# Project Subjects

## Pipe Wall Thinning Evaluation & Seismic Evaluation of Thinned Pipeline

### Background and Objective

Pipe wall thinning due to Flow Accelerated Corrosion (FAC) and Liquid Droplet Impingement Erosion (LDI) is a one of the major degradation mechanisms in aged nuclear power plants for fitness-for-service. Though pipe wall thinning rate and the remaining period are managed based on wall thickness measurement, more than several hundreds of inspection are currently conducted in every periodic outage.

In this project, evaluation methods for FAC and LDI are developed to rationalize the number of inspection points, where local thinning distribution can be evaluated. A conservative evaluation assuming the overall (full circumference) thinning is required for seismic evaluation. The pipe with local thinning will be shown to have a comparable strength with the pipe without thinning to rationalize the criterion of wall thickness.

### Main results

**1. Approach to performance improvement of FAC prediction**

- FAC prediction model under single phase flow was proposed. The corrosion of carbon steel and the diffusion (mass transfer) of iron ion were taken into consideration. Prediction performance of FAC rate is revised by model verification using basic test data with PWR secondary water condition (Fig.1) [L09006].
- The corrosion potential of the carbon steel in FAC are predicted by using the theoretical concentration of chemical species at a materials/solution interface. Predicted results demonstrate that the corrosion potential increases suddenly when the dissolved oxygen concentration approaches the FAC suppression value (Fig.2) [Q09028].

**2. Rapid evaluation of wall thinning for FAC and LDI**

- With the proposed model, “Geometry Factors” for typical pipe elements, such as elbows and orifices, are derived to evaluate the relative FAC trend. In addition, FAC susceptible locations are pointed out for each element. As a result, maximum FAC rate is able to be rapidly predicted by using simple equations without precise 3D-CFDs for each element [L09006].
- For evaluation of thinning surface shape by LDI, high-speed evaluation method without 3D calculation is developed. This method enables to evaluate the thinning surface shape and position of maximum thinning rate in a short time (Fig.3) [L09004].

**3. Seismic experiments of wall thinning elbow**

- Hybrid tests are conducted with a wall-thinning elbow model incorporating a numerical analysis of whole piping system. By these results, the full circumference thinning condition is found to be too conservative to evaluate seismic response of wall thinning piping system. The seismic evaluation method of wall thinning piping system can be rationalized by the consideration of locally wall thinning (Fig.4).

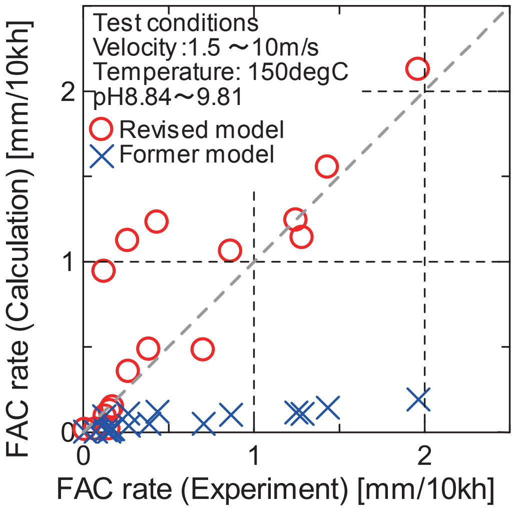


**Fig. 1　Prediction of FAC rate**

Prediction accuracy of FAC rate is revised by model verification using basic test data with PWR secondary water condition.

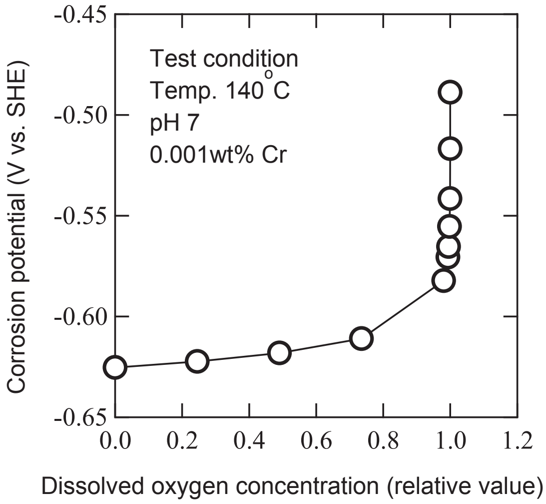


**Fig. 2　Effect of dissolved oxygen concentration on corrosion potential.**

**Table 1　General FAC trend for pipe elements**

(Geometry Factor evaluated by comparison with straight pipe)

| Pipe element | Sample of Geometry Factor (varied by geometric paramters) | Susceptible location of FAC in the element |
|---|---|---|
| Elbow | 4.8 (short elbow) | upstream to middle region of intrados |
| Orifice | 3.8 (dia. contraction ratio 0.6) | downstream region within 2-times dia. from orifice |
| Reducer | 9.0 (reducing angle 20 degree) | downstream region in reducer |
| Globe Valve | 10.2 (open ratio 100%) | upper region of valve downstream |
| Tee-Union | Main:7.0, Branch:3.0 (Branch/Main dia. Ratio 1.0) | branch adjacent region of main pipe |
| Tee-Separation | Main: 7.8, Branch: 9.6 (Branch/Main dia. Ratio 0.66) | region from junction upstream to branch back-side |

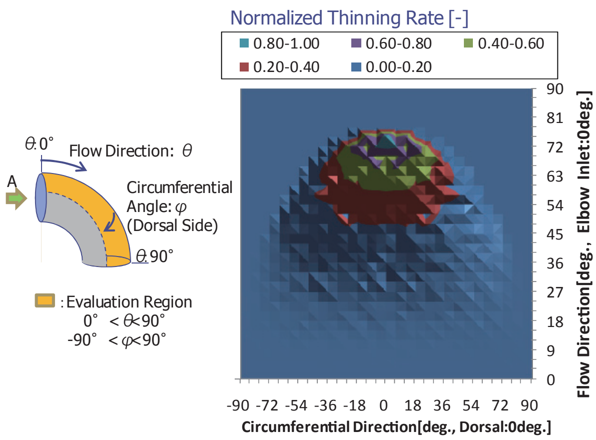


**Fig. 3　Example of Thinning Shape by High-Speed Evaluation Method**

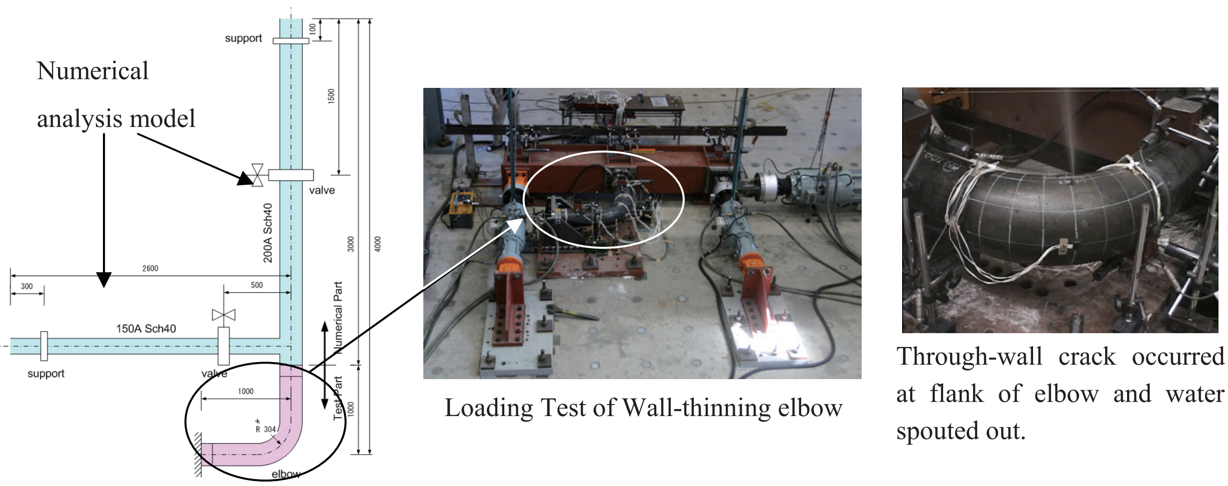


**Fig. 4　Hybrid Test of wall-thinning piping system**

Hybrid tests have been conducted incorporating a seismic response analysis of piping system as a whole model with a static loading test of wall thinning elbow model. The through-wall crack only occurred in the case of full circumference thinning model, although cracks didn't penetrate in the non thinning model and the partially thinning model.