EXTENSION OF RETAINER LIFETIME TO 4 CYCLES

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INTRODUCTION

Retainer assemblies are used to provide positive hold down and retain fixed control components during operation in the core. The retainers have previously been licensed by B&W for 3 cycle use(1). B&W has now performed a post-irradiation site-examiniation on two retainers which operated for 3 cycles to evaluate their use for 4 cycles. The results of this examination demonstrate the adequacy of the retainer to operate successfully for four, 18-month cycles.

BACKGROUND

The retainer assembly has been designed to ensure positive hold down of fixed control components inserted in fuel assemblies during operation. The addition of the retainer assembly was necessitated by a previous operational problem(2) associated with the lift of burnable poison rod assemblies. Retainers are used to ensure positive hold down of the following components:

Burnable Poison Rod Assemblies (BPRA)
Modified Orifice Rod Assemblies (MORA)
Regenerative Neutron Source Assemblies (RNSA)

The only design difference for the two types of retainers used for the different control components is the manner in which the retainer mates with its respective control assemblies.

The purpose of this paper is to present the post irradiation site-examination results and the engineering justification for the use of retainers for four, eighteen-month cycles.

POST IRRADIATION SITE-EXAMINATION

A post irradiation site-examination has been performed on two RNS retainer assemblies (used on RNSA's and MORA's) which completed 3 cycles of operation in the Oconee III reactor in May of 1984. The tests covered the major time dependent factors identified from the analysis(2) which are fatigue, wear, and spring relaxation. These RNS retainers were chosen because they were the first to complete 3 cycles of operation. However, previous testing(2) had shown that the severity of service is essentially the same for both types of retainers (RNS and BPRA). Thus, the results from one type are applicable to all.

FATIGUE

The retainer is subjected to fatigue loading from two different sources. The first source is low cycle loads resulting from start-up and shut-down of the reactor. These loads result in negligibly low stresses. The second source is high cycle loading caused by flow induced vibration. The fatigue analysis performed on the retainers showed that the combined fatigue usage factor seen by the retainer for 10^{10} cycles would be less than 0.1 (1 being acceptable). The areas of highest fatigue usage (see figure 1) were the:

foot (smallest cross-section)
arm to hub weld (highest stress concentration)

These areas were examined for fatigue cracks in the first PIE examination(1) using liquid dye penetrant and a scanning electron microscope (SCM) at up to 500 X. The peak stress point at each location was examined. For the weld, this involved sectioning to examine the weld root. As expected, there was no evidence of fatigue cracks in any of the areas examined.

In the second site-examination, these same areas of the two retainers were visually checked for surface cracks through a periscope. As no cracks were identified, this was evidence to support the retainers' use for a fourth cycle of operation. This is also supported by the following evidence on the small effects of high cycle fatigue on the retainer after the first operating cycle.

The cumulative effect of fatigue loads is non-linear. As noted earlier, the high cycle loads are the major fatigue factor. Because of this, the first operating cycle of use experienced by the retainers represents 95% of the fatigue usage which would be experienced in three, eighteen-month cycles. Once past 10^6 cycles, additional cycles contribute to the fatigue usage at only a rate of 5% per decade. The first cycle of operation represented 10^9 cycles and three, eighteen-month cycles represents 10^{10} cycles. A fourth cycle of operation is less than 10^{11} cycles, and represents only an additional 2% fatigue margin loss. The evidence of no fatigue cracks after the first operating cycle was excellent proof that the retainers would perform for additional operating cycles without problems. As no visual cracks were seen during this second site-examinaton and the fact that additional cycles will contribute only about 2% to the fatigue usage, the retainers will perform normal operation for a fourth operating cycle when placed on fuel assemblies that will have less than 25,000 MWd/mtU burnup at the end of the cycle in which they are inserted.*

WEAR

The retainer contact surfaces were visually examined for wear using a periscope.

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* The 25,000 MWd/mtU limit on the fuel assembly is imposed to insure adequate growth clearance for the fuel assemblies throughout the cycle when a retainer is placed on it.

The surfaces examined (see figure 1) were the:

(1) top of the foot
(2) sliding contact areas on the arm and the housing slot
(3) mating surface (retainer to RNS interface area)

There was only one small scrape mark on a foot, and no other visual indication of wear. In addition all surfaces were covered with a light crud which indicates little, if any, relative motion or impact between parts. These results indicate that there is no wear problem through 3 cycles of operation and that 4 cycles of operation is acceptable.

SPRING RELAXATION

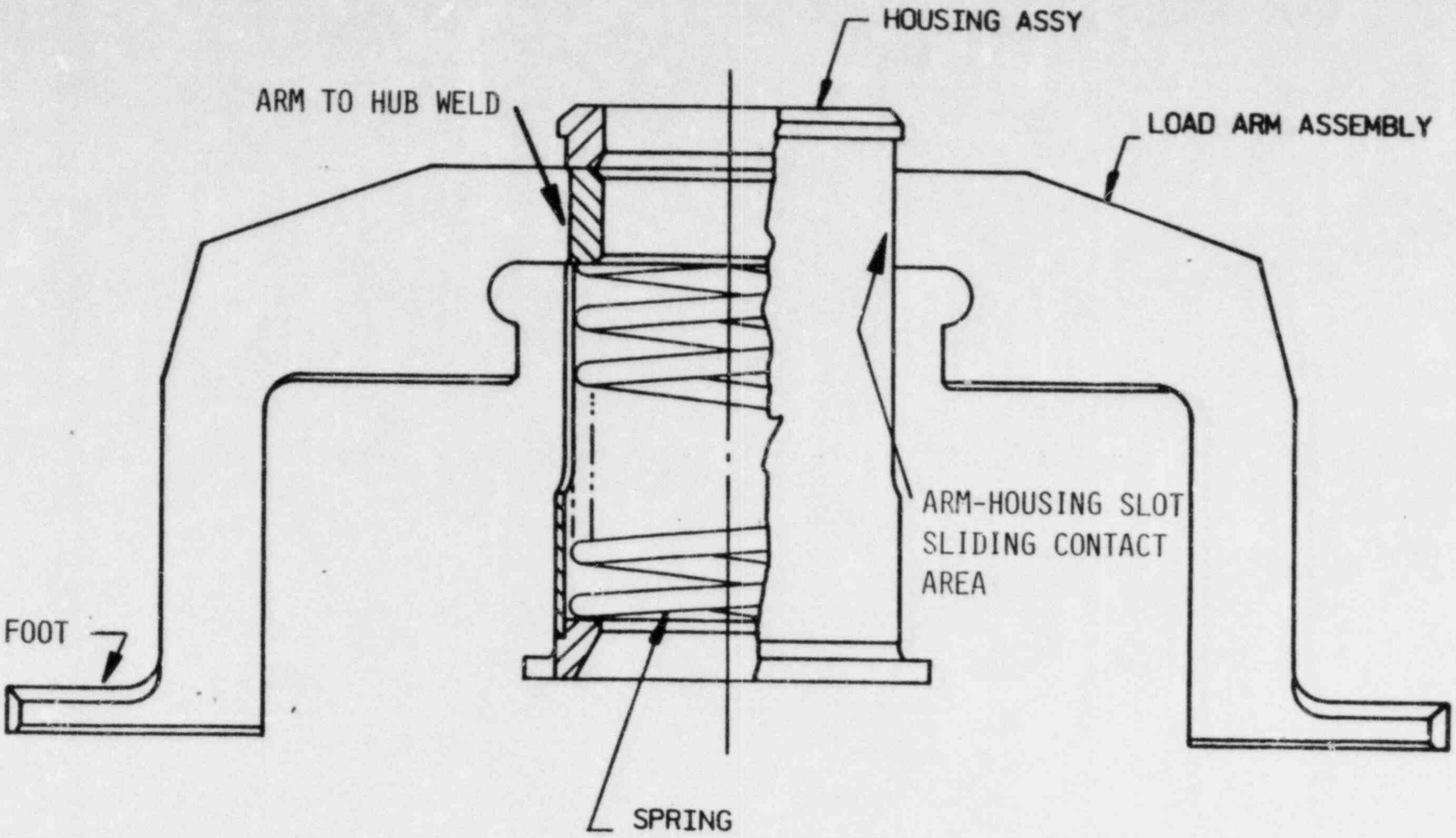
The major purpose of the retainer assembly is to provide a net downward force on the fixed control assembly. The retainer is designed to provide a minimum net holddown force of 30 lb., which is approximately 100% margin over the required 15 lb. (set by thermal hydraulic analysis). The spring for the retainer is made of Inconel X-750 (spring temper) material. This material has excellent high temperature properties and is resistant to radiation induced stress relaxation. Analysis shows that stress relaxation due to temperature and radiation is negligible. The major reason for this is that the retainer spring is well above the active core which greatly reduces its exposure to radiation.

Spring relaxation on the two 3-cycle retainers was determined by measuring the preload force and comparing it to as-fabricated values. Although there was some measurable relaxation (which was analyzed to provide a conservative evaluation for all retainers) the evaluations show that all retainers are expected to provide the 30 lb. minimum holddown force requirement through a fourth cycle of operation.

CONCLUSION

This post irradiation site-examination of two 3-cycle retainers has shown that the analysis and prototype testing, and first cycle PIE were accurate or conservative in predicting 3 cycles of operational effects on the retainers. This examination analysis confirms that the retainers are acceptable for a fourth cycle of use provided they are placed on fuel assemblies that will not exceed the 25,000 MWd/mtU burnup limit by the end of the cycle in which they are inserted.

Figure 1. Side View of Retainer



REFERENCES

(1) Letter: James H. Taylor to Mr. Steven A. Varga, U.S. NRC, "Extension of Retainer Lifetime to 3 cycles". January 14, 1980.

(2) B&W Report - BAW-1496, "BPRA Retainer Design Report," May 1978.