Flaw Evaluation Procedure for Reactor Vessel Internal Components

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1. Introduction

The reactor vessel internal (RVI) components in pressurized water reactor (PWR) are very important structure to support reactor core, distribute the reactor coolant flow, guide control elements and to provide gamma and neutron shielding for the reactor vessel. Fig. 1 shows the representative Korean RVIs

As nuclear power plants age, the degradation of RVI components become more likely and potentially more severe. All PWRs in the U.S. must have in place a program for the aging management of reactor vessel internal (RVI) components in accordance with MRP-227 Rev. 1 [1].

For the most, however, Korean reactors are not likely that of U.S nuclear circumstances. The current inspection & evaluation (I&E) guidelines of RVI components do not provide detailed acceptance and evaluation criteria for each component. This paper introduces the flaw evaluation procedures based on the aging management strategies for RVIs operating in Korea.

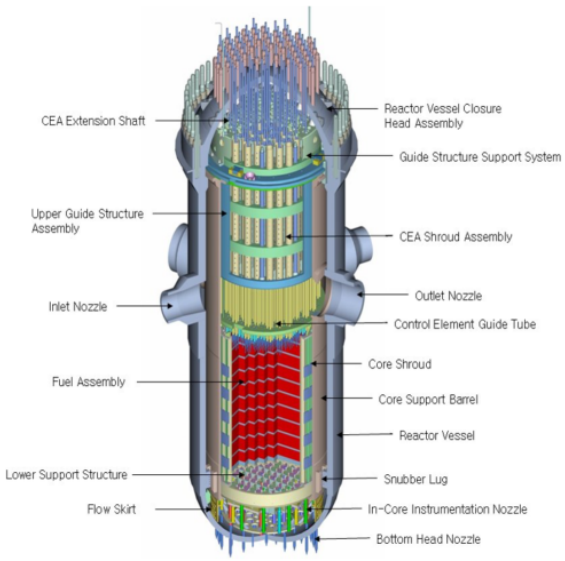


Fig. 1 Reactor Vessel Internal Components for CE

2. Acceptance Standard for RVIs

2.1 I&E guidelines for RVIs

MRP-227, Rev.1 provides a framework and strategy for managing the effects of aging in PWR internals. The I&E guidelines in Reference [1] are based on a through screening of both potential degradation and operating experience. They are designed to target inspections of locations where aging degradation can potentially impair component function. Functionality analyses associated with the original screening evaluations have identified the potential operational concerns, and inspection methodologies have been identified for each component. [2-7] For the most however, the current I&E guidelines do not provide detailed acceptance and evaluation criteria for each component.

2.2 Acceptance standards for RVIs

The I&E for Korean RVIs has been only carried out under ASME Section XI program [8] and operating experiences. ASME Examination categories for RVIs are consisted of B-N-2, the welded core support and B-N-3, removable core support structures. Once the cracks and indications in pipes are founded during outage, the structural integrity on pipes are evaluated according to ASME Section XI, IWB-3510 which is summarized in Fig.2. Although acceptance standards for B-N-2 and B-N-3 are currently provided in IWB-3520, they are only specified to visual examination. In case of defects on RVIs, there are no detailed standards like IWB-3510.

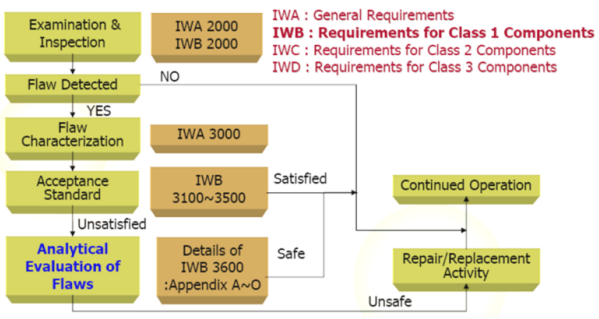


Fig. 2 Flaw Evaluation Chart for ASME Sect. XI [8]

2.3 Limitations of ASME Section XI for RVIs

When the inspection results indicate flaws, the flaws may be evaluated using the acceptance standards in ASME Section XI, IWB-3500 to determine if the

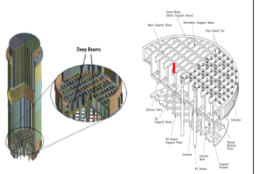
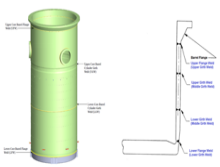
flawed component can be safety returned to service. However, ASME Section XI does not provide the acceptance criteria for RVIs components. Also, fracture toughness and crack growth curves for stainless steels in associated with irradiation environments have are not established in ASME Section XI.

3. Flaw Evaluation Procedure for RVIs

3.1 Selection of RVI components

As shown in Table 1, a total of eight components for each reactor type are selected as a result of detailed screening and the major degradation mechanism are summarized to fatigue, stress corrosion cracking, and irradiated stress corrosion cracking. These degradation mechanisms result in the crack-like defects, and are needed to set up the allowable flaw size based on the fracture mechanics methodologies.

Table. 1 Lists of Flaw Evaluation for RVI Components

Reactor Type	Components	Representative Examples
CE	Deep Beam	
	Guide Tube	
	Fuel Alignment Plate	
	Core Support Column Weld	
	Upper Flange Weld	
	Lower Cylinder Girth Weld	
	Lower Flange Weld	
	Shroud Plate	
Westinghouse	Guide Plate	
	CRGT Lower Flange Weld	
	Upper Flange Weld	
	Upper Girth Weld	
	Lower Girth Weld	
	Lower Flange Weld	
	BF Assembly	
	Hold Down Spring	

3.2 Flaw Evaluation Process of RVI components

In the case of a single flaw, the procedure for evaluating flaws for RVIs is as shown in Fig. 3. The first step is to determine the failure mode in associated with the neutron dose for each component. Failure mode can be determined to the level of neutron dose to limit load method, elastic plastic fracture mechanics (EPFM) evaluation and linear elastic fracture mechanics (LEFM) evaluation. The second step is to determine the fracture toughness for LEFM and J-R curves for EPFM. The third step is that locations with high probability of defects are selected for the consideration of stress and fatigue usage factor. The fourth step is to determine the critical defect size using calculation formula for the stress intensity factor in ASME code, API Code, or etc. The next steps are to calculate the crack growth and to determine the allowable defect size.

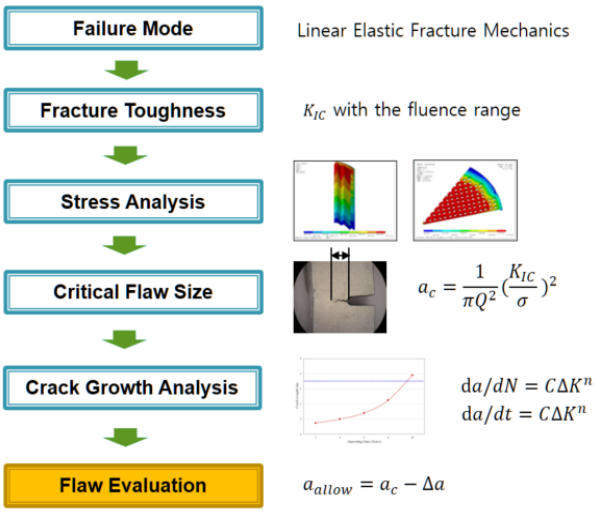


Fig. 3 Process of Flaw Evaluation for RVI Components

4. Conclusions

In Korea, the I&E for RVI components are currently performed according to ASME Section XI program and overseas operating experiences. The current I&E guideline for RVI components does not provide the detailed evaluation and acceptance standard except for visual inspection. In case of flaws of RVI components, acceptance criteria and evaluation methodologies must be established before MRP-227, Rev.1 could be applied. This paper addresses the flaw evaluation procedure and methods for RVI components, which can be based on the establishment of aging management for RVI components operating in Korea.

REFERENCES

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