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Series A

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INITIAL TEST OF SODIUM PUMP AND INSTRUMENT LOOP

by

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I. INTRODUCTION

An isothermal loop for testing a full scale sodium pump for SRE and associated instruments has been operated for approximately 600 hours. A summary of data obtained, together with recommendations, is given.

II. APPARATUS

The loop layout is shown in Figure 1. Basically it consists of a vertical pump with a closed loop from the discharge to the suction side. The pump is a modified hot oil pump manufactured by Pacific Pumps. The shaft packing has been replaced with a frozen sodium seal. The latter for this initial test was a "long seal" (5-1/4" long) tapered toward the cold end (from .060" to .020" radial clearance at cold end). The impeller housing to pump case flanges have been replaced with a static frozen sodium seal. All moving parts can be removed by unbolting the top face plate and lifting out the inner assembly. The pump motor is a 75 HP d.c. unit continuously variable from 40 to 1740 rpm.

A surge tank located on the discharge line accommodates the changes in sodium volume due to expansion on heating and also serves as high point in sodium circuit. To vary pump discharge pressure, a 6" throttling valve at the far end of the loop is used. This valve employs a frozen sodium seal at the stem. The valve seal is backed up with helium pressure plus a teflon chevron-type packing. Sodium flow is measured using an 8" electromagnetic flowmeter supplied by General Electric.

Pressures are measured using Moore Nullmatic pressure transmitters. A plugging loop for oxide determination is installed across the throttling valve.

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Sodium is stored in a tank placed at a lower level from the loop. This storage tank also serves as the filtering unit. All small operating valves are Powell Y pattern bellows sealed units. Drain valves used only for cleaning and complete draining are stainless steel bar stock types. All helium used in the system is passed through a NaK bubbler unit to minimize the oxygen content.

Level indication is by means of air-cooled low mass thermocouple probes. GE monel sheathed flexible heating cable is used for all tank and pipe preheating. Standard insulation (Superex - 85% Magnesia combination) is used throughout. All lagging is cloth-wrapped and weatherproofed. Leak detecting tape has been installed on the underside of piping to detect sodium leaks. A section of the pipe has been ducted to provide forced convection air cooling to aid in maintaining constant loop temperature. At present all cooling for freeze seals is provided by "once-through" filtered plant water.

III. PROCEDURE

After final assembly of all components and connections, the system was purged of air by pumping down the system to about one mm and filling with NaK purified helium three successive times. Initial charging of the storage tank was done using an auxiliary melt tank.

Bricks were loaded cold into the melt tank (capacity approximately 100 pounds of sodium). The charge was forced into the storage tank when it reached a temperature of 250° F. Argon gas was used for pressuring the sodium through a sintered stainless steel filter (5 μ pore size).

Storage tank piping is so arranged that the filter is bypassed by sodium entering the tank. This prevents disturbing the filter cake built up during successive filterings. Positive inert gas pressure is used for all sodium transfer operations.

To avoid cold spots in loop during filling, all freeze seal coolant was turned off until the actual start of sodium filling. With proper sodium level in surge tank, the loop was pressurized with helium to insure positive pressure at the pump suction. Just prior to starting the pump motor, the lubricator was started and primed to get oil flow to bearings and rotating shaft seal. Oil bleed line was opened to start removal of oil from lower shaft slinger catcher.

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IV. OBSERVATIONS

Initial startup was uneventful with no problem achieving seals. The rotating seals (pump shaft and valve stem) were initially short as evidenced by the small increase in tightness over the dry sodium-free condition. During operation the seals lengthened. No sodium extrusion was observed at the pump shaft seal until the seal temperature was raised to about 150° F.

No difficulty in starting the unit was observed except in two instances after 415 hours of running with a seal temperature of 85° F. Seizure of a turning shaft (900 rpm) occurred at 580 hours with a seal temperature of 103° F. A pool of sodium was above the seal at this time. It is quite possible that the sodium above the seal was cooled sufficiently to become solid thereby causing seizure. In all cases, allowing the seal to warm up overcame the difficulty.

The Moore pressure transmitters operated erratically at the start of the run and in a few days became completely inoperative. As a result, no pressure-flow characteristics were obtained during the run. After about 600 hours of operation at various sodium temperatures up to 800° F, the pump suction side unit developed a leak forcing shutdown.

V. RESULTS

Total running time for this test was 597.6 hours, as shown in Figures 2 and 3. Time at various temperatures is shown in Figure 4. Higher temperature operation was initiated at the time of the transmitter failure.

No difficulties were encountered in disassembly, but the pump assembly always necessitated rocking in order to assemble. This occurs when impeller is 6" to 12" above final position.

Starting torque - The measurements of torque necessary to move the shaft are given in Table I. There is no clear trend evidenced. At best only a few observations can be given at this time. Some tendency toward increased break-away torques with increased shut-down time was noted. This would indicate that with lower freeze seal temperatures, the shear strength of sodium in seal tends to increase. Increased torque was noted occasionally with higher pressure differential across seal. Additional measurements will be made in the future. During the test, a total of 152 starts were made. Of these only 2 (previously mentioned under observations) required seal warm-up.

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Seal cooling - A variety of cooling data has been obtained for the various freeze seals used in the system. Although the majority of the data was obtained at a sodium temperature of 500° F, some data for other temperatures is given. The pump shaft freeze seal cooling loads as a function of system sodium temperature are shown in Figure 5. During the tests filtered plant water was used for all cooling. Supply temperature averaged 75° F days and 69° F nights. For 100° F seal temperature with 500° F sodium temperature, the rise was 14° F with 75° inlet water flowing at 1.2 gpm. There was some indication of an increase in cooling load on the shaft seal as a function of pump speed but the results were not consistent. In the tests that this trend was indicated, the change in heat removal from 300 rpm to 1000 rpm at 500° F sodium temperature was 0.45 kw. Figure 6 shows the variation in seal cooling as a function of seal temperature at constant pump speed and 500° F sodium temperature. Figure 7 gives case seal cooling loads as a function of sodium temperature. Figure 8 gives cooling load on the 6" throttle valve seal. Figure 9 shows bearing housing cooling load at 500° F sodium temperature. It is quite small and maximum temperature of 150° F was reached on the bearing with no cooling water.

With present data, there is no good indication of incipient seal leakage. Once leakage begins, the event is over in a matter of seconds.

Gas consumption - Purified bottle helium was used for all inert gas blankets. Cleanup was achieved by bubbling the bottle gas through columns of NaK before using in the system. The chief usage was for purging oil from pump case. Average rate for entire run was 10 cubic feet per hour.

Oil Consumption - Oil rate is determined by the feed rate of pressure oiler and quite independent of operating speed or temperature. Average measured use during the test was 2-1/4 pints per hour. Turbine oil is the present lubricant and has been found satisfactory.

Plugging Indicator - Oxygen concentration of the sodium in the loop was measured by using a plugging indicator. Basically the device consists of an economizer, cooling section, and perforated plug in the cold zone. Flow through the indicator was measured using an electromagnetic flowmeter. Entire unit constructed of 1" schedule 40 pipe. In operation sodium is passed through the loop at system temperature until a plugging run is to be made. At that time insulation from cooling section is removed and air blower turned

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on. The only measurements required are plug temperature and flow rate. A representative curve of a plugging run is shown in Figure 10. Figure 11 is a plot of change in oxide content of circulating sodium as a function of operating time.

VI. RECOMMENDATIONS

1. Pressure transmitters other than Moore Nullamatics should be tested for use in SRE.
2. Oil removal system should be modified to insure more complete removal of oil from pump case.
3. Pump case seal might be altered to add rings in order to cut down sodium free convection heat transfer in this seal.
4. Rotating freeze seal should have metal sheathed thermocouples built into unit for measuring seal temperatures and control of coolant flow through seal.
5. Add provision for removing sodium from pump case in event of extrusion or leakage. The line should be heated. Heater in collecting basin would also be helpful.

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TABLE I

SUMMARY OF PUMP STARTING TORQUE

SODIUM PUMP & INSTRUMENT TEST LOOP

Date	Sodium Temp. T/C 26	Seal Temp. T/C 35	Starting Torque
	°F	°F	(Ft-lbs)
10-14-54	480	87	22
10-14	492	91	12
10-14	466	83	16 (10 minutes later)
10-15	605	103	31
10-15	482	85	36 (30 minutes later)
10-15	590	92	22
10-15	590	90	29 (15 minutes later)
10-16	410	93	6
10-16	470	84	5
10-16	450	85	6
10-17	440		6
10-17	506	95	22
10-17	496	93	30 (15 minutes later)
10-17	480	84	44
10-18	500	122	36
10-18	495	122	15
10-19	480	140	6
10-20	440	116	4
10-20			4.5 (15 minutes later)
		128	15
		129	22
		137	12
		135	12
		134	17
		131	25
		128	15
		129	
10-21	500	100	3.5
10-21	500	97	3.5
10-21	340	119	5
10-21		118	3.5 (5 minutes later)
10-21		117	3.5 (10 minutes later)
10-21		116	3.5 (15 minutes later)
10-22		96	20
10-22		93	25 (28 minutes later)
10-23	470	140	6.7
		139	6.7 (5 minutes later)
10-24	400	110	18.5
10-26	450	113	3.5

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A vintage black and white photograph showing a mechanical testing apparatus, likely a wind tunnel or engine test cell. The foreground features a large, dark, vertical cylindrical duct supported by a complex metal frame. Various pipes, valves, and structural beams are visible. A large, light-colored wheel is attached to a horizontal pipe on the right side. The background, viewed through a chain-link fence, shows a parking lot filled with numerous cars from the mid-20th century, including sedans and convertibles. The scene is set outdoors in a sunny, open area.

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Figure 3

SODIUM PUMP
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TEST LOOP

NOTE: 152 PUMP STARTS
560 OPERATING HOURS (SCHEDULED)

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NOV FOR NOV. 3 HOURS & PPV

Figure 4

Figure 5

FIGURE 6

SODIUM PUMP
& INSTRUMENT
TEST LOOP

COOLING LOAD ON
GLAND SEAL VS.
GLAND TEMP.

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Figure 7

COOLING LOAD ~ KW
2 4 6 8

SODIUM PUMP
& INSTRUMENT
TEST LOOP

COOLING LOAD ON
PUMP CASE SEAL
VS LOOP TEMP.

400 500 600 700 800 900 1000
TEMPERATURE ~ ° F

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FIGURE 11

SODIUM PUMP & INSTRUMENT TEST LOOP

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