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ATOMICS INTERNATIONAL
A Division of North American Aviation Inc.

NAA-SR-MEMO COVER SHEET

REPORT TITLE

SODIUM PUMP RELIABILITY DEMONSTRATION

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NAA-SR-MEMO 11485

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The Hallam Nuclear Power Facility is one of the largest existing sodium graphite reactors today. It is a full scale, commercial, power producing plant which bears more than a family resemblance to proposed 200 Mwe and 1000 Mwe SGR plants. The installed sodium process equipment is similar in design, arrangement and complexity to the proposed equipment. The scale factor to enlarge the Hallam concept to 1000 Mwe is reasonable and within scale factors in use for many years for power and process plants.

It is this close family resemblance which makes the continued operation of Hallam desirable for the purpose of further reliability demonstration of sodium process equipment. Since operation of any power plant is to be of long duration, the reliability parameter of interest is the failure rate. For long lived equipment, the characteristic relationship of failure rate with time is referred to as the "bath tub curve" and is shown below.

The early part of the curve where the failure rate is descending with time is known as the Infant Mortality portion and represents the development phase of the design. The high early failure rate is caused by the debugging process. As experience with the equipment is gained, the time between failures becomes longer, and the failure rate decreases.

When the development period has ended, and the failure rate is essentially constant, the useful life of the equipment is realized. During this portion of the curve, failures are expected to occur at random. Design improvements tend to lower the curve and prolong the useful life. When the curve starts to rise sharply, the wearout phase has been entered. The end of life varies for different equipment and may be signified by complete inability to operate further, or by increasing cost of repair.

Demonstration testing should, ideally, show the true constant failure rate, estimate the useful life, and the end of life characteristics. For practical reasons, a demonstration program is limited and should, at least, approach the true constant failure rate and show its relation to the needs of the system.

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Reference 1 indicated that the required reliability for main sodium pumps is 91.7% in one year. The exponential relationship of $R = e^{-\lambda t}$, gives 9.45 failures per 10^6 hours as the required failure rate of the pumps. Sodium pumps have been chosen as representative of complex sodium process equipment. The pumps are not only dependent on many of the other systems for maintaining operating parameters within narrow limits, but are themselves a complex arrangement of basic machinery and sub-systems necessary for successful operation. The pumps require a sealing oil system complete with its own pumps, a cover gas system and associated controls, and cooling auxiliaries for the sub-systems.

Appendix A is a summarized history of the operation of pumps at the Hallam Facility. A more complete log is found in Appendix B. The failure rates demonstrated to date have been plotted on Figure 1. What is most important is the shape of the curves. It is evident by the rising and peaking nature that we are still very early in the development cycle of pumps. New failures are occurring as old ones are fixed, and some problems are still to be fixed.

Before continuing the discussion of failure rates and pump demonstration, some clarification of the meaning of the terms "pump" and "failure" is indicated. The pump is here considered in its total system context with all sub-systems necessary to its operation. These include the seal oil system, cover gas system, controls, drive, specific instrumentation, and the operator. Failure or malfunction of any of these affects adversely the ability of the pump to perform its primary function; that of moving large volumes of sodium. The pumps may also be unable to function if the sodium should cool to too low a temperature, or if the power to its driver should fail. Those failures have been included which apply to the pump, and any other component or system which is included in the HNPF solely on behalf of the pumps, or are necessary specifically for the operation of the pumps.

Failure is defined as the inability of the pumps to perform their primary function due to some incident or failure, actual or procedural. Several of the failures listed occurred when the pump could not be rotated by hand prior to starting. While the pump could probably be started by the driver motor, the operating procedures call for hand rotation to check shaft binding. In November 1962, operator error caused flooding of the pump casing and consequent shutdown. This, too, is carried as a failure against the pump.

The continued appearance of minor troubles in a system, and occurrence of failures which are each repaired by a different engineering approach is evidence that we are working in a new "state of the art." With the continued operation of sodium facilities, there is an increased probability that a significant breakthrough will occur. Without attempting to prove the statement by statistics, we know intuitively that the state of the art has a movable frontier which yields to the continued application of effort, both in terms of time and money.

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Figure 1 does show clearly that we are still early in the development cycle of sodium pumps. The failure rate curve has not indicated a definite downwards trend for a long enough period. We can project into the future by making some simple assumptions. The first is that in the next year before the HNPF will be ready to operate, further work on the pumps will solve some of the startup difficulties. The second is that the pumps and the facility would be operated for the next five or ten years at 80% plant operating factor, and with no further failures.

The demonstrated failure rate, taking an average of the six pumps, is 179 failures per 10^6 hours. Operation of Hallam for the next five years would provide a demonstration of only 64 per 10^6 hours. This is still far too high for use. There is every indication that reliability requirements for future plants will increase, rather than become lower. At the rate of progress shown, it would take some 50 years to demonstrate a failure rate equivalent to the reliability goal for pumps. By that time, the goal would have been significantly lowered by improved and faster reactors.

There are several other sodium cooled reactors currently in existence. Those of interest, at present, are: Fermi, EBR II, SRE, and the Sodium Pump Test Loop. If the combined operating experience of all of these is added to that of HNPF under the same conditions and assumptions, we obtain a family of curves as shown in Figure 2. It is immediately obvious that even in ten years operation of all sodium facilities, today's goal will not be reached. It is also apparent that five years operation of the facilities will see the establishment of a definite trend and cover the major reduction in failure rate.

The curves shown in Figure 2 are only one set that could be drawn. Any change in the assumptions will significantly change the shape and intercept of the curve. If redesign of the pumps should solve the hard turning problem at startup, it is considered justifiable to start calculating the failure rate and operating time from the date of completion of rework. This would allow the curves to be drawn starting from a point lower down.

The experience to be gained with operation of other plants than Hallam has been additionally drawn. If it were possible to obtain operating history comparable to that of Hallam as shown in Appendix B, a combined generic failure rate for sodium pumps could be established. No such curves have been drawn since we are now in the realm of pure conjecture. The number and shape is limited only by the imagination.

Conclusions: The operating history of Hallam shows that the development has not been completed and that several years of operation are still necessary to establish assurance that a constant failure rate would be reached. Within the limitations of time and funds, further operation for a period of three to five years is necessary to achieve this end. The time is dependent on the rework and early operating experience after startup.

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The increase in demonstrated reliability will decrease project costs in pump design, checkout and qualification time, and capital equipment costs. The later savings occurs when sufficient reliability has been demonstrated to eliminate the need for redundant pumps that would now be necessary to gain a reliability closer to the goal.

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ACKNOWLEDGEMENT

The author wishes to thank
O. G. Jenkins and R. J. Walters
for their work in searching the
Hallam ROAP files for the
operating data on the sodium
pumps which appears
in the appendix.

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PAGE 10 OF 21APPENDIX ASUMMARY OF HNPf SODIUM PUMP OPERATING HISTORY

<u>Pump</u>	<u>Date</u>	<u>Cumulative Operating Hours</u>	<u>Number of Failure</u>	<u>Failure Rate x 10⁶</u>
P-1	11-18-62	5,004	1	199.8
	10-15-63	11,268	2	177.5
	11-15-63	12,009	3	249.8
	2-10-64	14,076	4	284.2
	11-4-64	21,046	5	237.6
	12-11-64	21,198	*	235.9
P-2	3-19-63	7,623	1	131.2
	2-11-64	21,677	*	46.1
P-3	3-26-63	7,591	1	131.7
	10-15-63	11,820	2	169.2
	12-11-64	21,897	*	91.3
S-1	1-25-63	5,178	1	193.1
	6-9-63	6,799	2	294.2
	10-15-63	8,639	3	347.3
	1-4-64	10,592	4	377.6
	2-17-64	11,309	5	442.1
	10-29-64	17,375	*	287.8
S-2	2-4-63	5,413	1	184.7
	3-14-63	5,845	2	342.2
	6-9-63	7,919	3	378.8
	10-15-63	9,543	4	419.2
	2-26-64	12,660	5	394.9
	3-6-64	12,804	6	468.6
	4-20-64	14,112	7	496.0
	10-30-64	18,470	*	379.0

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<u>Pump</u>	<u>Date</u>	<u>Cumulative Operating Hours</u>	<u>Number of Failure</u>	<u>Failure Rate x 10⁶</u>
S-3	6-9-63	7,711	1	129.7
	10-18-64	16,597	*	60.3
TOTALS		117,214	21	

*Shutdown of pump and reactor for moderator element removal

$$\lambda = \frac{k}{\sum_{i=1}^k t_i + \sum_{j=1}^s t_j}$$

where k = number of failures observed t_i = time between failures in the i th observation s = number of observations terminated without failure t_j = time between failures in the j th observation

(References 2 and 3)

APPENDIX B

OUTAGE CATEGORY HNPFP PUMPS

Date of Outage	Date Back in Service	Pump(s) Involved	Est. Operating Times at Outage, Hrs.	Est. Outage Time, Hrs.	Classification	
6/30/62	9/1/62	S1	2376	1488	SM	Three Secondary loops modified to bypass bulk of sodium flow around the expansion tanks because of cover gas entrainment problem in expansion tanks.
6/30/62	10/1/62	S2	2376	2208	SM	
6/30/62	9/1/62	S3	2376	1488	SM	
8/21/62	8/21/62	P2	2398	6	P.F.	Drained and refilled sump on #2 pri. pump seal oil system-assume <u>6 hr</u> outage on #2 pri. with 2904 hrs - 6hrs = <u>2398</u> hrs operating time.
9/9/62	9/9/62	P1	3354	6	P.F.	Drained and refilled sumps on #1 and #3 pri. pump seal oil systems-assume <u>6 hr</u> outage on #1 and #3 pri. with 3360-6 operating hours = <u>3354</u> operating hours.
9/9/62	9/9/62	P3	3354	6	P.F.	
9/28/62	9/ /62	P1	3828	30	T&M	Sodium draining test conducted on reactor involved shutting down all pri. systems including pumps for an estimated 30 hrs.
9/28/62	9/30/62	P2	3828	30	T&M	
9/28/62	9/30/62	P3	3828	30	T&M	

Date of Outage	Date Back in Service	Pump(s) Involved	Est. Operating Times at Outage, Hrs.	Est. Outage Time, Hrs.	Classification	
11/18/62	12/13/62	P1	5004	624	(SF)(OE)	Leak in #1 IHX. Reactor shut down. Sec. loop 1 drained. During draining operation #1 pri. pump shut down and #1 pri. block and throttle valves closed. Helium pressure in secondary loop pushed sodium through to primary side and flood #1 pri. sodium pump and associated vent lines. No. 1 pri. pump removed from loop for steam cleaning. No. 1 pri. and No. 1 sec. pumps down for remainder of Nov. Down until IHX leak repaired. Four of the 8 pressure relieving weep holes in the impeller blade on pri. pump #1 were plugged to eliminate potential for gas entrainment by pressure reduction at higher impeller speeds. Pump reinstalled in loop and tested on Dec. 13. Gas entrainment problem solved.
11/18/62	2/10/63	S1	4272	1896	(PM) (SF)	
1/25/63	1/25/63	S1	5178	6	R.M.	Seal oil pump on #1 sec. pump replaced because of damaged gears. Oil and filters changed on sec. 1 and 2 seal oil systems about 6 hr outage. All 6 sodium pump speed controllers adjusted at 20% flow and at 50% flow to correspond to demand (Automatic operation).

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Date of Outage	Date Back in Service	Pump(s) Involved	Est. Operating Times at Outage, Hrs.	Est. Outage Time, Hrs.	Classification	
1/15/63*	1/15/63	P1	6535	5	S.F.*	Scrams 106 thru 109 no pump malfunctions.
1/15/63*	1/15/63	P2	7135	5	S.F.*	
1/15/63*	1/15/63	P3	7135	5	S.F.*	
1/15/63*	1/15/63	S2	4944	5	S.F.*	
1/15/63*	1/15/63	S3	6397	5	S.F.*	
2/4/63	2/10/63	S2	5413	168	P.M.	Metallic noise noted in secondary sodium pump #2. The frequency of this noise varied as the pump speed was varied, indicating metal to metal impeller interference--Problem being investigated. Sec. Na pump #2 disassembled; internal parts inspected and cleaned. Pump shaft machined to eliminate interference.
3/14/63	3/14/63	P2	7403	16	P.M.	Driver units exchanged between pri. Na pump #2 and sec. Na pump #2 in successful effort to reduce vibration (about 16hrs. down time on #2 pri. and sec.).
3/14/63	3/14/63	S2	5845	16	P.M.	
3/18/63	3/18/63	S1	5629	16	P.I.	Sec. Na pump 1 removed and disassembled to inspect upper bearing. Bearing in good condition.
3/19/63	3/25/63	P2	7623	114	P.M.	Pri. sodium pump 2 removed from system and installed in pump wash cell to be cleaned for modification (plugging of impeller weep holes).

*Scrams

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Date of Outage	Date Back in Service	Pump(s) Involved	Est. Operating Times at Outage, Hrs.	Est. Outage Time, Hrs.	Classification	
3/26/63	3/29/63	P3	7591	114	P.M.	Pri. Na pump No. 3 removed from system washed in wash cell, preparing for disassembly and plugging of impeller weep holes.
3/28/63	4/21/63	S3	6541	504	(PI)(SM)	Sec. Na pump #3 motor drive unit removed for inspection of upper motor bearing.
3/28/63	4/21/63	S1	5629	504	(PI)(SM)	Secondary Pump #1, inspection of upper bearings.
5/15/63*	5/15/63	P1	8191	6	S.F.*	About 6 hrs lost to May scrams.
5/15/63*	5/15/63	P2	8639	6	S.F.*	
5/15/63*	5/15/63	P3	8647	6	S.F.*	
5/15/63*	5/15/63	S1	6205	6	S.F.*	
5/15/63*	5/15/63	S2	7325	6	S.F.*	
5/15/63*	5/15/63	S3	7117	6		
6/9/63	7/2/63	S1	6799	648	(SF)(PM)(SM)	All 3 sec. pumps were binding because of tramp metal in hydraulic bearings. Pumps removed, cleaned and necessary maintenance performed.
6/9/63	7/2/63	S2	7919	648	(SF)(PM)(SM)	
6/9/63	6/30/63	S3	7711	648	(SF)(PM)(SM)	
7/6/63	7/10/63	P1	9428	104	S.F.	One loop shutdown. Steam generator #1 leak at sample probe.
7/6/63	7/10/63	S1	6895	104	S.F.	

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Date of Outage	Date Back in Service	Pump(s) Involved	Est. Operating Times at Outage, Hrs.	Est. Outage Time, Hrs.	Classification	
7/15/63	7/15/63	P1	9500	8	S.F.*	Flow disturbance in secondary loops caused scram 130. Cold trapping.
7/15/63	7/15/63	P2	10092	8	S.F.*	
7/15/63	7/15/63	P3	10100	8	S.F.*	
7/15/63	7/15/63	S1	7015	8	S.F.*	
7/15/63	7/15/63	S2	8135	8	S.F.*	
7/15/63	7/15/63	S3	7933	8	S.F.*	
8/3/63	8/23/63	P1	9996	480	S.F.	Reactor programmed down to 15% power and scrammed intentionally on loss of power to primary sodium pump #1, demonstrating proper functioning of interlock. All 6 pumps shut down at this time.
8/3/63	8/23/63	P2	10540	480	S.F.	
8/3/63	8/23/63	P3	10548	480	S.F.	
8/3/63	8/23/63	S1	7367	480	S.F.	
8/3/63	9/3/63	S2	8535	744	S.F.	
8/3/63	9/6/63	S3	8381	816	S.F.	
10/15/63	10/15/63	P1	11268	3	S.F.*	No. 1 sec. Na pump rotated hard by hand during startup after scram. No. 2 sec. Na pump would not rotate at all by hand.
10/15/63	10/15/63	P2	11812	3	S.F.*	
10/15/63	10/15/63	P3	11820	3	S.F.*	
10/15/63	10/15/63	S1	8639	3	S.F.*	
10/15/63	10/15/63	S2	9543	3	S.F.*	
10/15/63	10/15/63	S3	9317	3	S.F.*	
						Sec. Na pump #2 removed from system, disassembled, cleaned, and inspected for abnormal wear—none noted. About 4 in. of Na found in upper oil reservoir. Pump reinstalled in system on 19th (out for about 6 days or about 144 hrs). Started up on 21st.
						Sec. Na pump #1 removed from system, disassembled, cleaned, and inspected with no signs of abnormal wear.
						Some time lost on Primary loop #2 when drive unit for pri. block valve #2 failed (#2 pri.

*Scrams

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Date of Outage	Date Back in Service	Pump(s) Involved	Est. Operating Times at Outage, Hrs.	Est. Outage Time, Hrs.	Class- fication	
						pump outage about 13 days or 312 312 hrs. Other pump outages due to scrams about 3 hrs each). Pri. pumps 1 & 3, seal oil pump repairs. (wkly. highlights-HNPF)
11/15/63	11/15/63	P1	12009	3	R.M.	About 9 hrs. pump operating time
11/15/63	11/15/63	P1	12009	6	S.F.*	lost on all 6 Na pumps due to
11/15/63	11/15/63	P2	12241	9	S.F.*	scrams.
11/15/63	11/15/63	P3	12912	9	S.F.*	Excessive noise noted in reduc-
11/15/63	11/15/63	S1	9140	9	S.F.*	tion gears of seal oil pump on
11/15/63	11/15/63	S2	10040	9	S.F.*	No. 1 pri. Na pump. The seal
11/15/63	11/15/63	S3	10058	9	S.F.*	oil pumps was replaced. During
						the replacement the Na pump was
						maintained in service at min-
						imum flow-Metal particles found
						in gear oil-some wear on gears
						(about 6 hrs. lost).
12/15/63	13/15/63	P1	12714	3	S.F.*	About 3 hours pump operating
12/15/63	12/15/63	P2	13052	3	S.F.*	time lost due to scrams.
12/15/63	12/15/63	P3	13272	3	S.F.*	Rubbing noise encountered on
12/15/63	12/15/63	S1	9851	3	S.F.*	#2 sec. pump eliminated by
12/15/63	12/15/63	S2	10851	3	S.F.*	changing pump barrel cooling
12/15/63	12/15/63	S3	10769	3	S.F.*	distribution.
1/15/64	1/15/64	P1	13455	3	S.F.*	Sec. Na pump No. 1 could not be
1/15/64	1/15/64	P2	13793	3	S.F.*	turned by hand after scram.
1/15/64	1/15/64	P3	14033	3	S.F.*	Five ft. bar used as persuader.
1/15/64	1/15/64	S1	10592	3	S.F.*	About 3 hr. pump operating time
1/15/64	1/15/64	S2	11592	3	S.F.*	lost due to scrams. Rubbing
1/15/64	1/15/64	S3	11510	3	S.F.*	noise on sec. Na pump #1 elimin-
						ated by changing pump barrel
						cooling distribution.

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Date of Outage	Date Back in Service	Pump(s) Involved	Est. Operating Times at Outage, Hrs.	Est. Outage Time, Hrs.	Classification	
2/10/64	2/11/64	P1	14076	35	P.F.	Oil leakage developed on #1 Pri. Na pump upper mechanical seal. Stationary & rotating faces of seal removed during scheduled reactor outage, and replaced. Showed signs of wear. (Pump outage about 35 hrs)
2/14/64	2/17/64	S1	11309	76	S.F.	After sec. Na loop #1 was drained & refilled, it was necessary to use a five ft bar to "hand" rotate sec. Na pump #1. Pump ran with no difficulties after starting.
2/15/64	2/15/64	P1	14196	3	S.F.*	
2/15/64	2/15/64	P2	14534	3	S.F.*	
2/15/64	2/15/64	P3	14754	3	S.F.*	
2/15/64	2/15/64	S1	11333	3	S.F.*	
2/15/64	2/15/64	S2	12333	3	S.F.*	
2/15/64	2/15/64	S3	12251	3	S.F.*	
2/19/64	2/19/64	P1	14292	6	T&M†	Work on throttle valves controls entailed about 6 hr. operating time loss on all 6 Na pumps.
2/19/64	2/19/64	P2	14630	6	T&M†	
2/19/64	2/19/64	P3	14850	6	T&M†	
2/19/64	2/19/64	S1	11429	6	T&M†	
2/19/64	2/19/64	S2	12429	6	T&M†	
2/19/64	2/19/64	S3	12347	6	T&M†	
2/26/64	2/26/64	S2	12660			On 2/26/64 during hot restart following scram, #2 sec. Na pump stuck, but started when demand speed increased, pump overspeed caused flow ratio scram #155. About 3 hr. lost on all 6 pumps due to scrams.

* Scrams

† Throttle valve testing

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Date of Outage	Date Back in Service	Pump(s) Involved	Est. Operating Times at Outage, Hrs.	Est. Outage Time, Hrs.	Classification	
3/6/64	3/6/64	P1	14632	3	S.F.*	Reactor shut down until 3/10 for control rod drop tests. Sec. pumps operated during this period for sure acc. to cold trapping data. Assume only 2 hr. outage on pri. and secondary pumps. #1 sec. Na pump hard to turn by hand. #2 sec. Na pump turned hard but would turn by hand after cooling fan for pump case turned off.
3/6/64	3/6/64	P2	15005	3	S.F.*	
3/6/64	3/6/64	P3	15225	3	S.F.*	
3/6/64	3/6/64	S1	11725	3	S.F.*	
3/6/64	3/6/64	S2	12804	3	S.F.*	
3/6/64	3/6/64	S3	12722	3	S.F.*	
3/6/64	3/6/64	S2	12804	3	P.F	
4/15/64	4/15/65	P1	15589	6	S.F.*	No. 2 sec. Na pump hard to turn by hand. No. 2 sec. pump require a bar lever persuader to be turned by hand. No. 1 & No. 3 sec. Na pumps squealing.
4/15/64	4/15/64	P2	15962	6	S.F.*	
4/15/64	4/15/64	P3	16182	6	S.F.*	
4/15/64	4/15/64	S1	12685	6	S.F.*	
4/15/64	4/15/64	S2	14112	6	S.F.*	
4/15/64	4/15/64	S3	13679	6	S.F.*	
5/15/64	5/15/64	P1	16303	3	S.F.*	N. 2 sec. Na pump squealing. Helium supply lines to the sec. Na pump oil sump areas installed to maintain a differential pressure and minimize possibility of flooding pump cases with sodium.
5/15/64	5/15/64	P2	16676	3	S.F.*	
5/15/64	5/15/64	P3	16896	3	S.F.*	
5/15/64	5/15/64	S1	13399	3	S.F.*	
5/15/64	5/15/64	S2	14472	3	S.F.*	
5/15/64	5/15/64	S3	14393	3	S.F.*	
5/29/64	6/19/64	S3	14729	508	S.F.	No. 3 sec. Na loop drained to permit work on #3 evaporator steam leak. Assume pump shut-down at 0900. Pump down 64 hrs. to end of month.

* Scrums

Date of Outage	Date Back in Service	Pump(s) Involved	Est. Operating Times at Outage, Hrs.	Est. Outage Time, Hrs.	Classification	
6/15/64	6/15/64	P1	16044	1	T&M	No. 3 Sec. Na loop remains shut down. No. 3 Sec. Na loop filled with sodium. Assume pump started with sodium. Assume pump down for 444 hrs. prior to this in month. Assume about 1 hr lost on all 6 sodium pumps for throttle valve testing. Reactor shut down for all of June.
6/15/64	6/15/64	P2	17417	1	T&M	
6/15/64	6/15/64	P3	17637	1	T&M	
6/15/64	6/15/64	S1	14140	1	T&M	
6/15/64	6/15/64	S2	15213	1	T&M	
7/15/64	7/15/64	P1	17663	1	S.F. [‡]	Assume about one hr operating time lost on all sodium pumps for throttle valve testing.
7/15/64	7/15/64	P2	18136	1	S.F.	
7/15/64	7/15/64	P3	18356	1	S.F.	
7/15/64	7/15/64	S1	14859	1	S.F.	
7/15/64	7/15/64	S2	15932	1	S.F.	
7/15/64	7/15/64	S3	15348	1	S.F.	
8/27/64	8/27/64	P1	18694	3	S.F.*	Pumps operated for all but about 3 hr on Aug 27 when scram occurred. August
8/27/64	8/27/64	P2	19167	3	S.F.*	
8/27/64	8/27/64	P3	19387	3	S.F.*	
8/27/64	8/27/64	S1	15890	3	S.F.*	
8/27/64	8/27/64	S2	16963	3	S.F.*	
8/27/64	8/27/64	S3	15379	3	S.F.*	
9/15/64	9/15/64	P1	19147	9	S.F.*	Pumps remained in continuous operation except for after scrams on 9/2, 10, 22. Assume about 9 hr lost due to scrams (not pump fault).
9/15/64	9/15/64	P2	19620	9	S.F.*	
9/15/64	9/15/64	P3	19840	9	S.F.*	
9/15/64	9/15/64	S1	16343	9	S.F.*	
9/15/64	9/15/64	S2	17416	9	S.F.*	
9/15/64	9/15/64	S3	15832	9	S.F.*	
10/18/64	---	S3	16597	Down for Duration		Sec. Na loop #3 drained due to expansion tank leaks. Assume pump shut off at 0600-operating hrs for mo. 414.

‡ Throttle valve testing
* Scrams

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Date of Outage	Date Back in Service	Pump(s) Involved	Est. Operating Times at Outage, Hrs.	Est. Outage Time, Hrs.	Classification
10/29/64	---	S1	17375	Down for Duration	All pumps except #2 sec. turned off at 0900 for convection flow control check. Primary pump restarted at 1500 (#1 sec. Na pump operating time for Mo. 681hr P.F.)
10/30/64	---	S2	18470	Down for Duration	
10/29/64	10/29/64	P1	20932	6 T&M°	
10/29/64	10/29/64	P2	21405	6 T&M°	
10/29/64	10/29/64	P3	21625	6 T&M°	
11/4/64	11/4/64	P1	21046	6	
12/11/64	--	P1	21198	Down for Duration	
12/11/64	--	P2	21677	Down for Duration	
12/11/64	11/4/64	P3	21897	Down for Duration	

Classification Key

P.F.	Pump Failure
S.F.	System Failure
P.M.	Pump Modification
S.M.	System Modification
O.E.	Operator Error
T&M	Testing and Miscellaneous
R.M.	Routine Maintenance

• Convection flow check.

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