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SUBJECT: PULSAFEEDER AND PURGE PUMP FAILURES ON THE HRT MOCKUP
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INTRODUCTION

Several failures have occurred on the pulsafeeder equipment of the HRT mockup which indicate possible trouble spots for the HRT system unless corrective measures can be put into effect. Three pulsator housings have failed, two pulsafeeder suction check valves have cracked and two purge pump suction check valves have cracked. A diaphragm failed in the south pulsafeeder head and pulsator failures have been experienced on both the purge pump and pulsafeders. The table on the next page gives further data on these failures.

PULSATOR HOUSING FAILURES

A size P-9 pulsator housing rented from Scott and Williams developed a crack on February 24, 1955. This housing had cracked previously and had been repaired by grinding out the flaw and welding. It was noted that the housing had a thin wall on one side due to the core having been off center during casting. The failure was located in the thin walled section. No repairs were attempted after the second failure.

The size P-14 drive was installed in the mockup in December, 1955. At this time the mockup pulsafeders with a size P-9 drive had operated approximately 2540 hours. The size P-14 drive had been run approximately 1500 hours on the pulsafeder test loop, which is similar to service in the HRT mockup. Scott and Williams Company had run it an undetermined number of hours and under unknown conditions before it was purchased by ORNL. The size P-14 north pulsator housing failed after 642 hours of operation on the mockup.

The following memo by J. K. White of the Metallurgy Division describes the condition of the housing.

"On February 3, 1956, a type 316 stainless steel pump housing was inspected after its failure in the 9204-1 mockup. 33 102

1. Fluorescent penetrant revealed a circumferential crack approximately 1/2" long on the O.D. of the dish. A crack about 2" long was found on the inside diameter where the dished end meets the cylinder wall. These cracks were

SUMMARY OF PULSAFEEDER AND PURGE PUMP FAILURES ON THE HRT MOCKUP

<u>Item No.</u>	<u>Unit</u>	<u>Date and Run Hrs. Installed</u>	<u>Date and Run Hrs. Removed</u>	<u>Run Hrs. on Mockup</u>	<u>Remarks</u>
1	Pulsator Housing P-9	Early 1955	Feb. 25, 1955 Exact run hrs. not known	300	This was the second failure of this item. It had cracked previously and had been welded. The run hours after welding were probably less than 60. This housing had some unknown service with Scott and Williams before being used at ORNL.
2	Pulsator Housing P-14 (North Head)	Dec. 5, 1955 PF Hrs - 2333	Feb. 2, 1956 PF Hrs. 2975	642	This unit had accumulated approximately 1500 hours previous at ORNL and had been operated by Scott and Williams previous to its installation on the HRT mockup.
2 Repaired	Pulsator Housing P-14	Feb. 4, 12:00 PF Hrs. - 3011	Feb. 13, 1956 PF Hrs. - 3162	151	Preliminary checks indicate partial lack of fusion in weld. Leak occurred in the weld.
3	Pulsator Housing P-14 (South Head)	Dec. 5, 1955 PF Hrs - 2333	Feb. 22, 1956 PF Hrs - 3370	1037	This housing had accumulated approximately 1500 hours service at ORNL and had been operated by Scott and Williams previous to its installation on the HRT mockup.
4	Pulsafeeder Suction Check Valve	Aug. 8, 1955 PF Hrs - 935	Oct. 14, 1955 PF Hrs - 1653	718	The crack occurred on the top of the housing in the heat affected zone between the closure weld and the outer edge.
5	Pulsafeeder Suction Check Valve (North Head)	Oct. 16, 1955 PF Hrs - 1653	Jan. 30, 1956 PF Hrs - 2939	1286	The crack occurred on the top of the housing in the heat affected zone between the closure weld and the outer edge.
6	Purge Pump Suction Check Valve	Jan. 10, 1956 Purge Pump Hrs - 1641	Feb. 5, 1956 Purge Pump Hrs - 2086	445	The crack was located on the side of the housing, one eighth inch from the top. Presumably, the metal at this point is in the heat affected zone near the closure weld.
7	Purge Pump Suction Check Valve	Feb. 7, 1956 Purge Pump Hrs - 2086	Feb. 26, 1956 Purge Pump Hrs - 2484	398	The crack was located on the side of the housing, one eighth inch from the top. Presumably, the metal at this point is in the heat affected zone near the closure weld.
8	Pulsafeeder Diaphragm (South Head)	Early 1955 0 Run Hrs.	Feb. 7, 1956 PF Hrs - 3098	3098 + 200 not on timer = 3298	One large circumferential crack was approximately 1-1/2" long. There were several smaller cracks. A complete report will be issued separately on this.
9	Pulsators - Inner and Outer - (North Pulsafeeder)	Late July, 1955 PF Hrs - 867	Aug. 2, 1955 PF Hrs - 900	33	The failure was due to over expansion, probably because the oil lines to the drive pump were under-sized.

SUMMARY OF PULSAFEEDER AND PURGE PUMP FAILURES ON THE HRT MOCKUP (Continued)

<u>Item No.</u>	<u>Unit</u>	<u>Date and Run Hrs. Installed</u>	<u>Date and Run Hrs. Removed</u>	<u>Run Hrs. on Mockup</u>	<u>Remarks</u>
10	Pulsator-Outer-South Pulsafeeder	Late July 1955 PF Hrs - 867	Aug. 2, 1955 PF Hrs - 900	33	This unit did not fail, but was damaged because it had been over-expanded and extruded into the intermediate system outlet pipe. As Item 9 above, the over-expansion is believed to be a direct result of attempting to operate with undersized oil lines.
11	Outer Pulsator-North Head	Aug. 2, 1955 PF Hrs - 900	Aug. 3, 1955 PF Hrs - 905	5	While the quality of the material in the outer pulsator is unknown, but doubtful, this failure is now believed to be a direct result of attempting to operate with a hole in the inner pulsator. At the time, no replacement for the inner pulsator was available.
12	Outer Pulsator-North Head	Aug. 3, 1955 PF Hrs - 905	Aug. 4, 1955 PF Hrs - 910	5	While the quality of the material in the outer pulsator is unknown, but doubtful, this failure is now believed to be a direct result of attempting to operate with a hole in the inner pulsator. At the time, no replacement for the inner pulsator was available.
13	Inner Pulsator-North Head	Aug. 4, 1956 PF Hrs - 910	Aug. 8, 1956 PF Hrs - 935	25	The inner pulsator had been extruded into the mandrel parts. Unless the pulsator material was very poor quality, an extremely heavy shock, or overpressure in the intermediate system, would have been necessary to produce this damage.
14	Purge Pump Pulsator	Spring 1955 Purge Pump Hrs - 30	Dec. 22, 1955 Purge Pump Hrs - 1403	1403	This failure occurred soon after starting the pump following a few day's shutdown. There was a break in the neoprene near the metal to neoprene seal. There was no obvious reason for the failure.
15	Purge Pump Pulsator	Dec. 23, 1955 Purge Pump Hrs - 1403	Jan. 4, 1956 Purge Pump Hrs - 1690	287	There was no obvious reason for the failure. It happened shortly after starting the pump following a few days shut down. This pulsator had been "run in" for approximately 500 hrs. prior to its installation in the HRT mockup. Again, the break was near the metal to neoprene seal, but the seal itself was intact.

apparently one crack extending through the vessel wall. The I.D. crack coincided with a machine mark which ran almost 360°.

2. X-ray showed stringy non-metallic inclusions running radially in the dished end. It showed a 2 - 3" crack located as above and a cluster of non-metallics at the center of the crack.

3. Ultrasonic inspection (immersed) showed a pronounced crack extending at least 2-1/2" circumferentially.

Apparently a sharp machine gouge and a cluster of non-metallic inclusions weakened the pump housing at this point resulting in failure.

The part was returned to Y-12 for repair."

After inspection the crack and the area of non-metallic inclusions was ground off and the ground out section was filled with heliarc weld metal. This housing developed a leak at the weld after 151 hours operation, and was replaced by a new housing. This new housing leaked immediately due to a casting flaw. A second replacement was installed on February 16, 1956, and has operated satisfactorily through the date of this report.

The south P-14 housing, which had been on the pump originally, cracked on February 22, 1956. It had been in operation 1037 hours on the mockup, in addition to its previous history. An examination of this failure has not yet been made.

With respect to minimizing the probability of housing failures for the HRT, the housings should be inspected and pre-run before installation. This is particularly true of replacements after the reactor is in operation. Forged housings might give better life, and this is being investigated by Scott and Williams.

PULSAFEEDER AND PURGE PUMP CHECK VALVE FAILURES

On October 14, 1955, the suction check valve on the north pulsafeder head developed a crack in the heat affected zone between the closure weld and the outer edge on the top of the housing, and the loop was shut down. At the time of this failure this check valve had operated 718 hours in the mockup. This was an HRT quality assembly which had not been operated previously. This check valve was

cut out and replaced. Figure 1 is a photograph of the sectioned check valve showing the failure.

On January 30, 1956, the replacement check valve failed, having operated for 1260 hours. The entire north pulsafeeder head assembly was removed and replaced with a new HRT-type unit containing, however, old style check valves.

During an outage from January 4, to January 18, 1956, a new HRT type remote head was installed in the purge system. On February 5, 1956, the suction check valve housing on this purge pump failed. This check valve had operated for 446 hours. The failure was a circumferential crack on the side of the housing about one eighth of an inch from the top of the check, originating at the root of the closure weld. The crack appeared to be about $3/8$ " long on the outside.

This check valve was cut out of the system and replaced with a valve from the HRT. The new check valve failed in exactly the same manner on February 26, 1955. Its life was 398 hours.

At the time of writing, a redesigned check valve is being installed on the mockup purge pump. New check valves will be put into the pulsafeeder heads later in March. The new check valves will have to be operated for as many hours as possible to prove their durability.

DIAPHRAGM FAILURE

On February 7, 1956, the south pulsafeeder head began behaving very erratically. The intermediate system gained water and an analysis of the water indicated a pH of 3.7. Uranium was found in the water also, and on February 8, the mockup was shut down to replace the south pulsafeeder head. This head and its associated check valves had operated for 3298 hours on the mockup, and was the original south pulsafeeder unit on the mockup.

On February 2, 1956, some difficulties had been experienced in pumping with the south head. The intermediate system appeared to gain some water for a period, but did not continue to do so. Also, a small leak above the check valve in the phasing was noted to have dried out leaving a yellow residue. After its

FIGURE 1

Top View and Section of Pulsafeeder Suction Check Valve Housing Crack. The large crater was drilled after the failure to determine if the crack might be repaired in place.

removal from the mockup, the diaphragm head was cut open and the diaphragm was found to have a circumferential crack about two and a half inches long about two inches from the outer edge. A careful inspection of the diaphragm is in progress now and the results will be reported at a later date. The diaphragm failure brings out at least two points which should be given attention during operation.

(1) All particulate matter should be kept out of both sides of the diaphragm heads. The intermediate system should be cleaned carefully at the start, and maintained clean during operation. The condition of the soup side of the head is harder to control, but diaphragm appearance indicates that the pulsafeeder feed is reasonably free of solids.

(2) Care should be taken to see that the diaphragm operates only in the central volume of the head with the objective of reducing the number of contacts between the diaphragm and head to a minimum.

PULSATOR FAILURES

Pulsators have failed on both the pulsafeeder and purge pumps. After the installation of the new Scott and Williams drive unit and pulsator units, an attempt was made to start up the mockup on August 2, 1955. At this time the inner and outer pulsators failed on the north pulsafeeder and the outer pulsator on the south pulsafeeder was damaged. Both pulsators had expanded so as to fill the pulsator housing and had been extruded into the intermediate water system outlet pipe.

It is likely that the 1/2" steel tubing between the oil pump and the pulsators was too small to handle the return flow from the pulsators and consequently, each pump stroke added more oil until the over expanded pulsator failed. The 1/2" tubing was replaced with 5/8" tubing after this first pulsator failure. The 5/8" tube size had been recommended by Scott and Williams, but the 1/2" tubing was installed originally to avoid a delay involved in procuring the 5/8" size. No spares were available for the broken inner pulsator so it was left in place and the outer pulsator was replaced with a new one. The damaged, but not ruined, outer pulsator on the south pulsafeeder was also replaced.

On August 3 and August 4, the outer pulsator on the north head failed and was replaced twice, after which a new inner pulsator was obtained and installed with a new outer pulsator.

To try to find the cause of the failures, the valve timing of the oil pump was checked and found to be correct. The stroke adjustment of the oil pump was reduced to see if this would prevent further failures. The system was operated intermittently until August 7 when the north pulsator failed again. This time the outer pulsator was in good condition, but the inner pulsator had been extruded inwardly through the mandril holes. Following this, a hydrostatic pressure of 2000 psi was applied to a new inner pulsator against the mandrel for 18 hours without apparent damage to the pulsator.

It was concluded from the above information that the oil pump was operating properly, but that the diaphragm head-check valve assembly was somehow at fault. Accordingly, the north diaphragm pump assembly was cut out of the system and replaced. Since this replacement, there have been no further pulsator failures on the feed system.

The pump assembly that was cut out has not been proved to be faulty. As a matter of fact, the diaphragm head only was used to replace the unit which recently failed on the south pulsafeeder. This head has performed satisfactorily to date.

The most probable cause of the last inner pulsator failure was faulty action of the discharge check valve. Inferior quality of the rubber or neoprene may be a primary or contributing factor in all the failures.

The series of pulsator failures on the feed pump brings out the importance of having adequately sized oil piping between the pulsafeeder drive unit and the pulsators. It also demonstrated that satisfactory operation cannot be expected even with adequately sized oil lines unless both inner and outer pulsators are in sound condition.

On December 22, 1955, a pulsator failed on the purge pump. The purge pump had accumulated 1400 hours service on the mockup and a maximum of 500 hours break-in time. This pulsator was replaced with a new pulsator that had been pretested for

approximately 200 hours at low pressure. The replacement pulsator on the purge pump failed after 284 hours operation on the mockup.

After this failure, a new HRT diaphragm head was installed in the purge system and the purge pump was modified to drive this head through an intermediate water system. The pulsator in this system has operated for 668 hours without further difficulties. This pulsator had operated for 3600 hours previously in a purge pump test loop.

Since the pulsator failures on the purge pump occurred in a system that was not representative of the HRT purge system, it is probably not advisable to draw any conclusions from the incidents. The present HRT mockup purge system is considered to be an acceptable facsimile of the HRT purge system and further experience in the development section should disclose whether pulsators are a weakness on the purge pump drive units.

CONCLUSIONS

The difficulties experienced thus far with pulsafeeder equipment on the HRT mockup point out several weaknesses of the system which may be at least partially avoided on the HRT if the following precautions and preventive measures are taken.

As thorough an inspection as possible is needed for preliminary screening of the pump parts. Inspection procedures should be developed which would detect defective units.

After inspection, pulsators, pulsator housings, diaphragm heads and check valves should be hydrostatically tested and "run in" on a test facility before being accepted as spares for the HRT facility.

It should be noted that repairs can be made in an intermediate system or a pulsator housing while the second head is running. In the HRT, if it becomes necessary to perform such maintenance while the reactor is in operation, it would be desirable to freeze off the intermediate line being repaired. This would protect the maintenance personnel against a failure in the diaphragm leaking highly active soup to atmosphere.

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