TEPCO'S EFFORTS FOR THE PRACTICAL IMPLEMENTATION OF PFM

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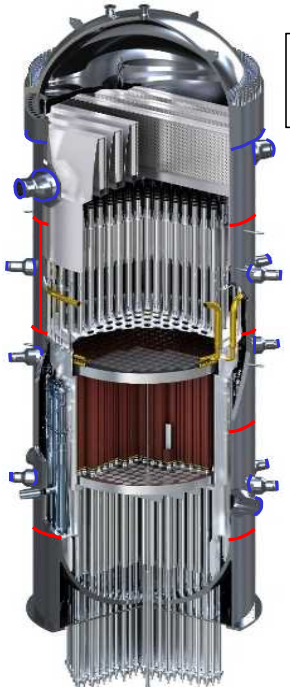
(1) INTRODUCTION

- The inspection coverage for ISI on the RPV shell welds have been expanded from 7.5% to 100% due to the revision of technical standards.
- This change has raised concerns about a significant increase in workers' radiation exposure doses during the inspection.
- In order to minimize radiation exposure through the optimization of inspection program, TEPCO have declared our intention to utilize PFM to the Nuclear Regulation Authority (NRA).



	Inspection region	Method of Inspection	Inspection coverage	
			Bofore change	After change
Shell welds	Circumferential welds (Core region)	Volumetric	7.5%*1 100%*2	100%
	Axial welds (Core region)	Volumetric	7.5%*1 100%*2	100%
	Circumferential welds	Volumetric	7.5%*1	100%
	Axial welds	Volumetric	7.5%*1	100%
	Circumferential welds (Upper/lower shell)	Volumetric	7.5%*1	100%
	Axial welds (Upper/lower shell)	Volumetric	7.5%*1	100%

*1 The level of testing during each inspection interval shall be 7.5% of the length of each weld joint. However, for circumferential joints, it may be 5%, and for axial joints, it may be 10%.
*2 Weld joints in the shell that have been exposed to neutron fluence exceeding $10^{23}n/m^2$(at 1 MeV or higher energy) must undergo testing for all applicable ranges.

As a result of this change, the radiation dose is significantly increased.

（2） Overview

■ The implementation status towards optimization of inspection program using PFM is as follows.

No.	Items	tasks	status
1	Collecting and understanding information on the United States	・Conducting a survey on the situation in the United States with regards to the implementation of ISI test level adequacy optimization using PFM evaluation. （NUREG 10CFR50.55，10CFR50.61a，BWRVIP05,329 etc）	Completed
2	Conducting PFM trial evaluations for representative Japanese BWR plants	・Conducting evaluations using the analysis code FAVOR for representative Japanese BWR plants. ・Conducting sensitivity analysis to identify parameters that have a high sensitivity to PFM evaluation.	In progress
3	Collecting basis for parameter settings	・Collecting data to serve as a basis for setting parameters such as initial flaw density and welding residual stress for PFM evaluation, and confirming the validity of the settings.	In progress
4	Conducting round-robin analysis with EPRI on PFM evaluation	・To demonstrate that it is an evaluation equivalent to that of the proven United States, conducting a round-robin analysis of PFM with EPRI for domestic pilot plants. ・Creating conditions that envelop domestic BWR plants similar to the United States (BWR fleet) and conducting PFM evaluation.	In progress
5	Expert review	・To confirm the validity of the evaluation, conducting a round-robin analysis with other analysis codes involving domestic experts.	In progress
6	Discussions with regulatory authorities	・Initiating technical discussions on PFM evaluation at the Fracture toughness committee of the JEA（Japan Electric Association）	In progress

■ Details for items No. 2,3,4,5 are on the next slide

（3） Detailed implementation items［1/5］

【No.2】Conducting PFM trial evaluations for representative Japanese BWR plants

- A PFM evaluation was conducted using the analysis code FAVOR on the RPV of Units 1 and 7 of the Kashiwazaki-Kariwa Nuclear Power Plant.
- For transients, similar to the United States, LTOP was selected, and for initial flaw density and welding residual stress, default values of FAVOR were used to conduct an evaluation assuming an operating life of 60EFPY.
- This established the evaluation method and confirmed that the TWCFs of both Units 1 and 7 are sufficiently small compared to the acceptance criteria of the United States (1.0×10^{-6} [per reactor year]).
- We plan to conduct sensitivity analysis for each parameter and confirm the sensitivity to the TWCF of each parameter in the future.Furthermore, we plan to proceed with collecting the basis for setting each parameter for the parameters with high sensitivity.

（3） Detailed implementation items［2/5］

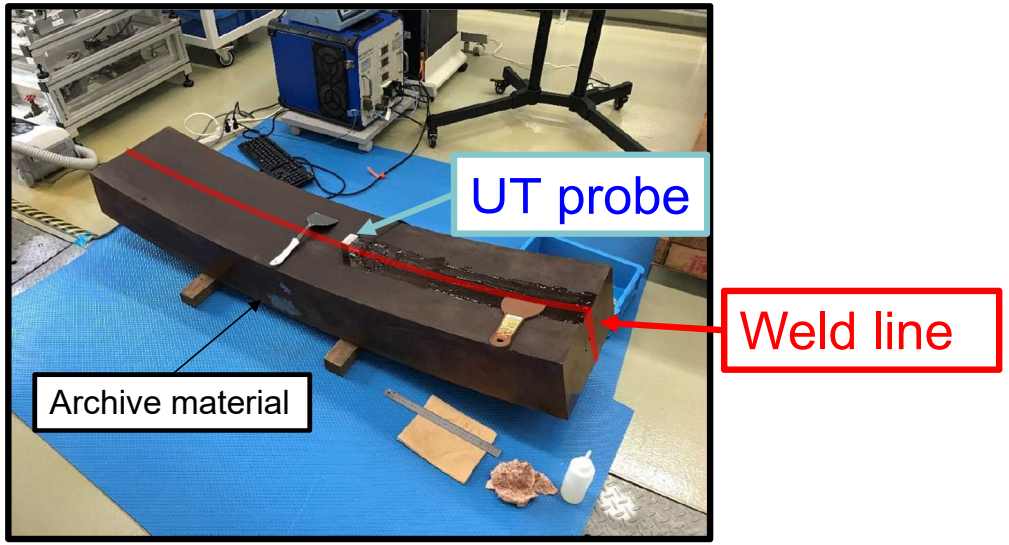
【No.3】 Collecting basis for parameter settings

■Currently, we are using the default values of FAVOR for inputs such as initial flaw density and welding residual stress in PFM. We are conducting efforts to confirm the validity of using these default values.

（**Initial flaw density**）

■We primarily conducted an investigation of flaw density using UT (Ultrasonic Testing) for the RPV archive materials of Units 2-7 at the Kashiwazaki-Kariwa NPP (which are actual RPV welding materials held for the production of surveillance test specimens) and the remaining materials from canceled reactor. We confirmed that the flaw density of Japanese RPVs is smaller than the default initial flaw density in FAVOR.

■In the future, we also plan to conduct similar investigations for other BWR plants in Japan and increase the amount of test specimens.



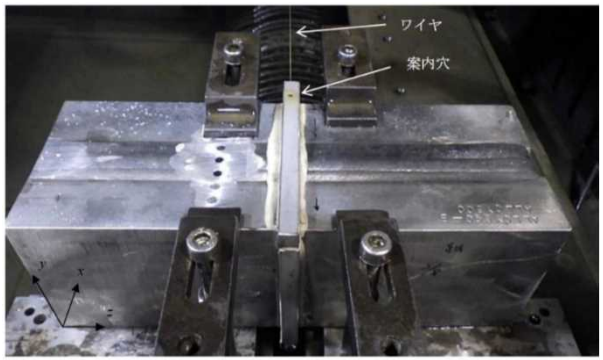
（3） Detailed implementation items［3/5］

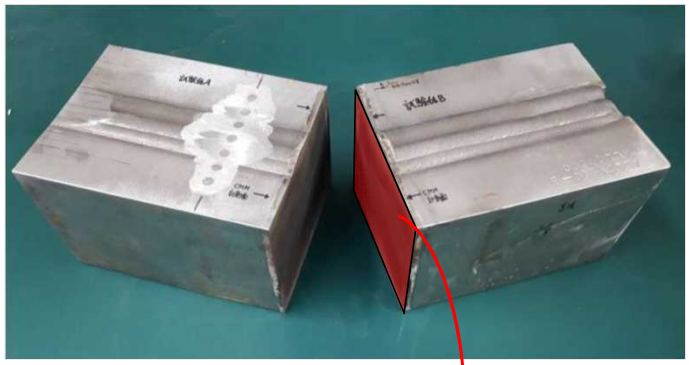
（welding residual stress）

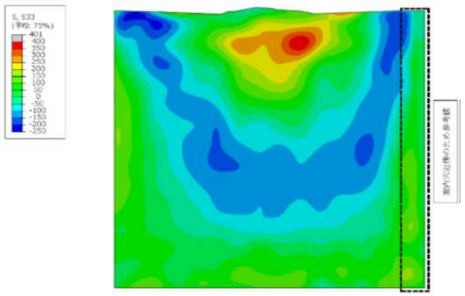
■We are collecting actual measurement data of welding residual stress for both Hitachi and Toshiba, who are vendors for BWRs, as their welding methods differ from each other.

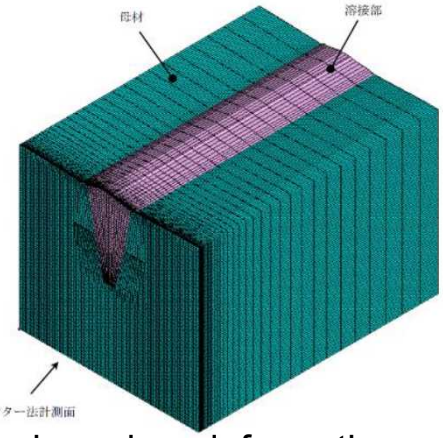
■We are also conducting analysis of welding residual stress. By using the actual measurement data, we aim to improve the accuracy of the analysis.

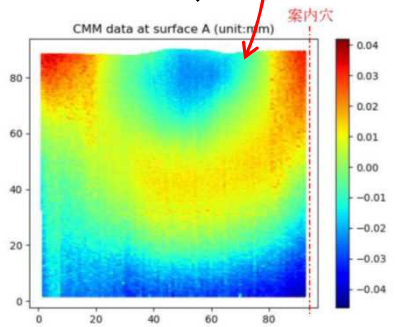
Fixation and cutting











「WRS」＝「Restore stress based on deformation」
Create stress contours using Finite Element Method (FEM)

Measure the amount of deformation on the surface of the cutting location

（3）Detailed implementation items［4/5］

【No.4】Conducting round-robin analysis with EPRI on PFM evaluation

- We conducted PFM evaluations on the RPV of Unit 7 at the Kashiwazaki-Kariwa NPP with EPRI, and compared the PFM evaluations conducted by TEPCO.
- As a result, it was confirmed that the evaluation results from EPRI and TEPCO were almost consistent, and that an evaluation equivalent to that of the United States could be conducted.

Analytical results	CPI [-]	CPF [-]
TEPCO	5.842×10^{-5}	5.837×10^{-5}
EPRI	5.84×10^{-5}	5.84×10^{-5}

The evaluation was conducted using a more conservative value for the neutron irradiation dose, assuming a value even higher than the expected value of 60 EFPY.

- In the future, we plan to create enveloping conditions (fleet) for domestic BWR plants and conduct PFM analysis by both EPRI and TEPCO to confirm the evaluation results.

（3） Detailed implementation items［5/5］

【No.5】Expert review

- We are participating in the "PFM Practical Application Study Group" in Japan, where PFM experts gather, and we are collecting information on the latest developments in PFM.
- Furthermore, we plan to conduct round-robin analysis using analysis code FAVOR and another code (PASCAL), in order to verify the differences in results between the analysis codes.
- As part of this effort, we are considering providing detailed explanations of TEPCO‘s PFM evaluation and seeking reviews from domestic experts.

（4）CONCLUSION

- In this presentation, introduced a part of TEPCO's efforts towards the practical use of PFM.
- We will continue our efforts to demonstrate the validity of PFM evaluation, including collecting basis for parameter settings and improving the accuracy of analysis reviewed by experts. We aim to achieve the ultimate goal of applying PFM to actual components through ongoing discussions with stakeholders.