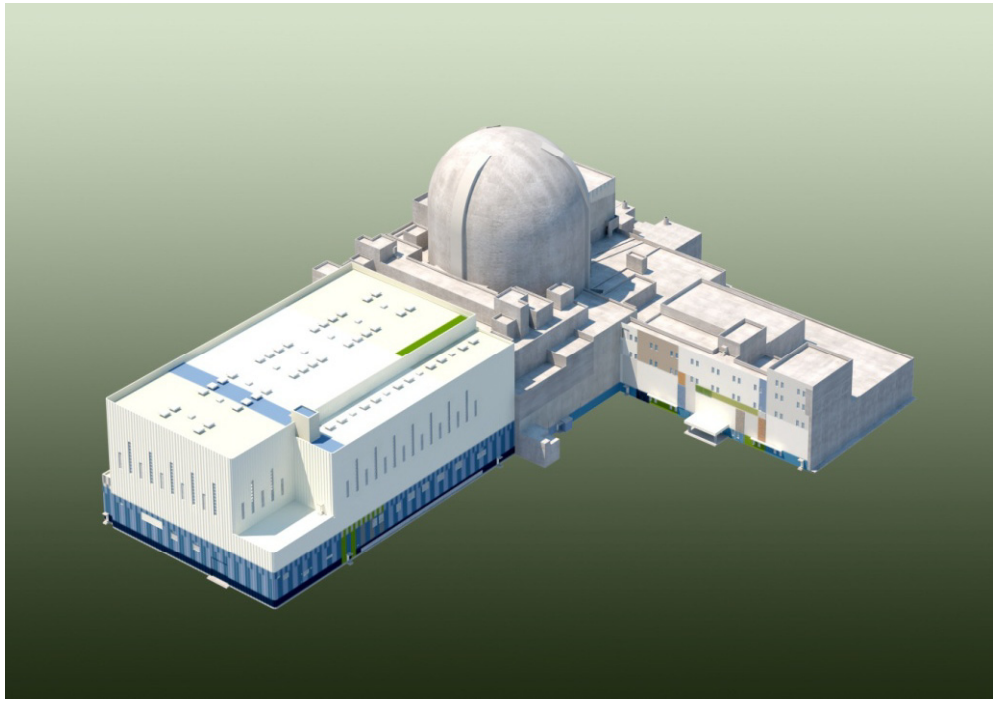
NON-PROPRIETARY

Debris In-vessel Downstream Effect Evaluation



KEPCO/KHNP

April 28, 2015

Public Meeting

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

Effect of a Flow Channel Gap Change

Effect of a Flow Channel Gap Change

- **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**

Effect of a Flow Channel Gap Change

- **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**

$$DP_{total} = DP_{FA} + DP_{debris}$$

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[ ]

Effect of a Flow Channel Gap Change

- **Assumptions and Analysis Conditions (2/2)**

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Effect of a Flow Channel Gap Change

- **Porous Media Model**

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

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

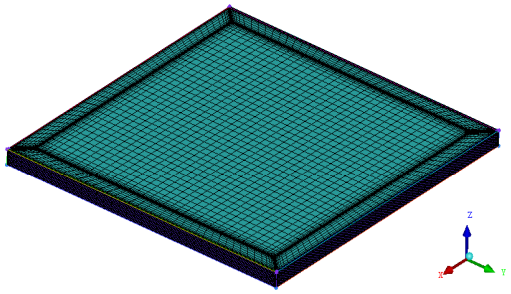
  Δp : differential pressure
  μ : fluid viscosity
  K_{perm} : permeability loss coefficient
  v : velocity normal to the porous face
  K_{loss} : quadratic loss coefficient
  ρ : fluid density
  Δt : thickness of the medium

  ✓ **By considering only the quadratic term, since the Reynolds number at the inlet is 6490, we can calculate K_{loss} as below.**

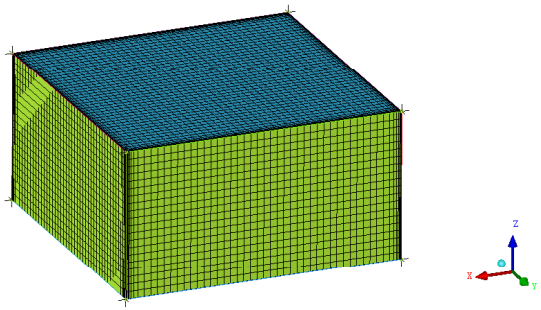
$$\frac{\Delta p}{\Delta t} = -K_{loss} \frac{\rho}{2} v^2$$

Effect of a Flow Channel Gap Change

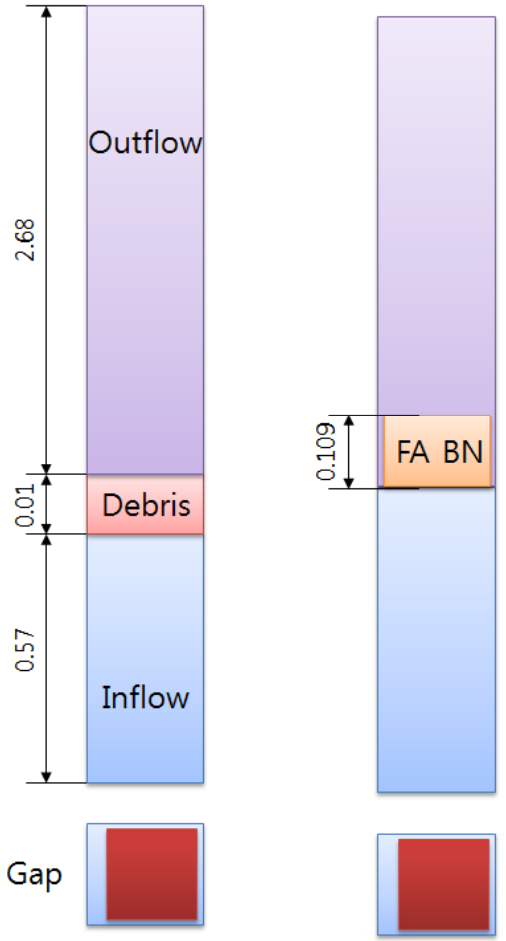
- **Loss Coefficient Calculation for Debris and Bottom Nozzle(1/3)**



(a) Debris bed



(b) Bottom nozzle



[Analysis Model Under the Manufacturing Condition]

Effect of a Flow Channel Gap Change

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

Effect of a Flow Channel Gap Change

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

TS

(a) Debris bed (b) Bottom nozzle

[Pressure for the Debris Bed and Bottom Nozzle Region]

Effect of a Flow Channel Gap Change

- **Analysis Results Comparison of the Manufacturing Condition with the Design Condition**

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Effect of a Flow Channel Gap Change

- **Conclusion**

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- ✓ **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 hot-leg break.**

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**
  - ✓ **Accuracy: ± 0.5% of rate at 50 ~ 250 lpm, ± 0.25 lpm at 7.5 ~ 50 lpm**
- **Evaluation Result at the Minimum Flow Rate**

• Standard flow rate(Y) • (lpm)	Measured flow rate(X) (lpm)	Deviation (X-Y) (lpm)	Requirement (lpm)	Evaluation
• 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

- ✓ **After the inspection, the flow meter was recalibrated.**

Accuracy of the Flow Meter

- **Results of the Evaluation**
  - ✓ Requirement of the flow rate to ensure control: target flow rate ± 5%
  - ✓ Minimum flow rate in the tests: 9.2 lpm
  - ✓ 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.