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A Preliminary 10-Year Periodic In-Service Inspection Program in a Research Reactor

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1. Introduction

This study is carried out early to clear the design interfaces and prepare a 10-year periodic in-service inspection (ISI, as below) program in a research reactor[(1)] according to the latest ASME code. This paper describes the preliminary ISI program for the research reactor, including an applicable code, an inspection scope, inspection methods, and an ultrasonic volumetric test for each primary pump flywheel bore and keyway according to the relevant code[(2)].

2. ISI program

2.1 Primary Cooling System

The primary cooling system (PCS, as below) consists of two parallel 50% capacity pumps and heat exchangers, etc. as shown in Fig.1[(3)]. The PCS circulates demineralized water (H_2O) to remove the heat generated by the reactor. The heat is transported by the coolant to the heat exchangers where it is transferred to the secondary cooling water.

In the figure, the cooled PCS flow is returned to the bottom of the pool through the PCS discharge header. It flows through the upper guide structure, fuel assembly loaded in the grid plate and the outlet plenum, and returns to the PCS to remove the absorbed the heat.

2.2 Applicable code

An ISI is a long-term inspection to verify the mechanical and structural integrity of pressure retained and safety-related systems, structures, and components (SSCs, as below) for maintaining a reactor safety operation. As the PCS is designed based on the requirements of Class 3 Components in ASME SCE. III, Subsection IWD in ASME SEC. XI will apply to conducting the ISI. The preliminary ISI program will be made based on the requirements of ASME SEC. XI edited in 2004, the latest version[(4)].

2.2. Inspection Scope

ASME SEC. XI is classified as Subsection IWB, IWC and, IWD for safety Classes 1, 2, and 3, respectively. Subsection IWF is applied commonly to the inspection of the supports for each safety class. The examination requirements of Subsection IWD apply to the pressure retaining components and their welded attachments on a Class 3 system in support of the following functions:

(a) Reactor shutdown
(b) Emergency core cooling
(c) Containment heat removal
(d) Atmosphere cleanup
(e) Reactor residual heat removal
(f) Residual heat removal from spent fuel storage pool

As the PCS, except for the PCS discharge header, is classified as safety Class 3 and is pressurized by the PCS pumps during normal operation for removing a reactor residual heat, the scope of the ISI contains the PCS, including connected systems with PCS within the specified boundaries, as shown in Fig. 1.

As the PCS discharge header does not perform any nuclear safety function[(3)], it is classified as non-nuclear safety and excluded in the ISI boundary. In the figure, as the reactor connected to the PCS is operated under an atmospheric pressure, the reactor is excluded in the ISI boundary.

Each flywheel, attached to each PCS pump motor shaft, provides an inertia force to ensure a slow decrease in the coolant flow in order to prevent a fuel melting. As each flywheel is not a pressurized component, it shall be excluded in the ISI boundary up to now based on the requirements of Subsection IWD in ASME SEC. XI. But it is included in the ISI boundary according to the notice of MEST[(2)] to perform a periodic inspection of each flywheel for verifying the mechanical and structural integrity.

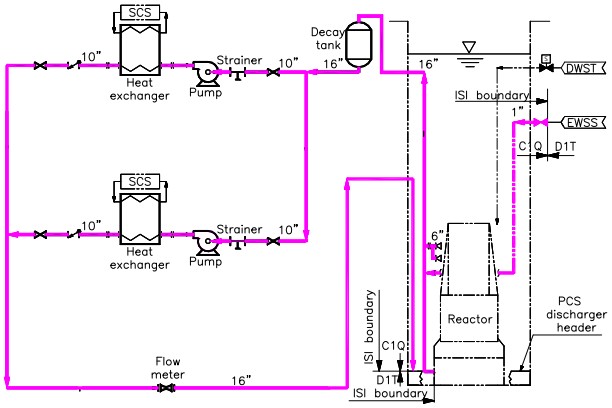

Fig. 1 Preliminary ISI boundary

2.3 Inspection method

2.3.1 System pressure test

For Subsection IWD, the required tests and examinations are a VT-2 visual examination of a system pressure test for pressure retaining components within the specified boundaries. The scope of the system pressure test contains the PCS, and the connected pipe lines, including the first isolation valves of the EWSS[(5)] which are joined to the reactor cooling water outlet line of the PCS. A system leakage test applies to the PCS boundary as the system pressure test.

The system leakage test of the PCS will be conducted during normal operation without holding time. The system normal operation will be maintained for at least 4 hours for insulated components or 10 minutes for non-insulated components after attaining normal operating condition[(6)]. For monitoring a water leak, the normal flow rate is maintained within a limit and there is no leak alarm during the test. After the PCS pump stop, an inspector shall walk down for checking any traces of a leak.

2.3.2 Visual examination

A VT-1 will be applied to the verification of the mechanical and structural integrity for welded attachments within the ISI boundary. The VT-1 will be performed to all integral welding attachments for vessels, piping, pumps, and valves larger than NPS 4 based on the IWD and to 10% of the rest of the pipe support welds based on the IWF[(7)].

2.3.3 Ultrasonic volumetric test

An ultrasonic volumetric test (UT as below) will be applied to the verification of the mechanical and structural integrity of a flywheel attached to each PCS pump motor shaft. To verify the integrity, the bore and keyway of each flywheel should be examined by the UT every three years, and the whole surface and body of each flywheel should be examined by the UT every ten years. Tests will be performed and the results will be evaluated by qualified experts. When the result exceeds a limit, the evaluation results shall be reported to the related regulation body.

Fig. 2 Preliminary ISI program

Inspection no.	Examination method	Inspection interval (year)									
		1	2	3	4	5	6	7	8	9	10
D2.10	System leakage test for all boundary under reactor operation									■	
D1.20	VT-3 for integral welded attachments for vessels, piping, pumps, and valves larger than NPS 4			■			■				■
IWF	VT-3 for 10% of the rest of the pipe support welds based on the IWF			■			■				■
UT-001	UT for bore and key way of no.1 pump fly wheel			■			■			■	
UT-002	UT for bore and key way of no. 2 pump fly wheel			■			■			■	
UT-003	UT for the surface and whole body of no. 1 pump fly wheel										■
UT-004	UT for the surface and whole body of no. 2 pump fly wheel										■

2.4 ISI program

Fig. 2 shows the preliminary ISI program in the research reactor. As the parts examined is not a lot, the ISI will be conducted in the 3rd, 6th, 9th, and 10th year within a ten-year period based on the required test period of the UT for pump flywheels.

3. Conclusions

Based on the requirements of Subsection IWD of ASME SEC. XI last edited in 2004, the preliminary program for 10-year periodic ISI made to clear design interfaces. The scope of the ISI contains the PCS except for the PCS discharge header, including connected systems with PCS until the first isolated valves. The reason is that the PCS is classified as nuclear safety Class 3, and retains the system pressure under a normal operation condition.

The only system leakage test applies to the PCS within the ISI boundary for VT-2 system pressure test based on the IWD. VT-1 visual examination applies to all welded attachment to vessels, piping, pumps, and valves larger than NPS 4 based on the IWD and to 10% of the rest of the pipe support welds based on the IWF. Also the ISI includes a ten-year periodic ultrasonic volumetric test of each flywheel attached to the PCS pump motor shaft.

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