BOILING WATER REACTOR RADIATION SHIELDED CONTROL ROD DRIVE HOUSING SUPPORTS

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ABSTRACT

The Control Rod Drive (CRD) mechanisms are located in the area below the reactor vessel in a Boiling Water Reactor (BWR). Specifically, these CRDs are located between the bottom of the reactor vessel and above an interlocking structure of steel bars and rods, herein identified as CRD Housing Supports. The CRD Housing Supports are designed to limit the travel of a Control Rod and Control Rod Drive in the event that the CRD vessel attachment were to fail, allowing the CRD to be ejected from the vessel. By limiting the travel of the ejected CRD, the supports prevent a nuclear overpower excursion that could occur as a result of the ejected CRD.

The Housing Support structure must be disassembled in order to remove CRDs for replacement or maintenance. The disassembly task can require a significant amount of outage time and personnel radiation exposure dependent on the number and location of the CRDs to be changed out.

This paper presents a way to minimize personal radiation exposure through the re-design of the Housing Support structure. The following paragraphs also delineate a method of avoiding the awkward, manual, handling of the structure under the reactor vessel during a CRD change out.

DISCUSSION

Existing Housing Support Structure

The CRD Housing Support, Figure 1, structure consists of individual Hanger Rods that are attached to a beam structure located immediately below the reactor vessel. The Hanger Rods extend to an elevation below the CRDs. Support Bars span the distance between each Hanger Rod in the area below the CRDs and are held to each Hanger Rod by means of a bolted connection. A pair of Grid Bars are installed on top of the Support Bars which interlock with adjacent Grid Bars to form an integrated system. The Grid Bars transfer the load of a ruptured CRD housing to the support bars and additionally limit any CRD travel should an ejection occur. The Grid Bars are held in place with two Grid Clamps and a Grid Clamp Bolt. In addition, each Hanger Rod has a nut which must be adjusted to provide the desired Grid Bar/CRD housing clearance.

To change out a CRD, the Grid Bars must first be removed. The quantity of Grid Bars removed is dependent upon the number and location of the CRDs selected for replacement. To remove the Grid Bars for each CRD, the operator must manually unscrew the Grid Clamp Bolt, remove the two Grid Clamps, and then remove the two Grid Bars. Each weighs approximately 40 pounds, and is awkward to handle in the confined space under the vessel. Since the Grid Bars are interlocking, all Grid Bars have to be removed starting from the peripheral row and working inwards to the specific CRD scheduled for removal. The CRD is then

replaced. Once the change out is complete, all of the removed Grid Bars must be re-installed, in the reverse order.

As the Grid Bars are heavy and awkward to handle, especially in the confined space under the reactor vessel, a dropped section could result in a serious injury. Additionally, removal and re-installation of the Grid Bars is a time consuming outage process. Because of the high radiation fields directly under the reactor vessel, manual handling of the Grid Bars results in a substantial radiation dose to personnel during each outage. Moving heavy pieces of metal in this area also carries the risk of snagging nearby electrical cables.

Proposed Solution

Description

The ABB solution (patent pending) shown in Figures 2 and 3, is to replace the existing Support Bars with a new Support Bar system that uses the same Hanger Rods but which run perpendicular to those in the existing system. The Grid Bars in the original system are replaced with a cylindrical Radiation Shield at each CRD. The Radiation Shield provides the same function as the original Grid Bars while doubling as efficient radiation shields for personnel working under the vessel. Each Radiation Shield interlocks with the adjacent Radiation Shields to ensure that it remains in its desired location. This interlock, however, has been configured such that it does not require disassembly of any adjacent CRD supports and Support Bars.

In addition to the CRDs exiting the bottom of the reactor vessel, detectors (Low Power Range Monitors (LPRMs) and Source Range Monitors (SRMs)) are located at various positions between CRDs. To avoid an interference in the areas where the detectors are located, the Support Bars are configured with a built in offset to bypass detector positions. In this manner, maintenance on the detectors and drive units can be performed without removing the Support Bars.

Operations Description

During refueling operations, specific CRDs are selected for change out. With the ABB Support Bar system, in conjunction with a remotely operated CRD Handling Machine, the Radiation Shields can be remotely removed and installed individually using a CRD Handling Machine without removing any of the Support Bars. This allows the remaining Support Bars and Radiation Shields to remain in place to provide shielding during the change outs. The removal process becomes a simple procedure, whether done manually or remotely. To remove a Radiation Shield, the shield is lifted slightly off the Support Bar network to clear its interlock with adjacent Radiation Shields, rotated 90^0 so that the interlocks now clear the Support Bars, then lowered out of the Support Bar network and stored out of the way. The Radiation Shield is re-installed after the CRD replacement is complete. This leaves the overall radiation shield intact and ready for the next CRD change out. By reducing the process to the removal of only one Radiation Shield per changed CRD, the time required for the change out is significantly reduced. Any CRD can be changed as fast as any other CRD with the same low dose. These unique features of the ABB system will result in considerable reductions of personnel exposure and time over the current Grid Bar configuration.

The new Support Bar and Radiation Shield arrangement would reduce the general area dose under the reactor vessel to approximately half of the radiation field that is presently seen. This corresponds to the dose rate reduction data recorded when temporary radiation shields are used. Therefore, an area which normally has a dose rate of 300 millirem per hour would have a reduced radiation field of approximately 150 millirem per hour after installation of the new system.

A typical accumulated dose accrued during the change out of 20 CRDs (exclusive of teh shoot out steel remaoval and installation) without radiation shielding has been recorded as approximately 10 man Rem. A

savings of approximately 5 man Rem is expected to be realized through the use of ABB's individual Radiation Shields and Support Bar system.

Considerable dose savings would also be achieved since, with the ABB system, the steel grid does not have to be removed or re-installed for a CRD change out. The removal and re-installation activities typically account for approximately 2 manRem during each outage. Hence, the total estimated savings for typical CRD replacement activities, using the new ABB system, is estimated to be approximately 7 manRem (5 manRem for CRD change out and 2 manRem for removal and re-installation of the Radiation Shields) or 60% of that now seen.

The following table shows accumulated doses and manhours for the replacement of 40 CRDs at a US BWR:

Task Description	Existing System (manhours)	Existing System (Rem)
Remove Shoot Out Steel	40	2.5
- PIP Work	100	1.2
- Prep CRD Tools and Equipment	16	0.16
- Decontaminate CRD	15	0.15
- Rad Protection	75	0.15
Remove/Install CRDs	80	2.5
- Rad Protection	20	0.7
- QC Support	10	0.2
- Under vessel Support	15	0.53
CRD Flush and Disassembly	344	2.65
Transport CRDs and Filters	31	0.6
Repair CRDs	65	2.2
Test Tip Tubing	16	0.2
Install Shoot Out Steel	50	0.8
- Rad Protection	10	0.15
- Under vessel Support	15	0.3
TOTAL	**902.00**	**14.99**

Authors' Biographies

Bengt Baversten is a BWR Consultant on loan to ABB Combustion Engineering Nuclear Operations (ABB CENO) from ABB Atom, Vasteras, Sweden. At ABB Atom, he is a Service Manager of BWR Service Technology. He is presently responsible for the transfer of BWR service technology to the US BWR utilities through ABB CENO. Previously, he was responsible for the field service related activities at ABB Atom which entailed not only field service activities, but the development of new tools and service methods. He has a B.S. in Mechanical Engineering from Eskilstuna Hogre Tekniska Laroverk, Sweden.

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DISCUSSION

Borst: Is the shielding material some sort of encapsulated lead?

Baversten: We think it would be steel only since we have about up to an inch and a half available of wall thickness in these buckets and also in the bottom of it. Steel would be enough. Each of these buckets would weigh about 40 to 80 pounds, meaning the same weight per steel grid. I mentioned 40 pounds per piece, that would be about 80 pounds (for the steel grid). These buckets could be twice as heavy, twice the amount of steel.

Borst: Is my Engineering Department going to have strong concerns when I say that I want to get rid of some their shoot-out steel?

Baversten: Actually, this is the project going on now at the Susquehanna plant. If you want to save dose you have to replace what you have today.

Borst: Is that actually installed at Susquehanna now?

Baversten: No, they are now planning for it. The design is going to be fine tuned. That is why, during this presentation, there are differences in many of the sketches that I showed. They have developed over the last few weeks. Of course, in order to replace the existing bars and install the new bars, you will take some dose. Actually, a fair amount of dose. I assume that the time to do that replacement would be twice as long as you do today to remove it and install existing shoot-out steel. But that's a one time job and after that you just have savings.

Giordano: The concept, as I understand it, is that you would leave the shielding installed undervessel during operation?

Baversten: Yes, that's right.

Giordano: Is that also going through the design considerations from seismics and other things at Susquehanna?

Baversten: Yes, to the same extent that you have for existing steel.

Giordano: It appeared to me that in the removal and installation of the CRD, there is one added step of taking that lead shield out on the pogo stick and then going up and getting the drive and removing that, or does it just sit there on the rail?

Baversten: Actually, there is an extra step. You go up with your mast until you touch the steel piece, turn it 90°, lower it down, remove the steel, and then you have access to your control rod drive.

Giordano: Then, when I am removing the drive, the plugs are there on the platform as I am doing the work, but off to a different side. Does a man have to move that out of the way?

Baversten: You mean the radiation shield?

Giordano: Yes.

Baversten: Just place it on the platform. You have a fixed position there to place it. You have only one of them out at a time. You don't need to store anything. You don't need to move shoot-out steel out of there to another area.