Debris In-vessel Downstream Effect Evaluation



KEPCO/KHNP April 28, 2015



APR1400-K-A-EC-15001-NP



Contents

Introduction

- ***** Meeting Topic
- * Background
- Effect of a flow channel gap change
 - * Analysis Method
 - * Analysis Results
- Accuracy of the flow meter used in the tests





Introduction





Introduction

• Meeting Topic

- ✓ Effect of a flow channel gap change
 - The impact of a flow channel gap on the validity of testing that has already been conducted to address in-vessel downstream effects of the APR1400
- ✓ Accuracy of the flow meter
 - The accuracy and measurement range of the GF630 flow meter which was used in the in-vessel effect tests of the APR1400







Introduction

Background

- ✓ NRC inspection of in-vessel downstream effect tests
 - Date: Sep. 22 26, 2014
 - Issued Inspection Report No. 99901453/2014-201
- ✓ Submission of documents
 - > Reply to a Notice of Violation: Dec. 10, 2014
 - Technical Report, "In-vessel Downstream Effect Tests for the APR1400", APR1400-K-A-NR-14001-P

Revision	Date	Description		
0	Dec. 2014	 Test results of the in-vessel downstream effect of the APR1400 Appendices on the effect of a flow channel gap change and the accuracy of the GF630 flow meter 		











• Purpose of Analysis

- The manufacturing tolerance in the gaps between the test column and the bottom nozzle resulted in some discrepancies compared to the design value.
- Presents the results of a differential pressure analysis in relation to the accumulation of debris under manufacturing and design conditions.
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(a) Manufacturing Condition

(b) Design Condition





- Assumptions and Analysis Conditions (1/2)
 - ✓ At the inlet, fluid flows at a constant velocity: 77.6 lpm (20.5 gpm)
 - ✓ The height of the gaps is maximized by modeling the bottom nozzle in the form of an hexahedron
 - ✓ The measured differential pressure (DP) comes from the mock-up fuel assembly (FA) and accumulated debris

 $\mathbf{DP}_{\text{total}} = \mathbf{DP}_{\text{FA}} + \mathbf{DP}_{\text{debris}}$





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Effect of a Flow Channel Gap Change

• Assumptions and Analysis Conditions (2/2)





Porous Media Model

✓ Based on Darcy's law and the ANSYS CFX theory

$$\frac{\Delta p}{\Delta t} = -\left(\frac{\mu}{K_{perm}}v + K_{loss}\frac{\rho}{2}v^2\right)$$

- Δp : differential pressure
- μ : fluid viscosity
- K_{perm} : permeability loss coefficient
- v: velocity normal to the porous face
- K_{loss}: quadratic loss coefficient
- ρ : fluid density
- Δt : thickness of the medium
- ✓ By considering only the quadratic term, since the Reynolds number at

the inlet is 6490, we can calculate K_{loss} as below.

$$\frac{\Delta p}{\Delta t} = -K_{loss} \frac{\rho}{2} v^2$$





• Loss Coefficient Calculation for Debris and Bottom Nozzle(1/3)



[Analysis Model Under the Manufacturing Condition]





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Effect of a Flow Channel Gap Change

• Loss Coefficient Calculation for Debris and Bottom Nozzle (2/3)





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Effect of a Flow Channel Gap Change

• Loss Coefficient Calculation for Debris and Bottom Nozzle (3/3)

(a) Debris bed

(b) Bottom nozzle

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[Pressure for the Debris Bed and Bottom Nozzle Region]





• Analysis Results Comparison of the Manufacturing Condition with the Design Condition





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• Conclusion

- ✓ The change of flow channel gap from the as-fabricated value to the design value will cause the pressure drop to increase by less than 1%.
- ✓ Therefore, the results of test that have already been conducted are valid because there is a plenty of margin under the limiting condition of hotleg break.



Public Meeting



Accuracy of the Flow Meter Used in the Tests





Accuracy of the Flow Meter

- Flow Meter Used in the Tests
 - ✓ Model: Toshiba GF630
 - ✓ Measurement range: 7.5 ~ 250 lpm
 - \checkmark Accuracy: $\pm 0.5\%$ of rate at 50 ~ 250 lpm, ± 0.25 lpm at 7.5 ~ 50 lpm

• Evaluation Result at the Minimum Flow Rate

• Standard	Measured	Deviation	Requirement	Evaluation
• flow rate(flow rate(X)	(X-Y)	(lpm)	
Y)	(lpm)	(lpm)		
• (lpm)				
• 7.748	7.91	0.162	0.25	Satisfactory
• 7.774	7.95	0.176	0.25	Satisfactory
• 7.362	7.52	0.158	0.25	Satisfactory

16

✓ After the inspection, the flow meter was recalibrated.





Accuracy of the Flow Meter

- **Results of the Evaluation**
 - \checkmark Requirement of the flow rate to ensure control: target flow rate ± 5%
 - ✓ Minimum flow rate in the tests: 9.2 lpm
 - \checkmark Control band at the minimum flow rate: 9.2 lpm ± 0.46 lpm
 - ✓ GF630 meets the required accuracy at a flow rate less than 9.2 lpm
- Conclusion
 - ✓ The GF630 flow meter met the required accuracy in the measurement range of 7.5 lpm to 250 lpm when it was recalibrated.
 - ✓ The tests under the cold-leg break condition were performed with a flow meter which met the required level of accuracy.





Thank you for your attention.



