Performance Verification of APR1400 Safety Injection Tank -Fluidic Device

History of APR1400 Fluidic Device Development

VAPER Test Facility

Test Conditions

Test Results

Summary

History of APR1400 FD Development

Date (yy. mm)	Test Category	Objectives
1997. 12 ~ 1999. 02	Model Tests (Phase-1)	Basic Design of APR1400 Fluidic Device (FD)

- AEA Technology, U.K.
  - Expert Group Developing Various Vortex Devices in Many Industrial Fields
- Model Test Facility
  - I.D. : 1.25 m (4.1 ft)
  - Height : 14.6 m (48.0 ft)

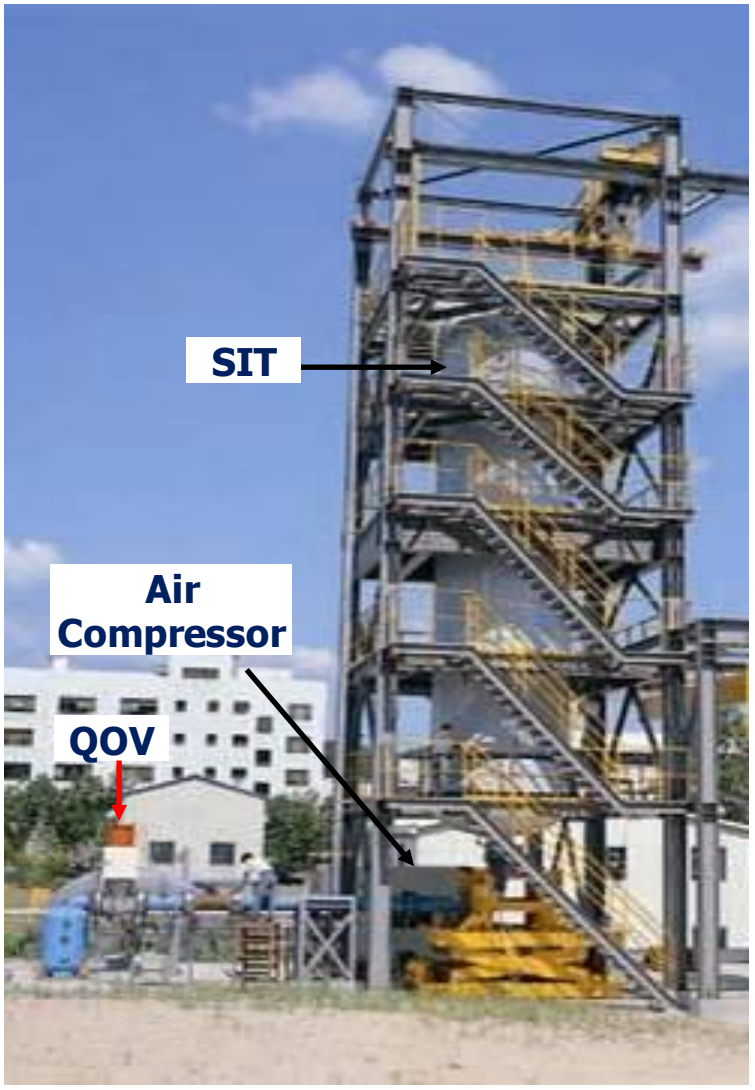
History of APR1400 FD Development

Date (yy. mm)	Test Category	Objectives
1999. 04 ~ 2002. 03	Full Scale Tests (Phase-2)	Standard Design Specification of APR1400 FD
2003. 08 ~ 2006. 02	Full Scale Tests (Phase-3)	Performance Verification of APR1400 FD

- Full Scale Test Facility at KAERI
- Development of Fluidic Device that Meets the Performance Requirements
- Confirmation of the Reproducibiltiy of Performance through Repetitive Tests
  - ✓ Including the Sensitivities of the Changes in the Initial Pressure and Water Inventory, and Manufacturing Tolerance

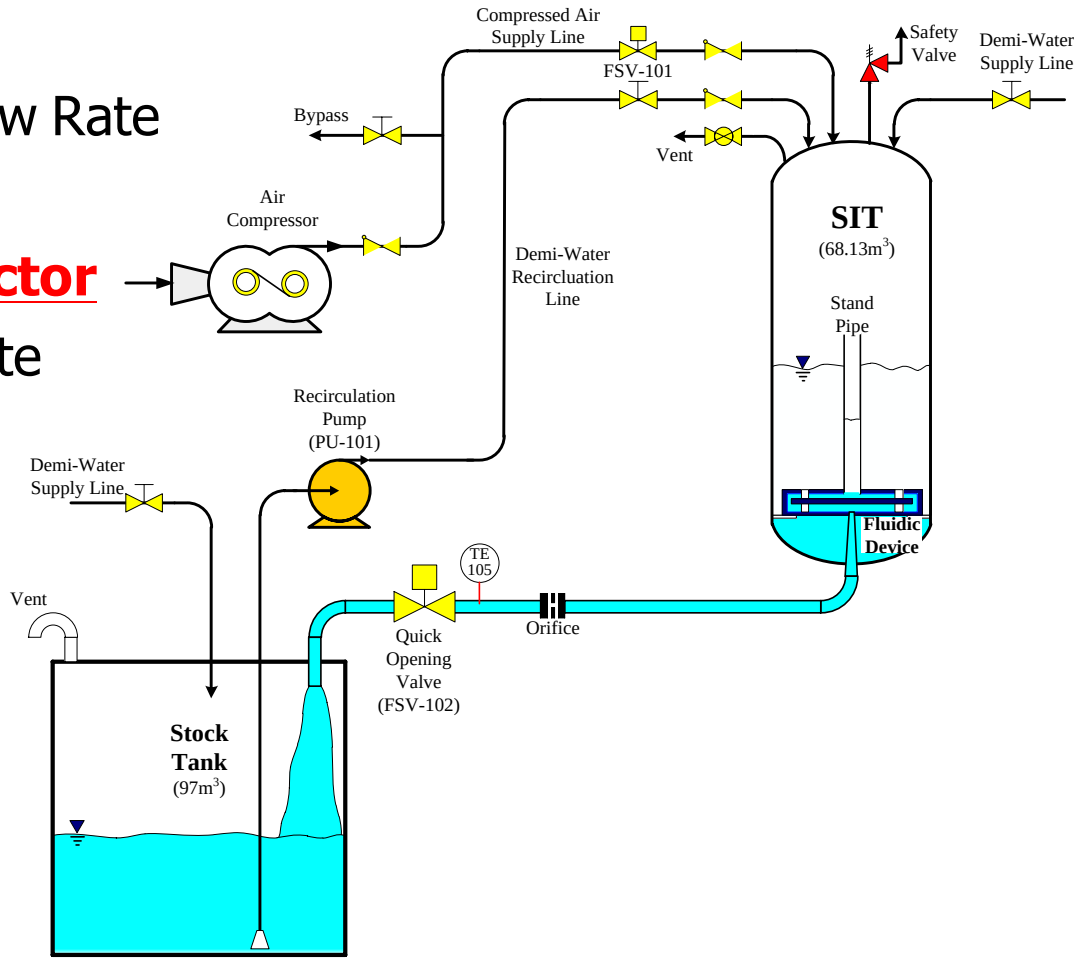
VAPER Test Facility (1)

- Prototype Full-Scale SIT
  - I.D. : 2.74 m (8.0 ft)
  - Height : 11.9 m (39.0 ft)
  - Volume : 68.13 m^3 (68.13 ft^3)
- Air Compressor
  - Max P.: 5.0 MPa (725 psi)
- **Final Goal**
  - **Verification of the Pressure Loss Coefficient (K-Factor) of Fluidic Device**, Which Is Used to Evaluate SI Water Injection Flow Rate in Safety Analysis Code



VAPER Test Facility (2)

- Major Parameters
  - SI Water Injection Flow Rate
  - Duration of Injection
  - **Fluidic Device K-Factor**
  - Air Discharge Flow Rate



Schematic of the VAPER Facility

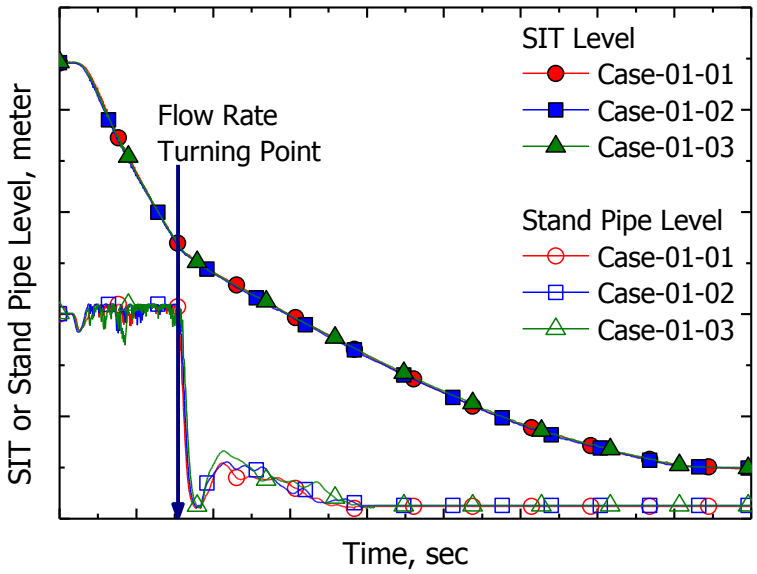
Test Conditions

Phase-3 Full Scale Tests

Test ID	Objectives	Remark
Case-01	Repeatability of Standard Design FD	4 Tests (One Is Low Press. Test)
Case-02	Effect of Water Inventory (or Stand Pipe Height)	3 Tests
Case-03	Effect of Manufacturing Tolerance (Expected Max. Values)	Height of Vortex Chamber (3 Tests)
Case-04		Height of Vortex Chamber & Width of Control Nozzle (3 Tests)

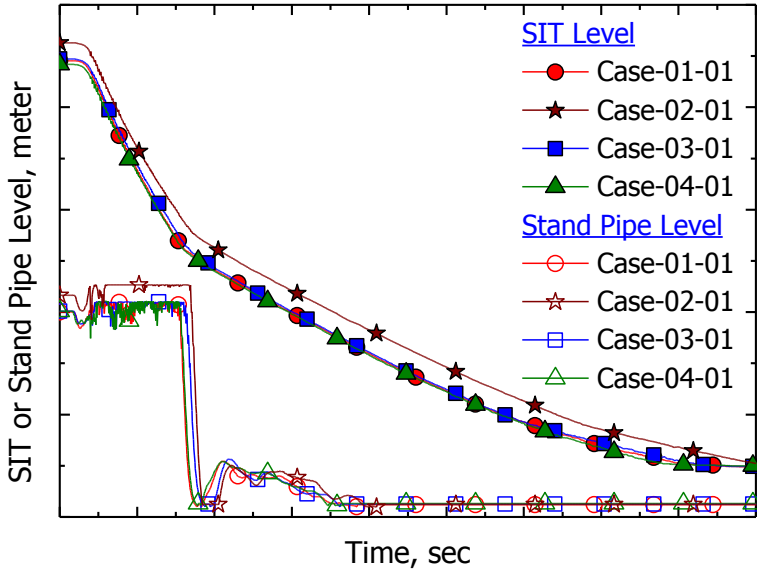
Test Results: SIT & Stand Pipe Levels (1)

- Measured by Differential Pressure Transmitters
- Almost Linear Decrease of SIT Level
- Sharp Depression of Stand Pipe Level at Turning Point



Case-01 Tests

Repeatable

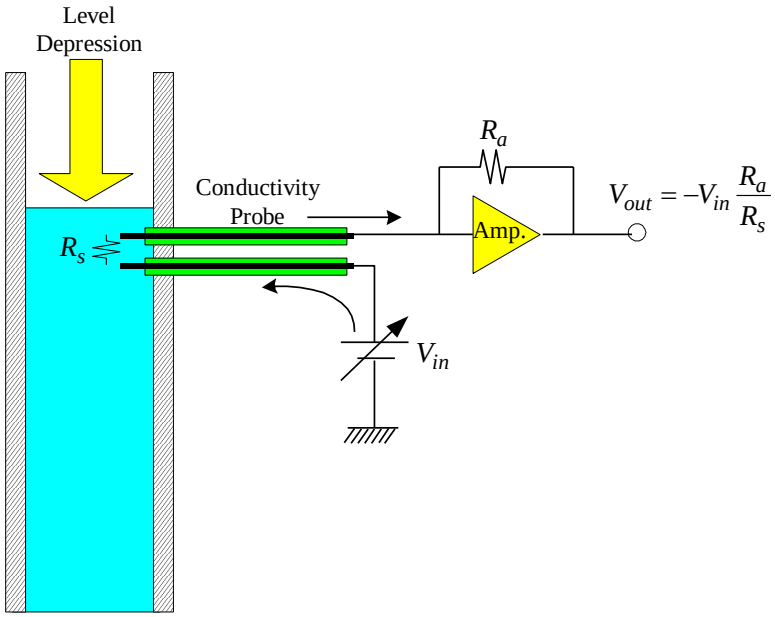


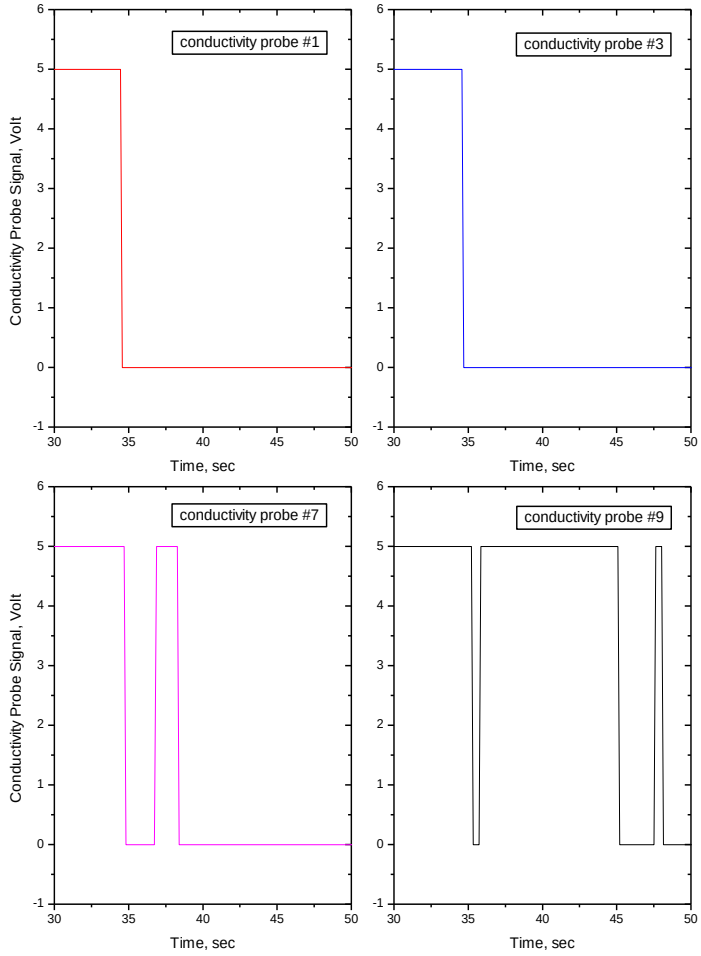
Case-01~04 Tests

Reproducible (Manufacturing Tolerance)

Test Results: SIT & Stand Pipe Levels (2)

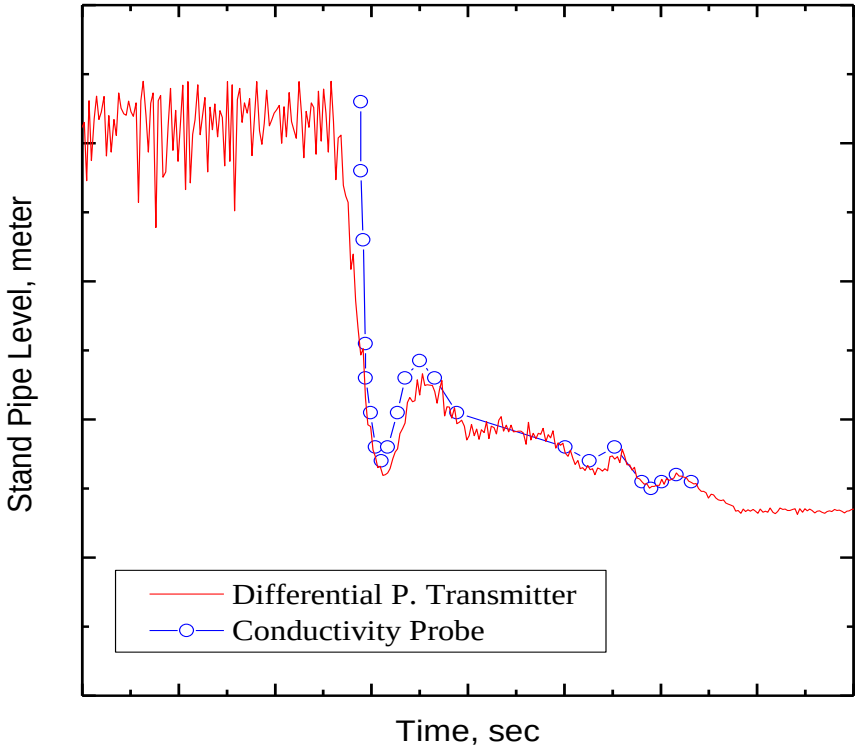
- Confirmation of the Sudden Depression of Stand Pipe Water Level
- 11 Conductivity Probes
  - Much Faster Response Time
  - Phase-2 Test Results





Test Results: SIT & Stand Pipe Levels (3)

- Almost Identical Level Behaviors Were Observed from the Differential Pressure Transmitter and Conductivity Probes.



Test Results: SI Water Injection Flow Rate (1)

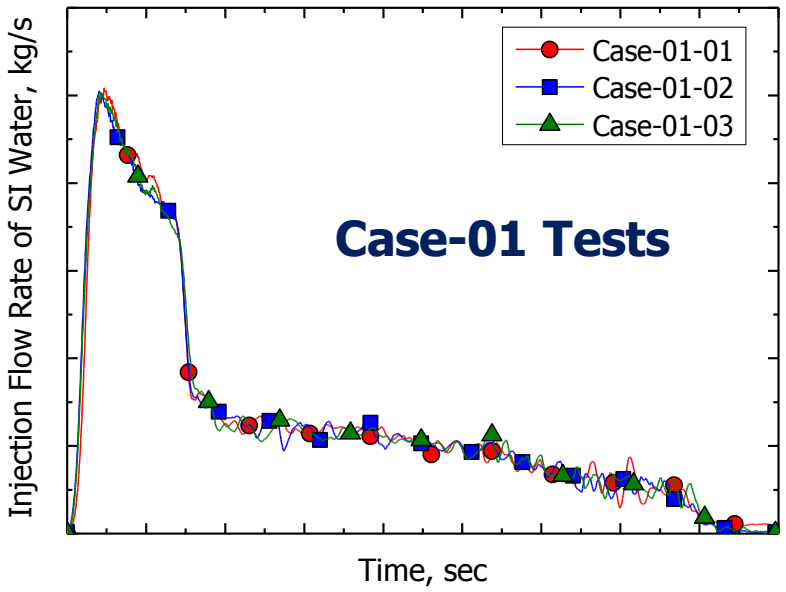
- Flow Rate Was Deduced from the Decrease Rate of Water Inventory.
- Instantaneous Change Rate of Water Level can Be Approximated by the First Order Differentiation.

$$W_{SI}(t) = -\rho_w A_{SIT} \frac{dh_{SIT}(t)}{dt} \approx \rho_w A_{SIT} \frac{h_{SIT}(t) - h_{SIT}(t+\Delta t)}{\Delta t}$$

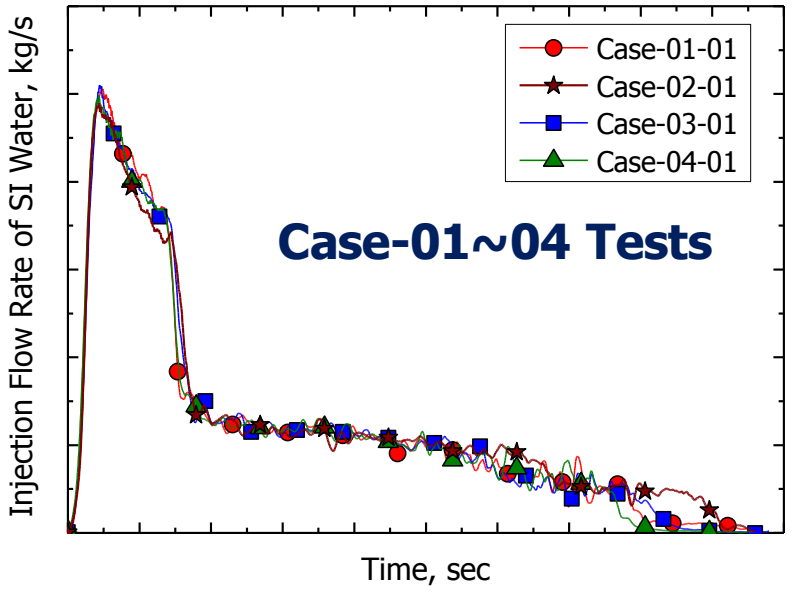
- ✓ **May Not Accurate at the Initial Period of Injection and at the Flow Rate Turning Period**
- ✓ **However, the Final Product Is Fluidic Device K-Factor at Stable SI Water Injection Period**

Test Results: SI Water Injection Flow Rate (2)

- The Injection Flow Rate Turned Sharply from Large Flow Rate to Small Flow Rate, as Required
- Repeatability Was Confirmed, and Effects of Water Inventory & Manufacturing Tolerances Were Minor.



Repeatable



Reproducible (Manufacturing Tolerance)

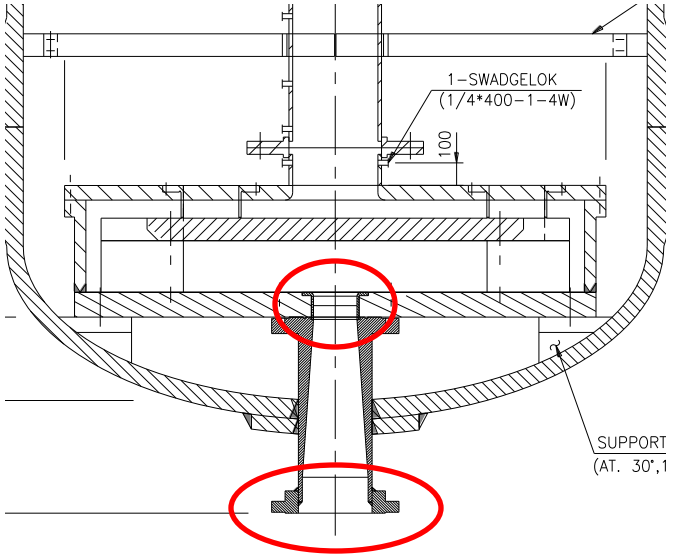
Test Results: Fluidic Device K Factor (1)

- K Factor was Evaluated from the SI Water Injection Flow Rate and the Pressure Difference across the Fluidic Device.
- The Throat Area Is Often Used as a Representative Area for the K Factor.
- Pipe Area of APR1400 SI Line Was Used to Be Consistent with the K Factor of SI Line.

$$K_{SI,Total} = K_{SI,Pipe} + K_{FD}$$

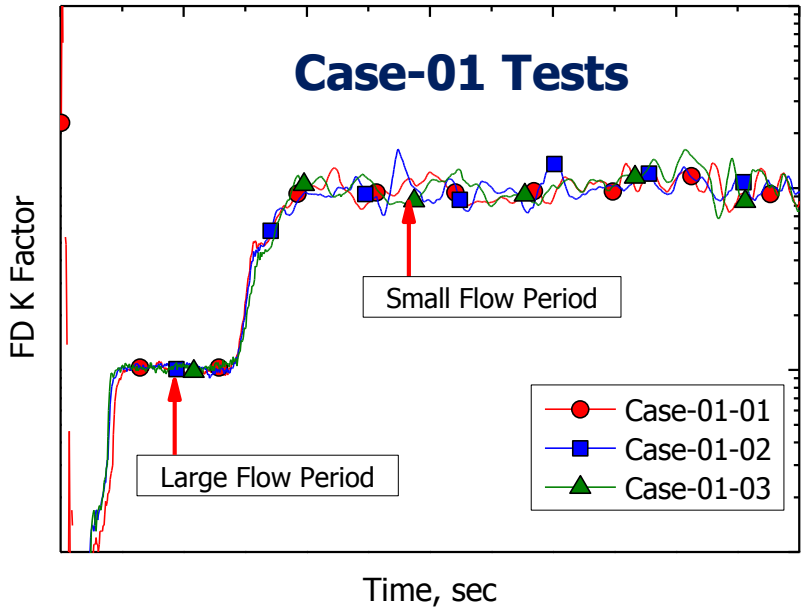
$$= \left(\Delta P_{SI,Pipe} + \Delta P_{FD}\right)\frac{2\rho_w A_{pipe}^2}{W_{SI}^2}$$

$$K_{FD} = \Delta P_{FD}\frac{2\rho_w A_{pipe,APR1400}^2}{W_{SI}^2}$$

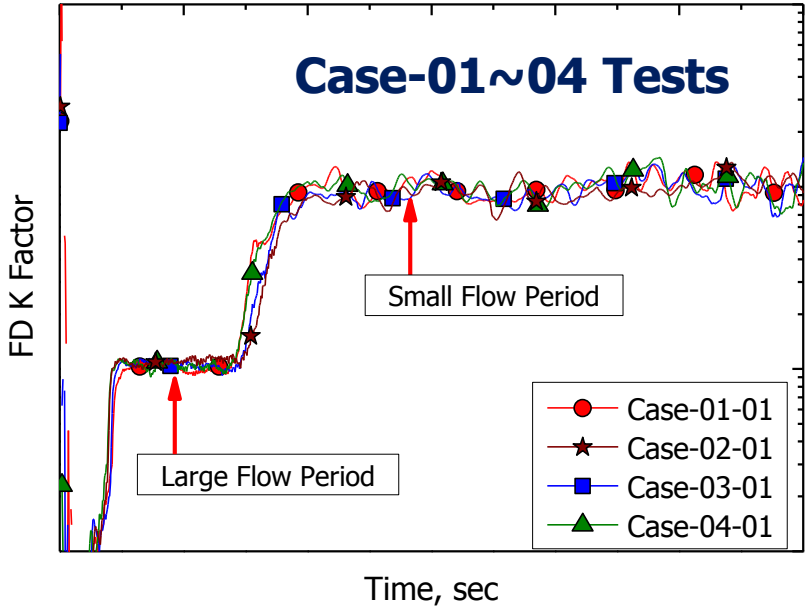


Test Results: Fluidic Device K Factor (2)

- Flow Resistance Increased Significantly due to the Strong Whirling Motion inside the Vortex Chamber.
- Repeatability Was Confirmed, and Effects of Water Inventory & Manufacturing Tolerances Were Minor.



Repeatable



Reproducible (Manufacturing Tolerance)

Summary

- Three Phases of Tests to Evaluate & Verify the Performance of APR1400 Fluidic Device
- Reproducibility of the Performance Fluidic Device
  - Performance of VAPER Fluidic Device Was Repeatable.
  - Performance Was Not Sensitive to the Changes in the Initial SIT Pressure & Stand Pipe Height.
  - Performance Was Also Not Sensitive to the Expected Manufacturing Tolerances

Thank you very much!!!