MASTER

EOCR CONTROL ROD LATCH RELIABILITY TEST

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US ATOMIC ENERGY COMMISSION

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ABSTRACT

The final Vard design latch mechanism and hook for the EOGR Control Rod Drive Assembly has been successfully and reliably operated in a hot organic medium containing particulates one hundred times the anticipated concentration in the EOGR and with a simulated heavy polymer deposition on all primary latch components.

EOCR CONTROL ROD LATCH RELIABILITY TEST

1. Statement of Problem

The EOCR control rod assembly has operated successfully for over 1000 successive latch release and rod drop tests. However, it was necessary to establish that the latch release mechanism would operate under abnormal conditions.

The primary organic coolant in the EOCR will contain particulates and possibly heavy polymers which may tend to form and deposit on equipment in the coolant system. The control rod latch mechanism is submerged in the hot organic coolant and it is possible that particulates could collect in the latch itself, and, at the same time, working parts of the latch may become heavily coated with polymer. Therefore, to determine the non-cyclic reliability of the mechanism under such conditions, it was necessary to test the latch in a hot organic coolant medium containing a high particulate concentration and simulated heavy polymer deposition upon all working parts. The experiment was conducted out-of-pile.

A detailed description of the latch assembly is found in IDO-24034, "Preliminary Hazards Report, Addendum No. 2 -- Experimental Organic Cooled Reactor", and shown in Fig. 1A.

2. Phase I -- Terphenyl-High Particulate Concentration Test

The test was designed to obtain information on the reliability of the latch operating under conditions of high concentrations of particulates

Fig. 1A: Latch Assembly

in a hot terphenyl mixture. The control rod drive mechanism from the EOCR test facilities was used with a special pot containing a latch hook and weighted to simulate operating conditions. The pot was equipped with a stirrer, three immersion heaters and a temperature control system. The pot was designed to permit the entire latch mechanism to be submerged in the terphenyl mixture. A sketch of the pot is shown in Fig. 1B.

The pot was charged with $12\frac{1}{2}$ lb of a terphenyl mixture (Santowax OMP) and 2000 ppm impurities. The make up of the impurities was as follows:

- (a) 60% Fe_3O_4 and Fe_2O_3 magnetite particles sized from sub-micron to 100 microns
- (b) 20% graphite particles sized from sub-micron to 100 microns
- (c) 20% mica flakes 50-75 micron thickness and approximately 1 cm in width and depth.

The impurity concentration of 2000 ppm simulates a condition approximately 100 times the expected impurity concentration in the EOCR. The latch mechanism and hook were the final Vard design parts scheduled for use in the EOCR.

The charged terphenyl mixture was melted and the latch mechanism assembled and placed in the pot. The terphenyl temperature was maintained at $500 \pm 30^\circ\text{F}$ during the test. The stirrer was operated during the entire test except for disconnecting when the unit was scrambled. A simulator control rod drive and scram panel was set up to permit scrambling or driving the mechanism up or down at location.

Fig. 1B: Latch Reliability Test Arrangement Schematic

The unit was scrambled according to the following schedule:

<u>Scram No.</u>	<u>Elapsed Time</u>
1	1 hour
2	5 hours
3	13 hours
4	17 hours
5	31 hours
6	41 hours
7	73 hours
8	89 hours
9	90 hours

After each scram, the latch was driven down and relatched and the assembly raised about one-half inch above the ground.

Results of the test were that the latch operated in a normal manner for all scrams.

Upon completion of the Phase I test, the pot was drained and the latch mechanism disassembled. All parts were carefully inspected and photographed. Particulates were found deposited on all parts of the mechanism indicating good dispersion and circulation of the impurities added to the terphenyl for the experiment.

Fig. 2 shows a slight buildup of particulates on the 45° land of the cam. Fig. 3 shows large particles in the ball cage. Fig. 4 shows some particles on the hook. These three figures show evidence that the particulate matter was well distributed through the system. Although the collar in Fig. 5

Fig. 2: Latch Cam - Phase I

Fig. 3: Latch Ball Cage

Fig. 4: Control Rod Hook - Phase I

Fig. 5: Latch Collar

and the remaining parts in Fig. 6 are not integral parts of the working latch (except for the balls), the picture indicates the good dispersion of impurities in the terphenyl mixture and subsequent deposits on latch parts.

3. Phase II -- Terphenyl-High Particulate Concentration, Simulated Heavy Polymer Test

This test was designed to obtain information on the reliability of the latch operating under conditions of high concentrations of particulates in a hot terphenyl mixture with a heavy simulated polymer deposition on primary latch components. The equipment arrangement, type and amount of particulates added were the same as employed in Phase I. The heavy polymer deposition was simulated by coating the working primary parts of the latch mechanism with a high temperature resistant paint.

The latch mechanism parts were painted with several coats of high temperature resistant paint and dried with warm air. The coated parts were then baked in a muffle furnace for 24 hours at a temperature of 450°F. Previous test strips indicated that the paint could withstand contact with 500°F terphenyl mixture. The paint deposit thickness varied from 2-20 mils with the high figure occurring on the balls in localized areas. Adjustment of the parts prior to the test required a disassembly operation. It was noted that much of the coating on the balls had broken off. The coating on the other parts appeared intact.

The charging of the Santowax OMP and the particulate addition was identical to Phase I. The terphenyl mixture temperature was maintained at $500 \pm 30^\circ\text{F}$ during the test. The scram schedule used in Phase I was not changed. After each scram, the latch was driven down and relatched, and the assembly raised about one-half inch above the ground level.

Fig. 6: Latch Balls

Results of the test were that the latch operated in a normal manner for all scrams.

After a release time experiment (see Section 4), the pot was drained and the latch mechanism disassembled. All parts were carefully inspected and photographed.

Figs. 7 and 8 clearly show the magnitude of the material deposit build-up on the 45° and 20° land of the cam. After some of the material was chipped out, as shown in Fig. 8, there were areas in which paint coating was still visible. Figs. 9 and 10 dramatically indicate the completeness of the deposit in and around the working mechanism of the cage. After removal of the balls from the cage, areas of paint coating were still adhering to the working surfaces. The hook is shown in Fig. 11 after the pot had been drained.

The inspection revealed a large amount of grey-black, carbonaceous material in which particles of mica were dispersed. The predominant build-up was on the primary parts of the latch which had been coated with the high temperature paint. The amount of material found was more than could be accounted for from the particulates added and was many magnitudes larger than the deposits found after the Phase I test.

The reason for the excess build-up of material is not known, but possibly could have been due to pyrolysis or interaction of the paint, particles, and the terphenyl.

4. Unlatching Time, Terphenyl-High Particulate Concentration, Simulated Heavy Polymer

The EOCCR control rod latch reliability test arrangement was modified to obtain information on the time required to unlatch after subjecting

Fig. 7: Latch Cam - Phase II

Fig. 8: Latch Cam After Removal of Material

Fig. 9: Latch Balls and Cage As Removed From Assembly

Fig. 10: Latch Balls and Cage Disassembled

Fig. 11: Control Rod Hook - Phase II

the mechanism to high concentrations of particulate matter and coating all primary latch parts with a high temperature resistant paint.

The modification consisted of installing a contact switch to the pot. The magnet contact switch, the newly installed pot contact switch, and scram button were wired to a Minneapolis-Honeywell Model 906 Visicorder. The time difference between the magnet contact switch break and pot contact switch break provided a measure of unlatching time.

The test arrangement was the same as existed following the completion of the Phase II reliability test. After bringing the system up to a temperature of 500°F, the latch was driven down and relatched, and the assembly raised about one-half inch above the ground level. The assembly pot switch was adjusted to just make contact at the raised position. No attempt was made to adjust the magnet contact switch. The Visicorder was started and the system scrambled, the various contact switch break points being recorded on the chart. The procedure was repeated several times.

Results indicated a variation in unlatching time from minus to plus three milliseconds. The negative value and variation in the unlatching times was caused by the positioning of the contact switch on the pot assembly. The error in setting the position of the contact switch on the pot assembly was estimated to be ± 10 milliseconds. The motion of the rod (pot) appears to occur simultaneously with the motion of the magnet armature. This fact concurs with results obtained from similar tests with the latch in the EOCRT loop and a clean terphenyl mixture.

It can be concluded that operation of the latch in a hot terphenyl mixture containing a high concentration of particulates and simulated

heavy polymer coating on latch mechanism parts did not significantly affect the unlatching time.

5. Detailed Summary

The results show that the Vard designed latch mechanism and hook for the EOGR control rod assembly will operate successfully under non-cyclic conditions in hot terphenyl mixtures containing a very high concentration of relatively large size particulates. Also, with a heavy polymer deposition on working parts of the latch, the mechanism submerged in a hot terphenyl-high particulate concentration mixture will operate normally. The unlatching time under the adverse conditions described above was not measurably different from the unlatching time of the mechanism under normal conditions.