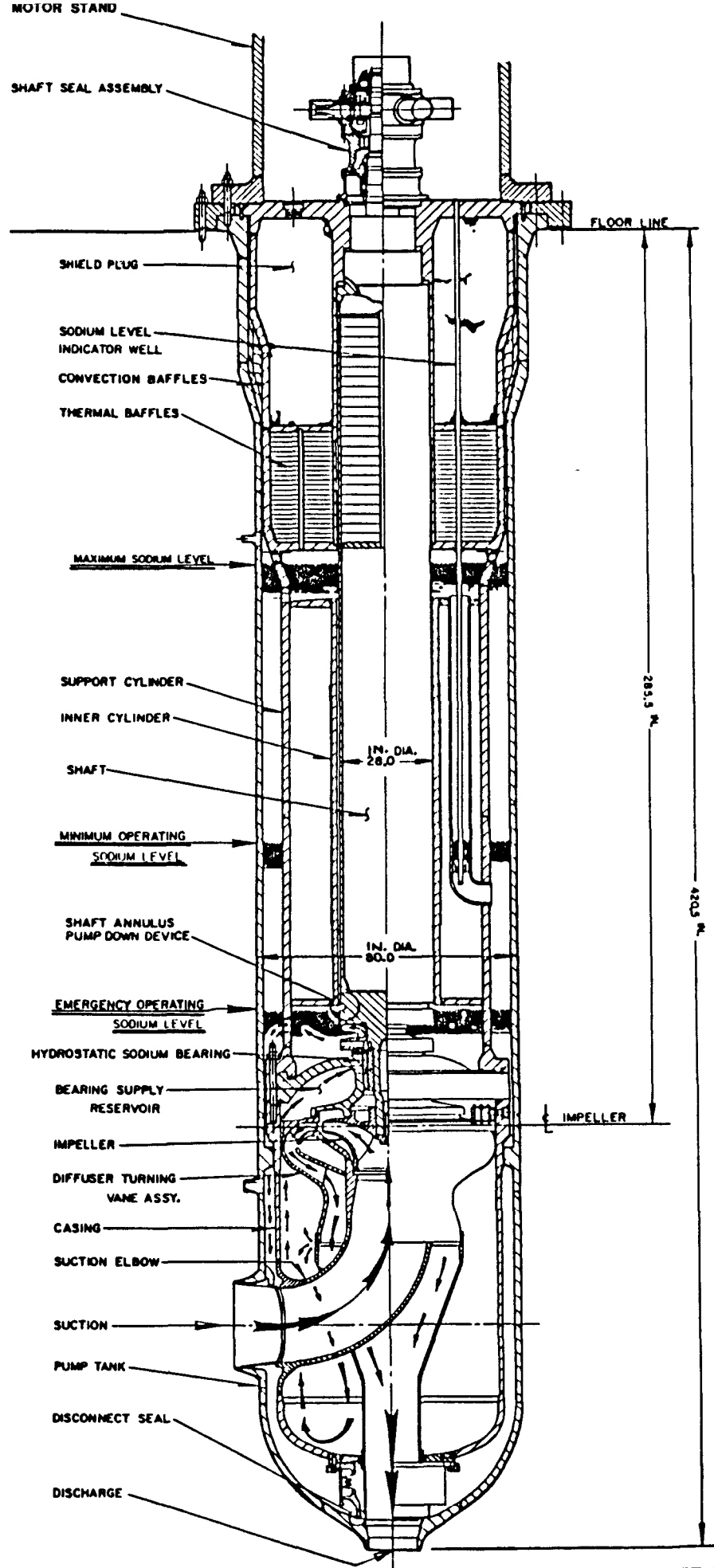
TABLE 3  
Seals Operational Time

Pump	<u>P-1</u>	<u>P-2</u>	<u>P-3</u>	<u>P-4</u>	<u>P-5</u>	<u>P-6</u>
Upper Seal	65218	44318	45742	40505	79087	4248
Lower Seal	65218	44318	74779	79089	79087	52495

An improved seal design which creates a negative hydrodynamic lift force and which offers the potential to significantly reduce the experienced leakage, is being field tested in secondary pump P-6. The operational experience to date supports the analytical and previous test data for the improved seal performance.

## CONCLUSION

In conclusion, the hydraulic and mechanical performances of the primary and secondary pumps are very satisfactory and consistent. It is expected that all HTS pumps will operate satisfactorily throughout the remainder of their 20-year design lives and beyond to support operation of the FFTF power addition.



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FIGURE 1. Primary Sodium Pump.

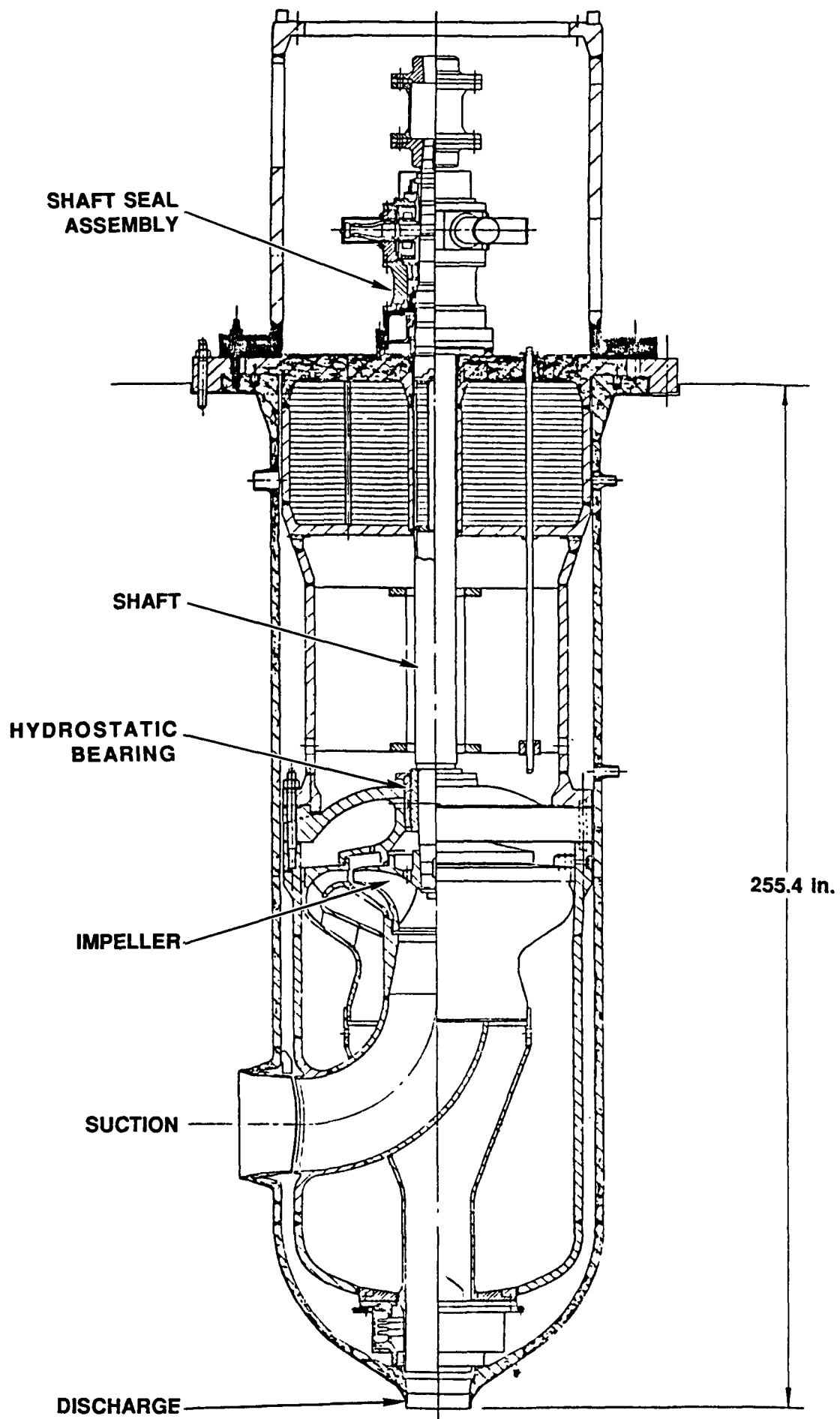


FIGURE 2. Secondary Sodium Pump.

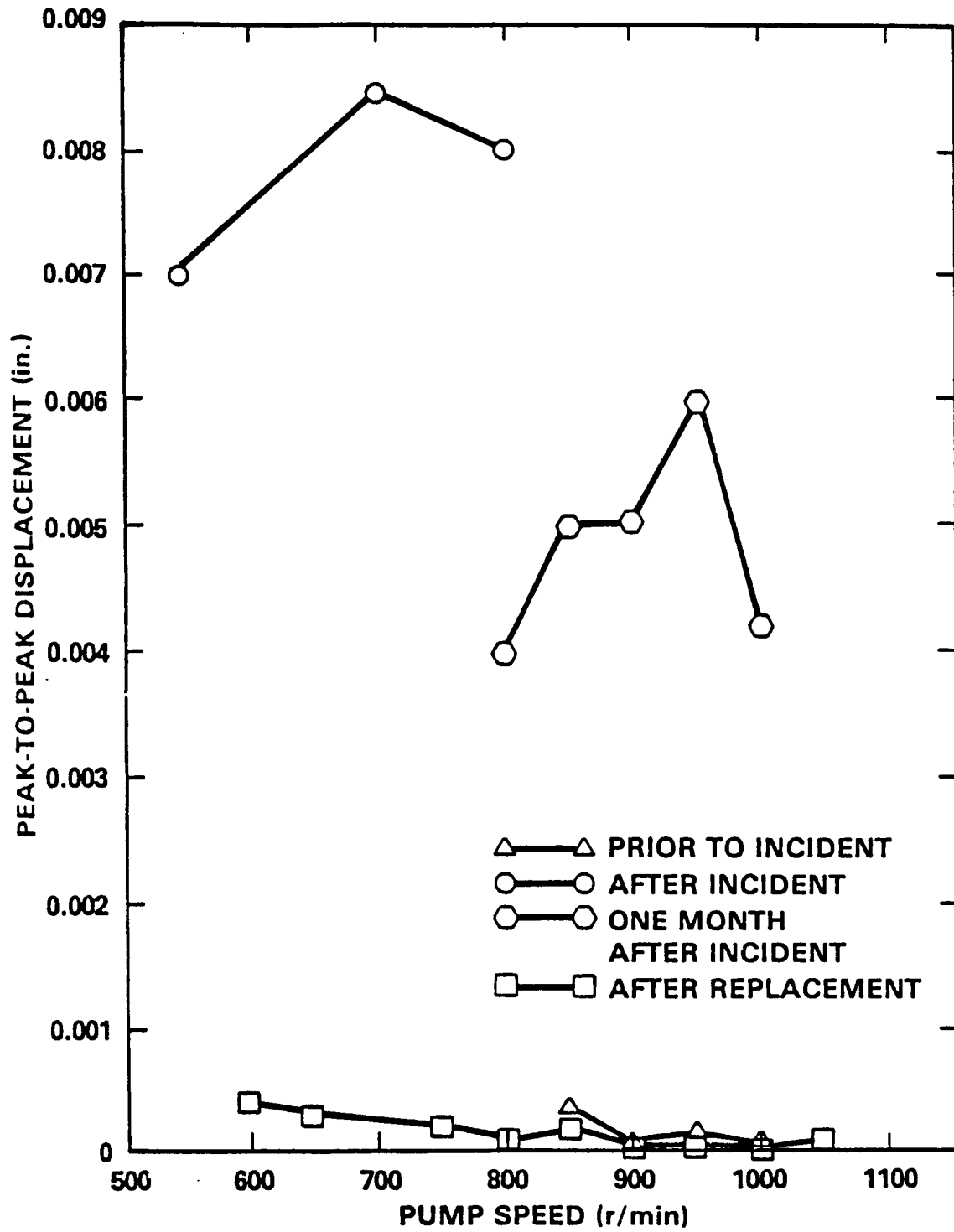


FIGURE 3. P-1 Discharge Nozzle Vibration History - Radial.

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