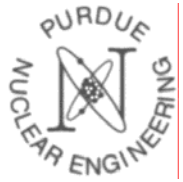
Institute of Thermal-Hydraulics

Task 6: Suppression Pool Void Distribution During Blowdown

Supported by US NRC



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Submitted to NRC
March 8, 2010

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Objectives & Technical Approaches

Project Objectives:

To obtain

- Distribution on local void fraction and bubble velocity with a special focus at the locations of ECCS strainers
- A series of test data that covers a range of air injection flow rates and noncondensable gas fraction for the blowdown conditions

Technical Approaches:

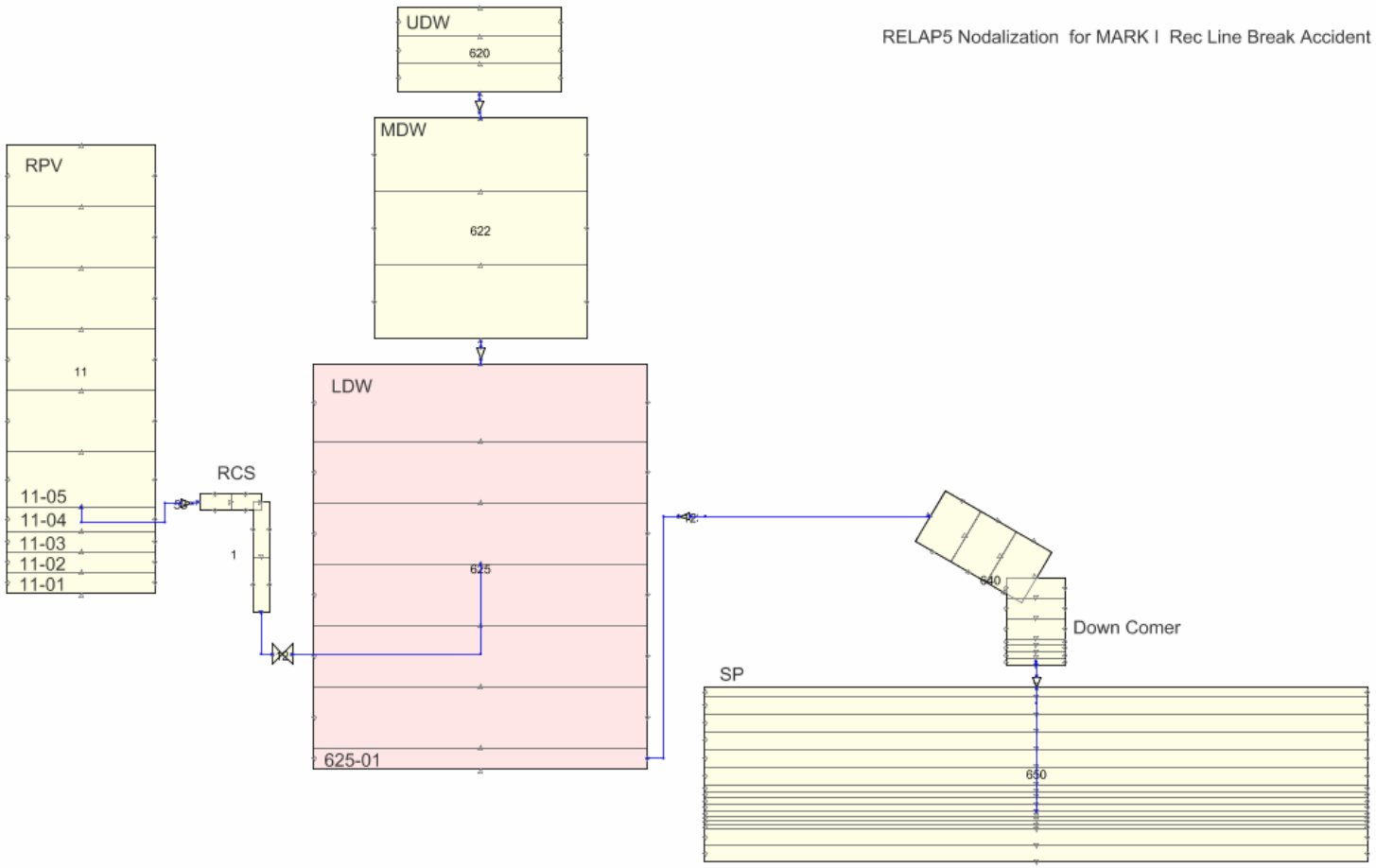
- Modification of the PUMA-E facility and SP configuration
- Simulating blowdown period of LOCAs

RELAP5 Simulation

Objectives:

- To simulate the physical phenomena of Mark I during the blowdown phase of LOCA
- To obtain the velocity profile of air and steam at the inlet downcomer during the initial blowdown

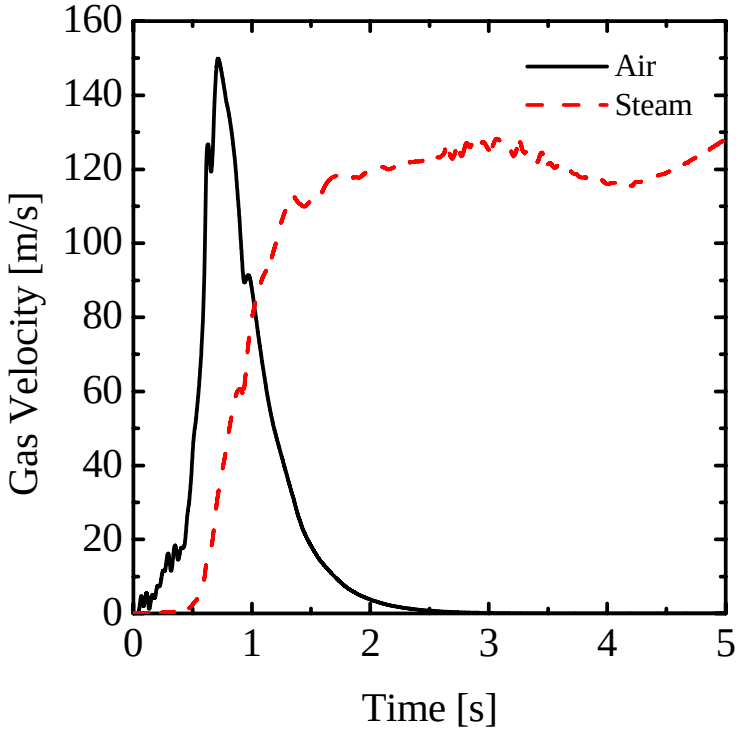
MARK I Nodalization



RELAP5 Results

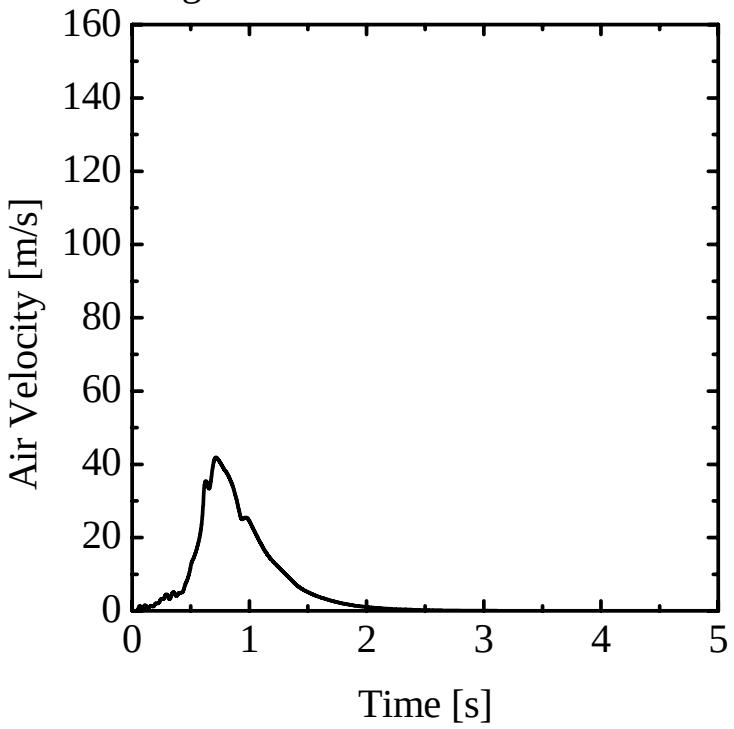
- Inlet air and steam velocity at DC of Mark I

MARK-I
max vel. = 150.2 m/s at 0.72s



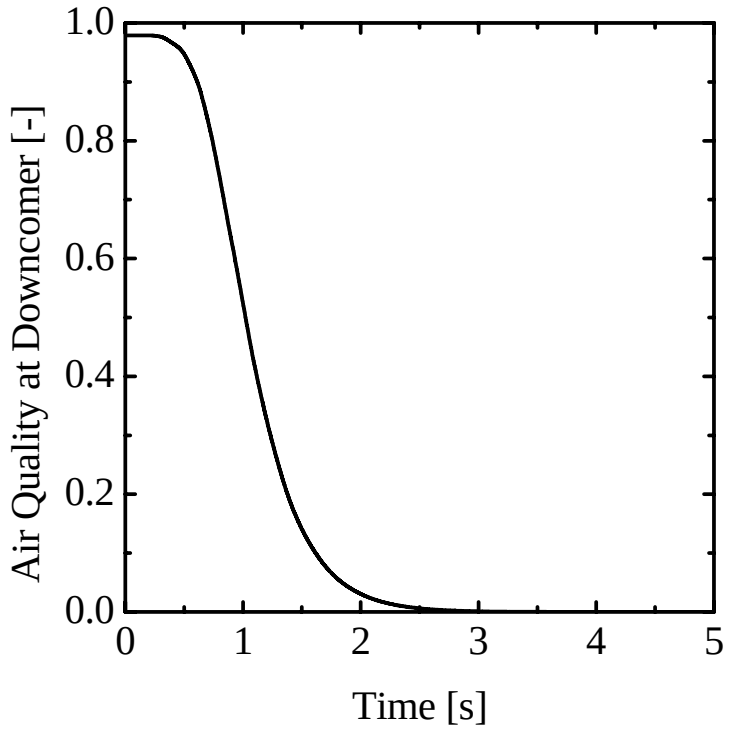
- Scaled down inlet air velocity of PUMA

PUMA
max vel. = 150.2/3.58=42.0m/s at 0.72s
Avg vel. = 12.2m/s

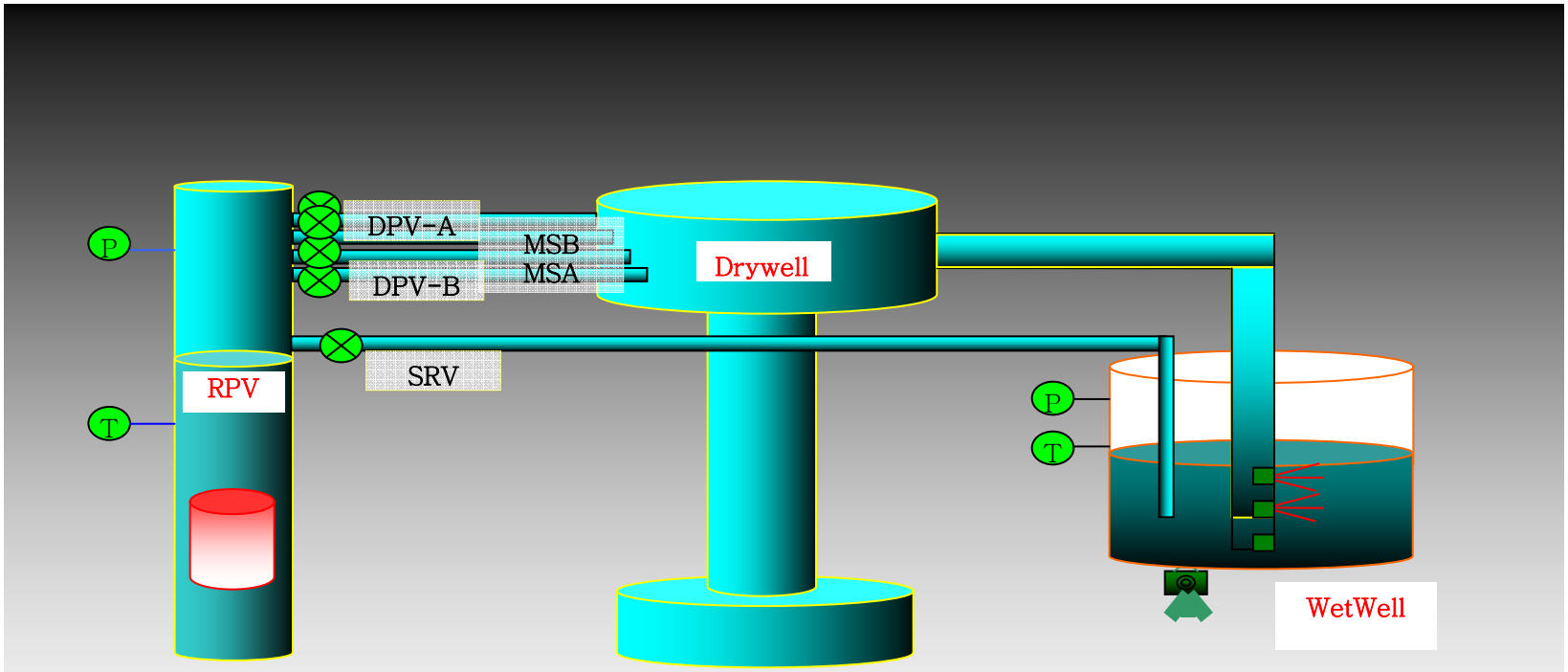


RELAP5 Results

- Air quality at downcomer section



Schematic of PUMA-E Facility



valve

Visualization

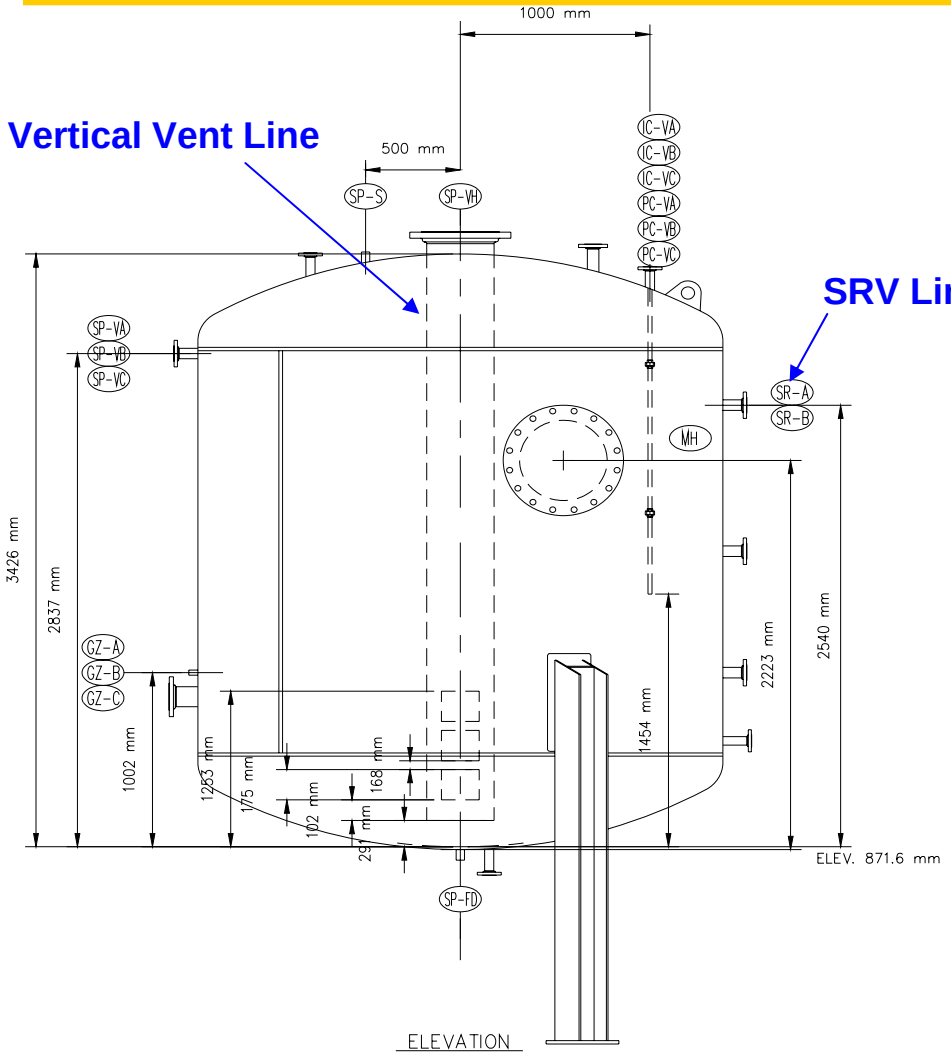
Thermocouple

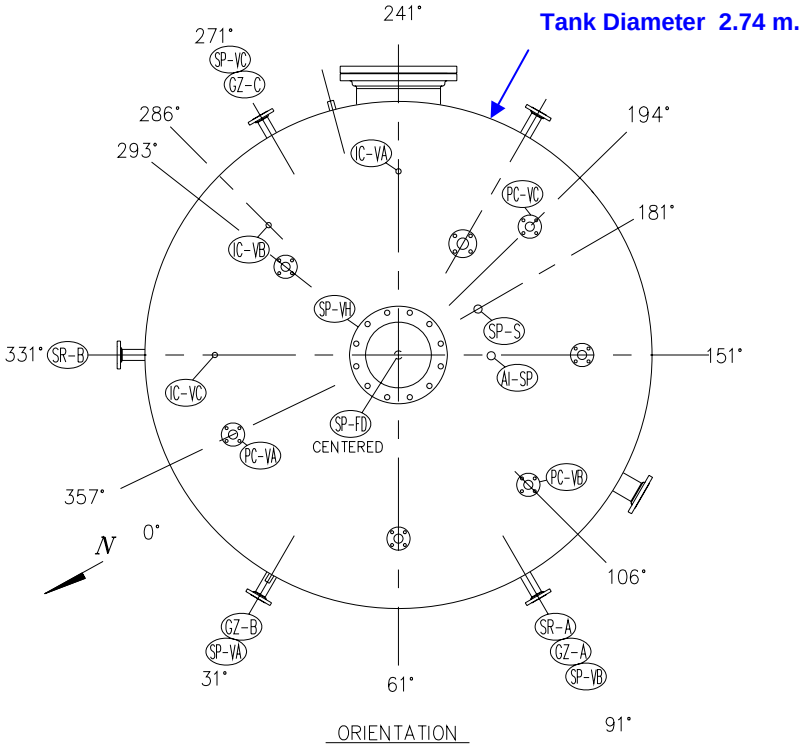
RPV heater

PUMA-E facility

- A scaled model of GE'S ESBWR
- Apply a well scaling approach in designing and building
- Use to study various thermal hydraulic phenomena involving the safety system
- provide data for the codes assessment

Geometry of SP





Types of Experiments

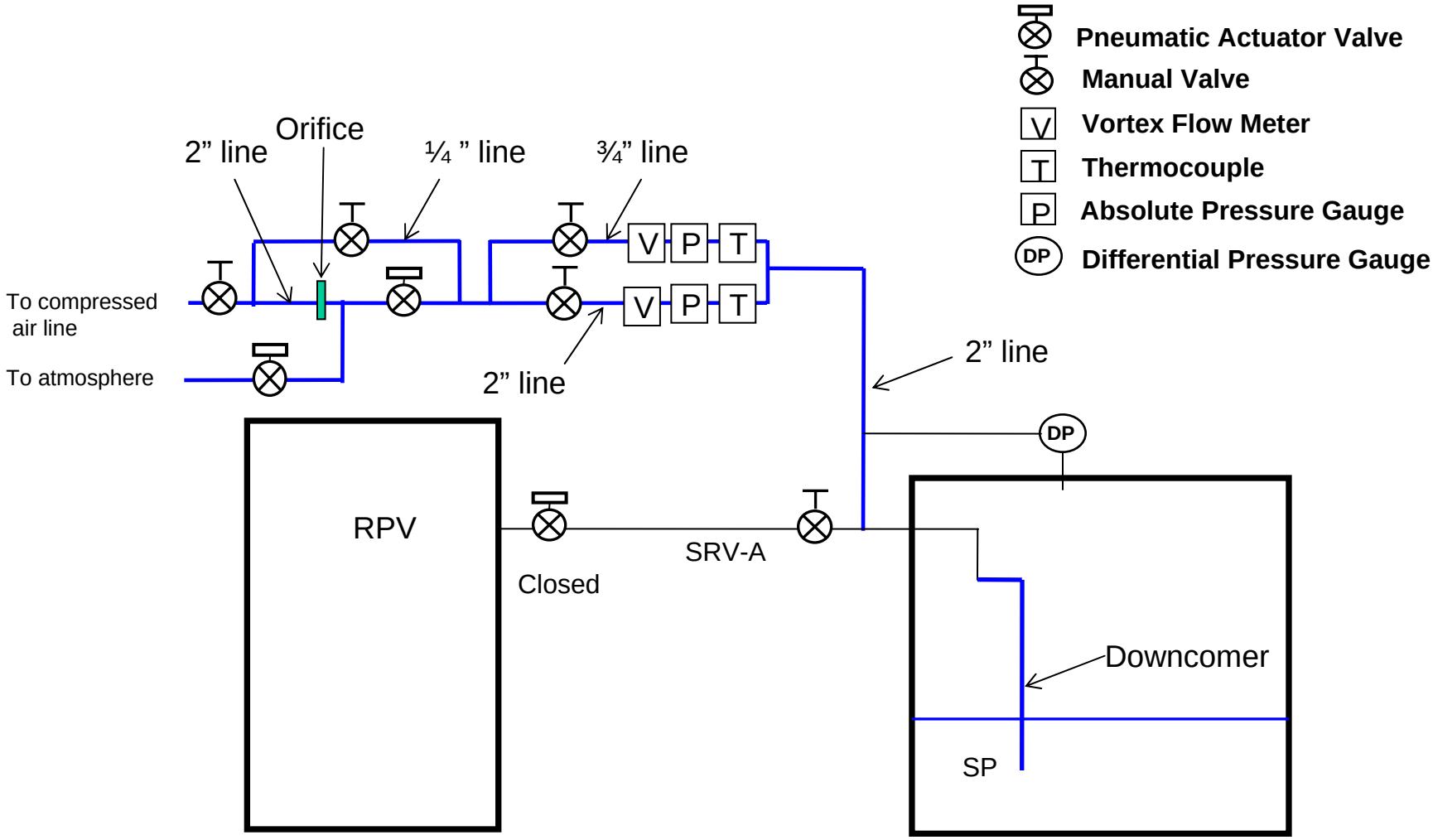
1. **Steady-state test**

- Air supply from the compressed air tank
- Stable air flow rate with the initial air velocity ramp

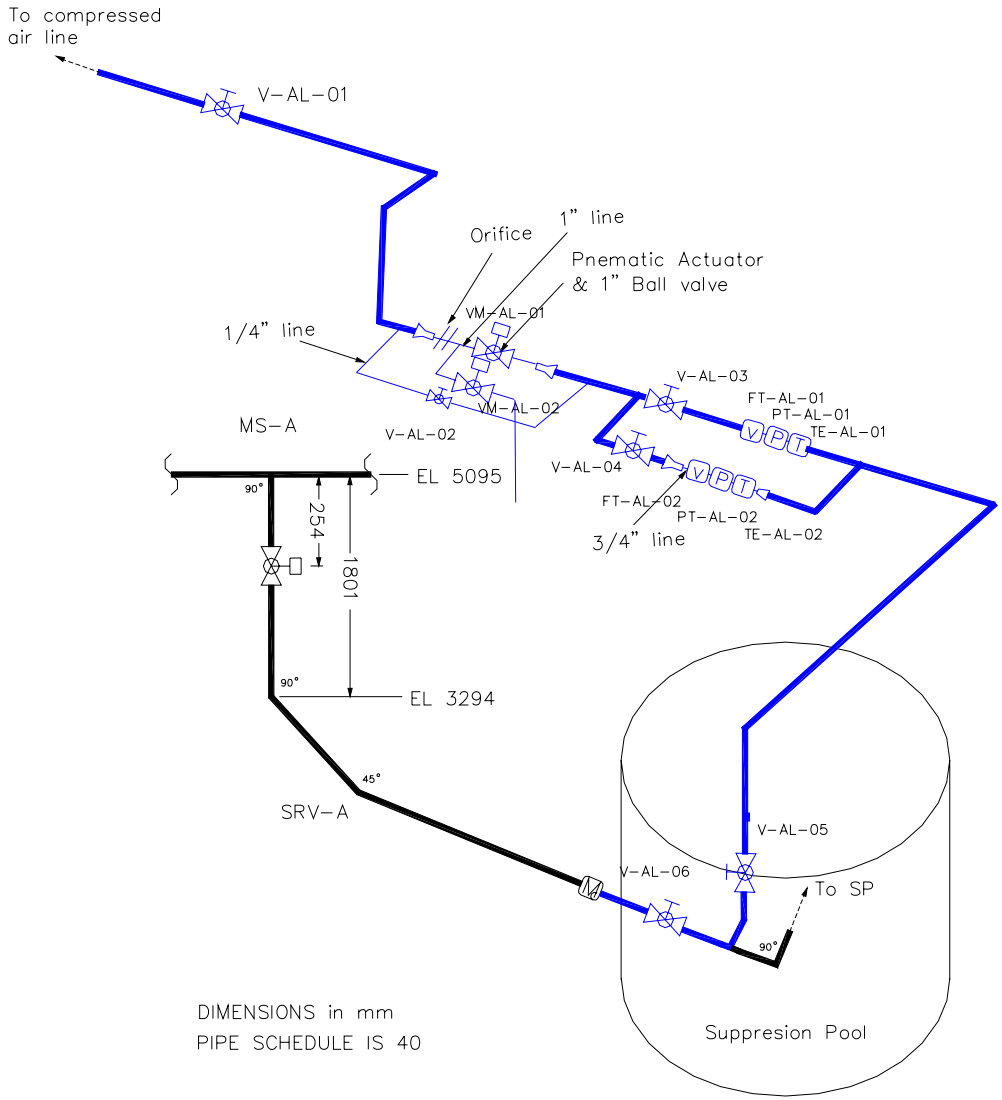
2. **Transient test**

- Simulation of LOCA
- Steam supply from RPV through DW

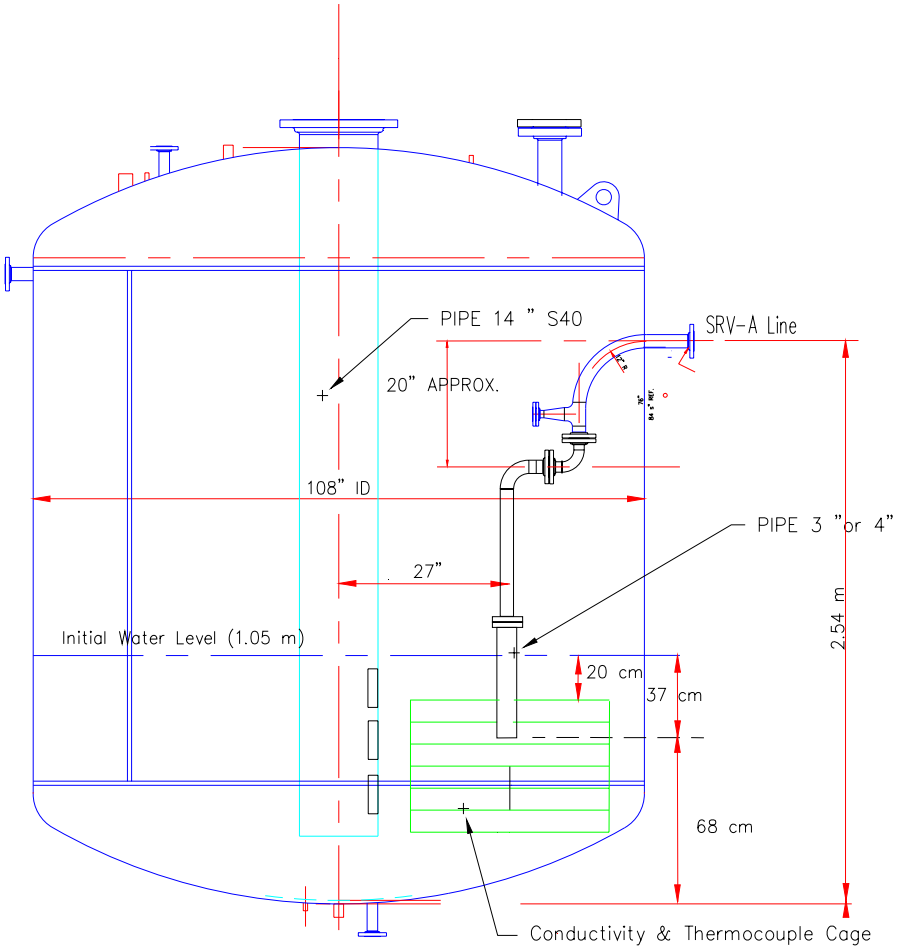
Experimental Facility for Steady-State Tests



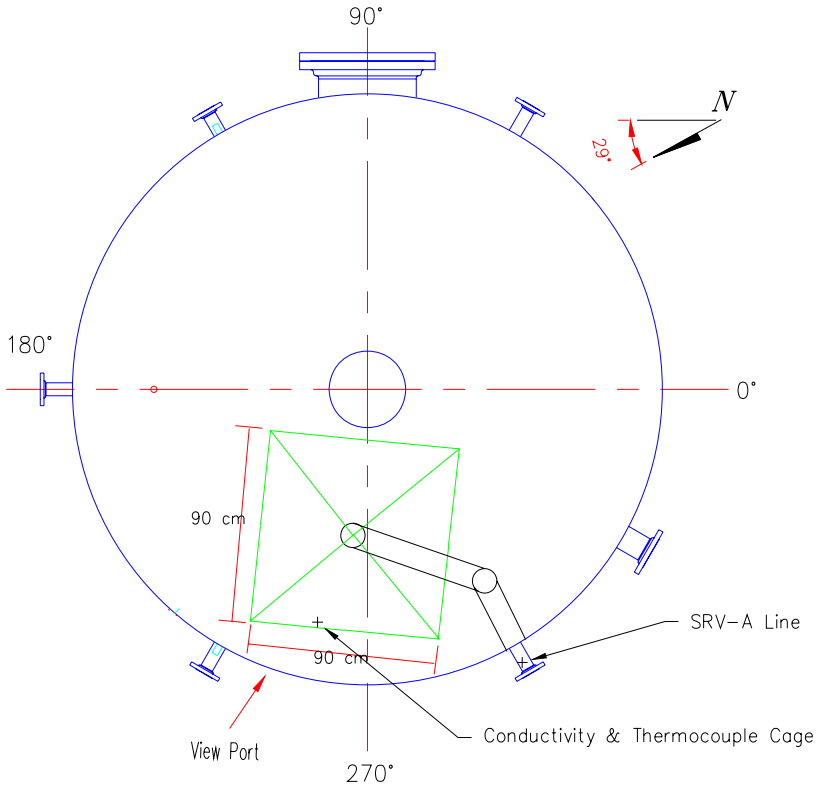
Air Supply Line outside SP



Air Supply Line and Downcomer in SP

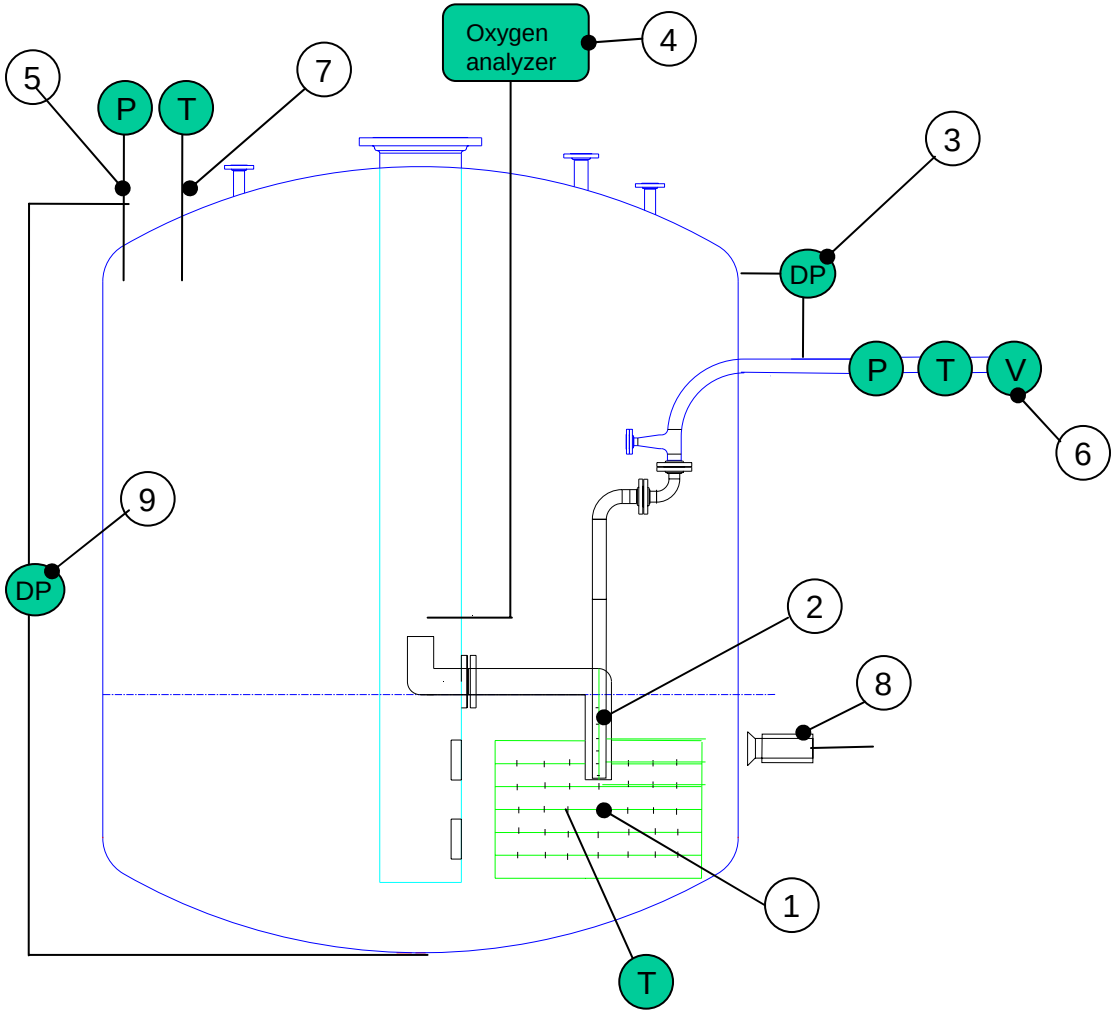


Front view



Top view

Measurement System



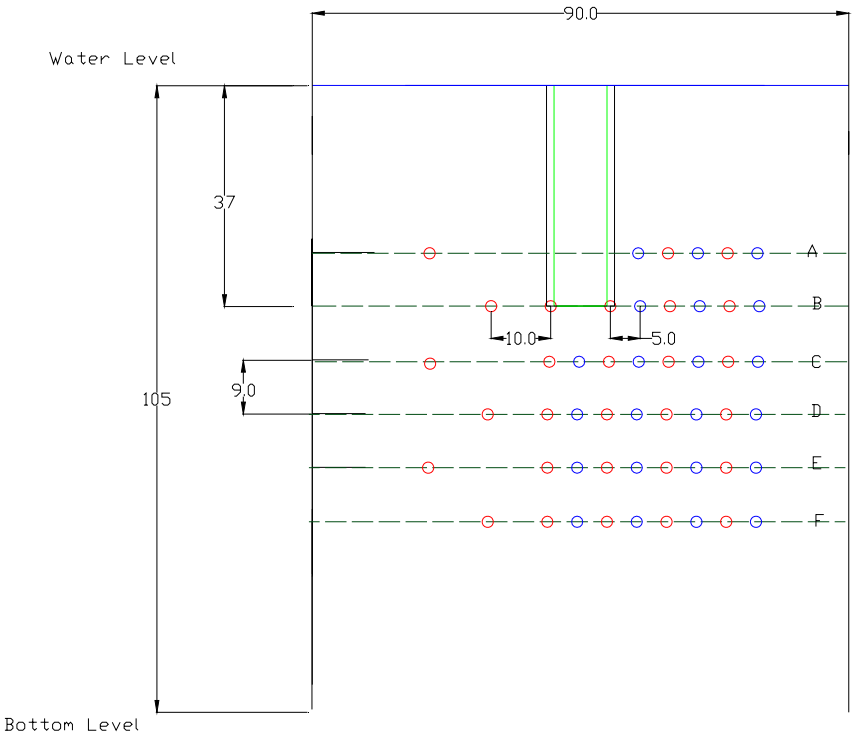
Instruments in SP

1. Instrumental cage with conductivity probes
2. Water level measurement in downcomer (Conductivity probes)
3. Water level measurement in downcomer (DP gauge)
4. Oxygen analyzer
5. Absolute pressure gauges
6. Vortex flow meters
7. Thermocouples
8. High speed video camera
9. SP Water level

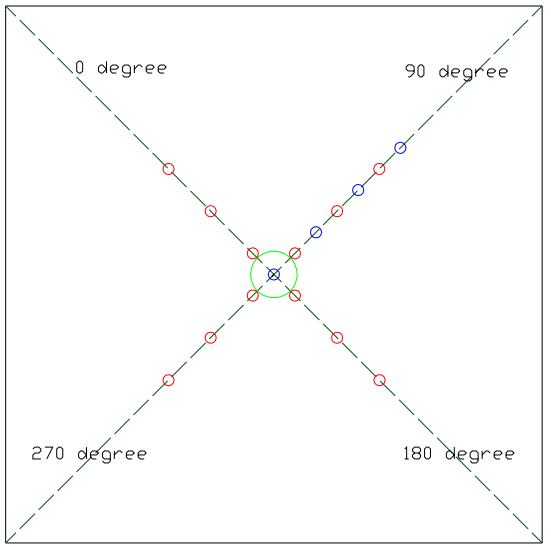
Instruments in DW and RPV

10. Vortex flow meters in DPV and MS line
11. Absolute pressure gauges in DW and RPV
12. Thermocouples in DW and RPV
13. Water Level measurement in DW and RPV (DP)

Void Measurement and Instrument Cage



Front view



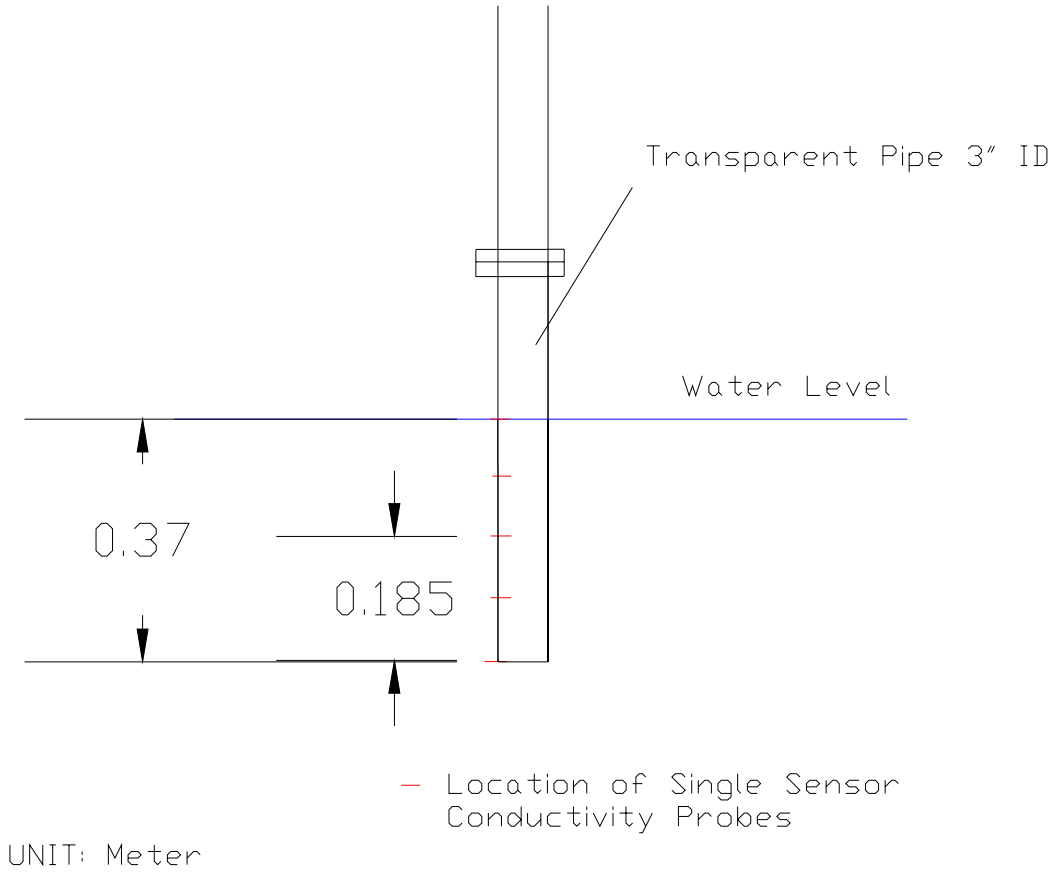
Top view

(45 deg from Front view)

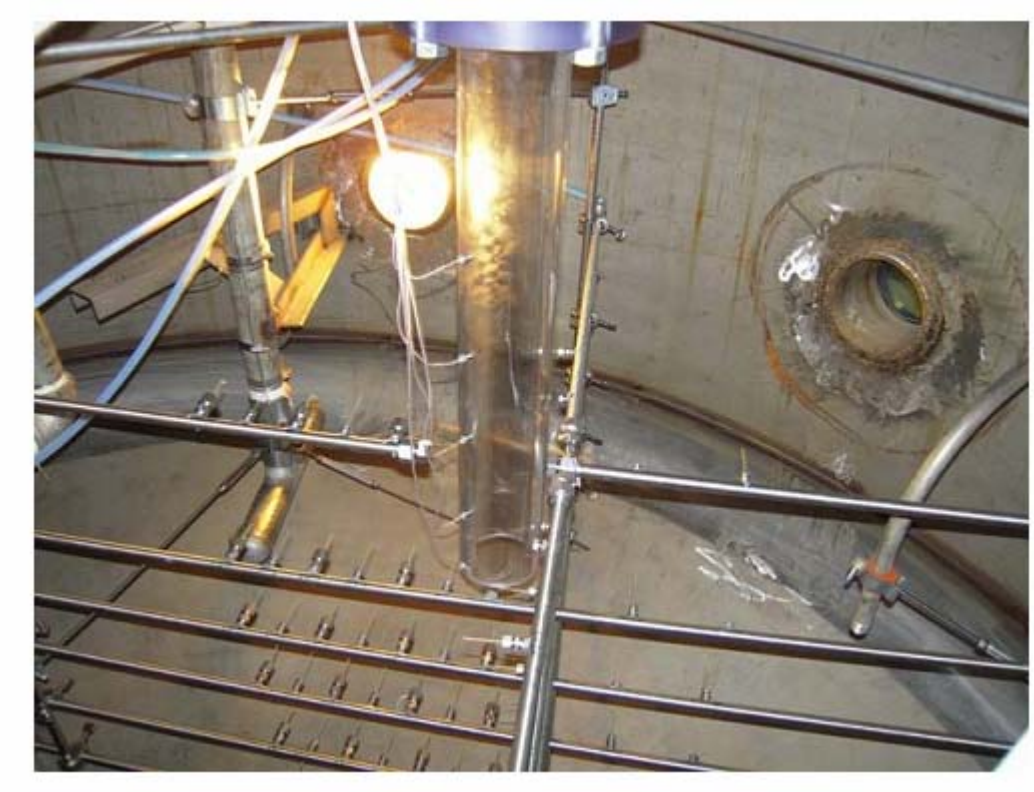
Single senser conductivity probe

Double senser conductivity probe

Water Level Measurement in Downcomer



Instrument Cage and Downcomer

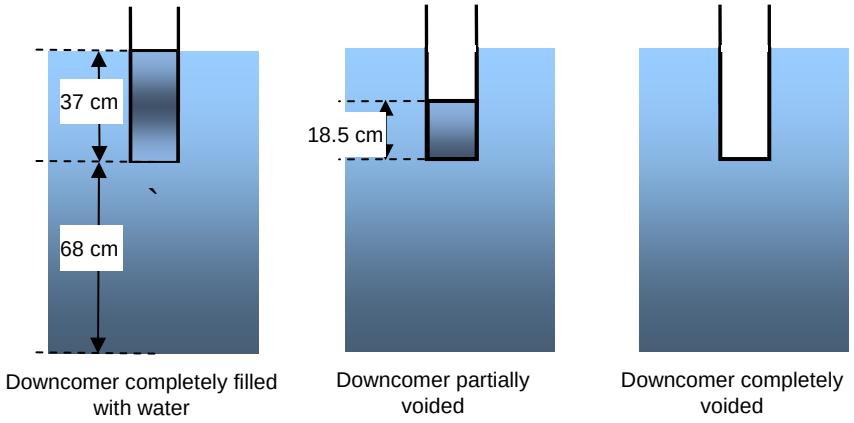


Test Matrix for Steady-State Tests

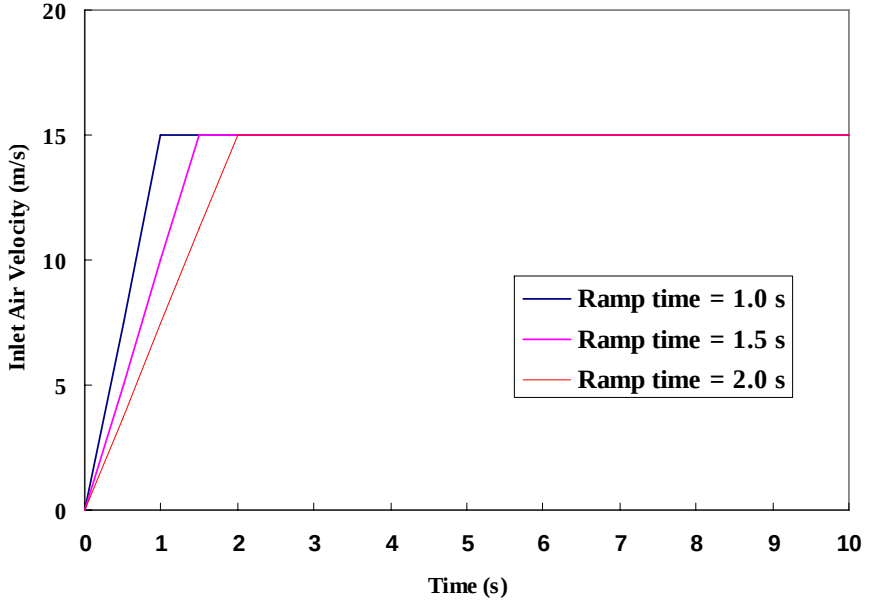
Test No.	Downcomer Size	Downcomer Condition	Flow Type	Air Mass Flow Rate (kg/s)	Velocity Ramp Rate (s)
A1	3 inch	Completely Filled with Water	DBA	0.081	1.0
A2					1.5
A3					2.0
A4			Category 4	0.045	2.0
A5			Category 2	TBD	TBD
A6		Partially Voided	DBA	0.081	1.0
A7					1.5
A8					2.0
A9			Category 4	0.045	2.0
A10			Category 2	TBD	TBD
A11		Completely Voided	DBA	0.081	2.0
A12			Category 4	0.045	2.0
A13	4 inch	Completely Filled with Water	DBA	0.138	1.0
A14					1.5
A15					2.0
A16			Category 4	0.077	2.0
A17			Category 2	TBD	TBD
A18		Partially Voided	DBA	0.138	1.0
A19					1.5
A20					2.0
A21			Category 4	0.077	2.0
A22			Category 2	TBD	TBD
A23		Completely Voided	DBA	0.138	2.0
A24			Category 4	0.077	2.0

Initial Condition

- Downcomer void condition

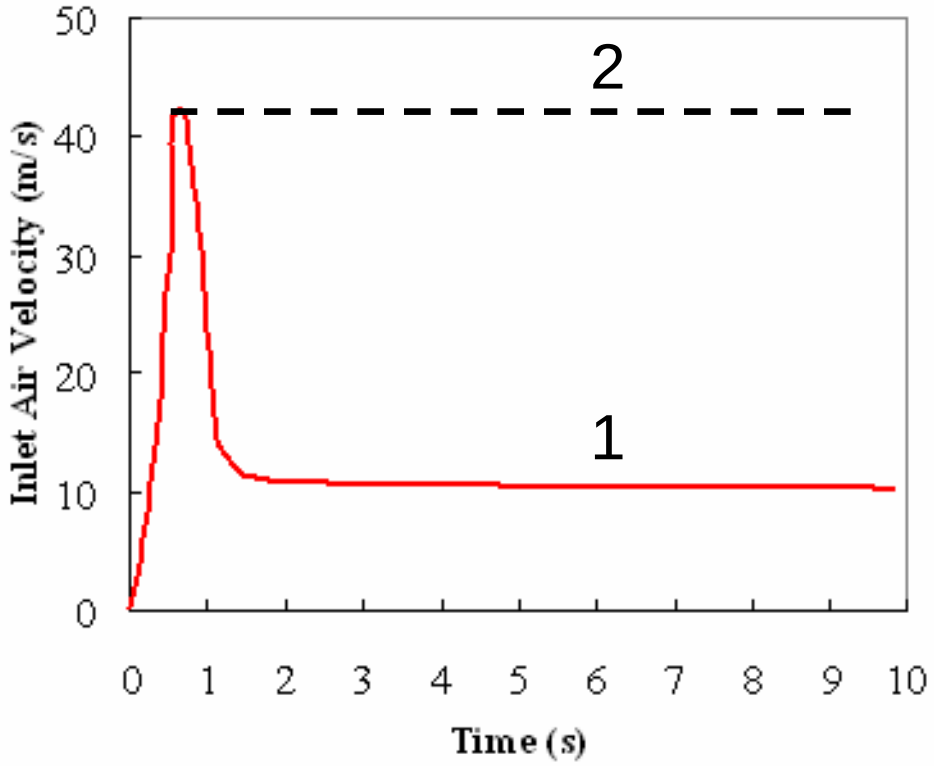


- Inlet boundary condition



Possible Alternate Inlet Boundary Condition

- Two possible alternate inlet boundary conditions based on RELAP5 calculated results.



Steady-State Tests

- Downcomer size : 3 inch
- Test inlet flow condition and downcomer void condition
- No. A1 : Air flow 0.081 kg/s (250 m^3/h), 1 sec velocity ramp time, downcomer completely filled with water
- No. A7 : Air flow 0.081 kg/s (250 m^3/h),1.5 sec velocity ramp time, downcomer partially voided

Ramp Rate of Air Velocity

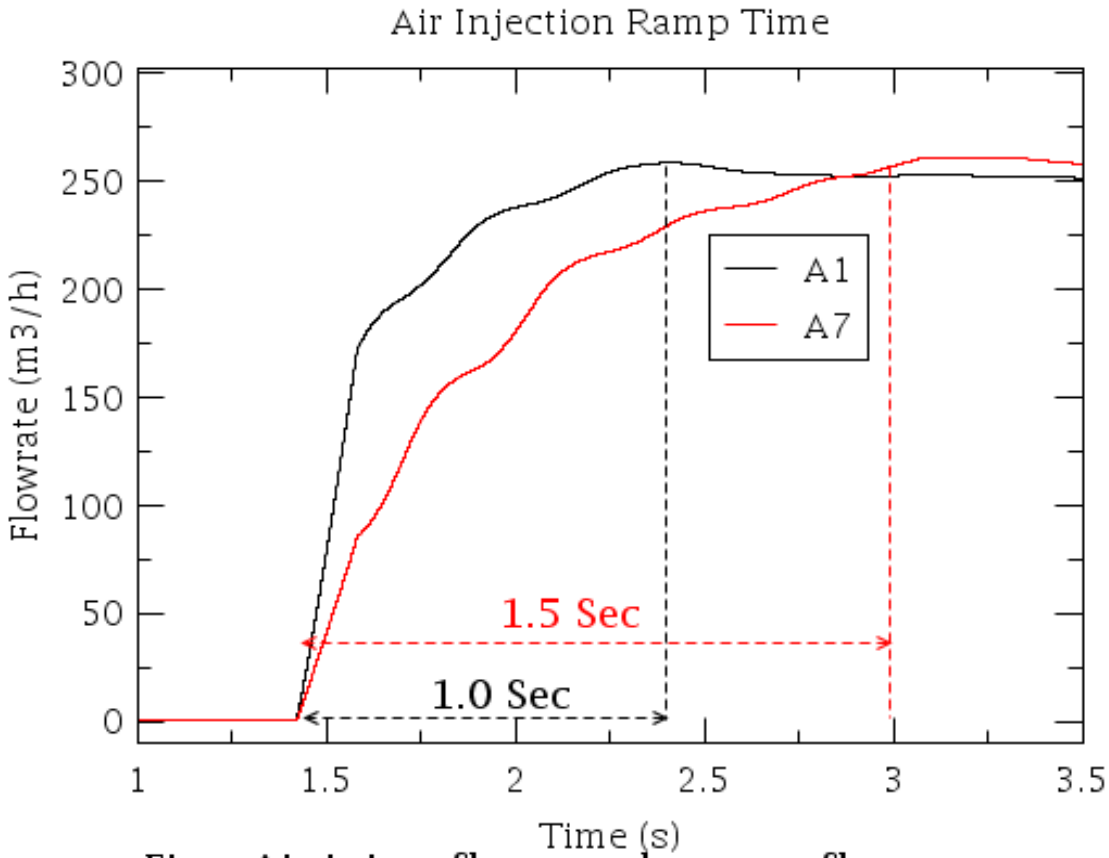
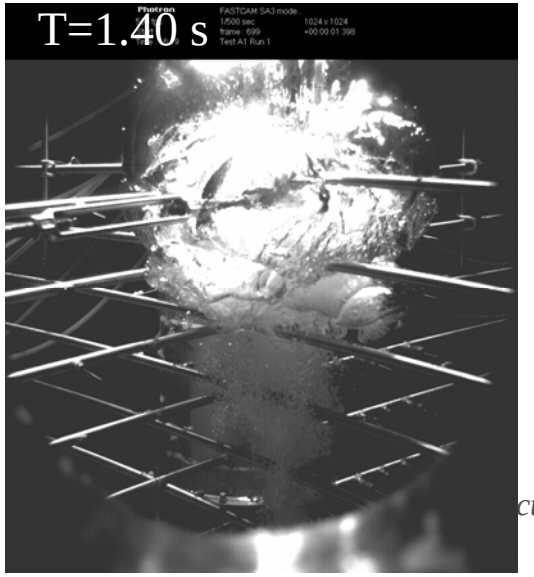
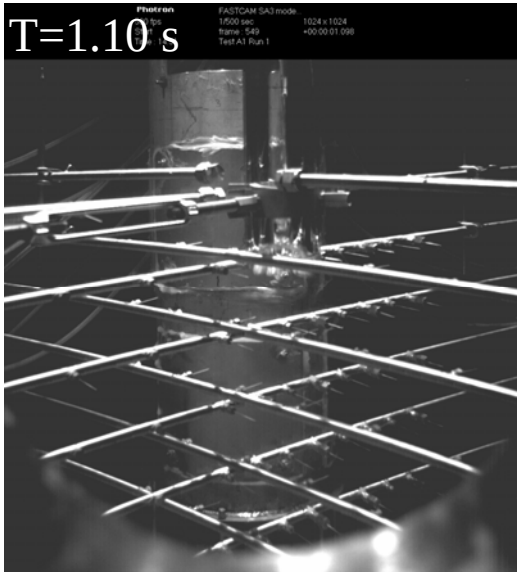


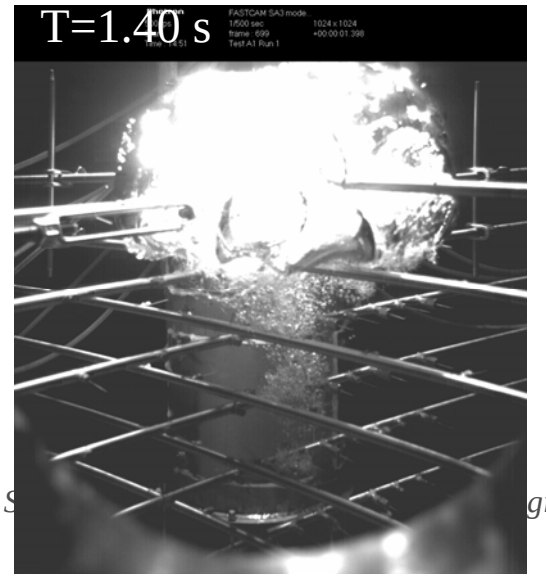
Fig. : Air inject flow rate by votex flowmeter
SP Void Distribution Test, sensor (FT–AL–01)

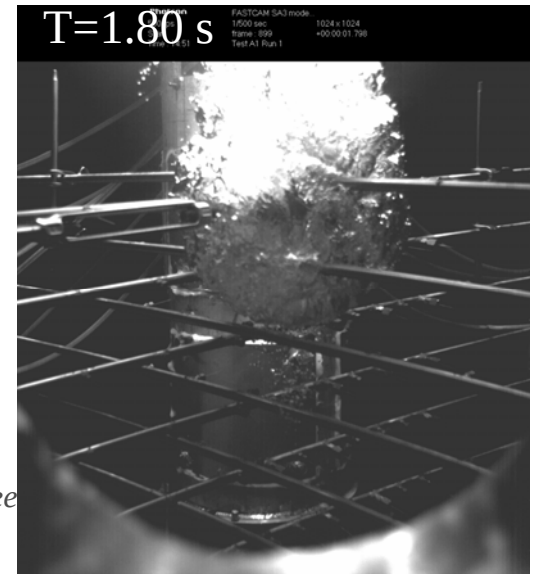
Test No. A1



Test No. A7

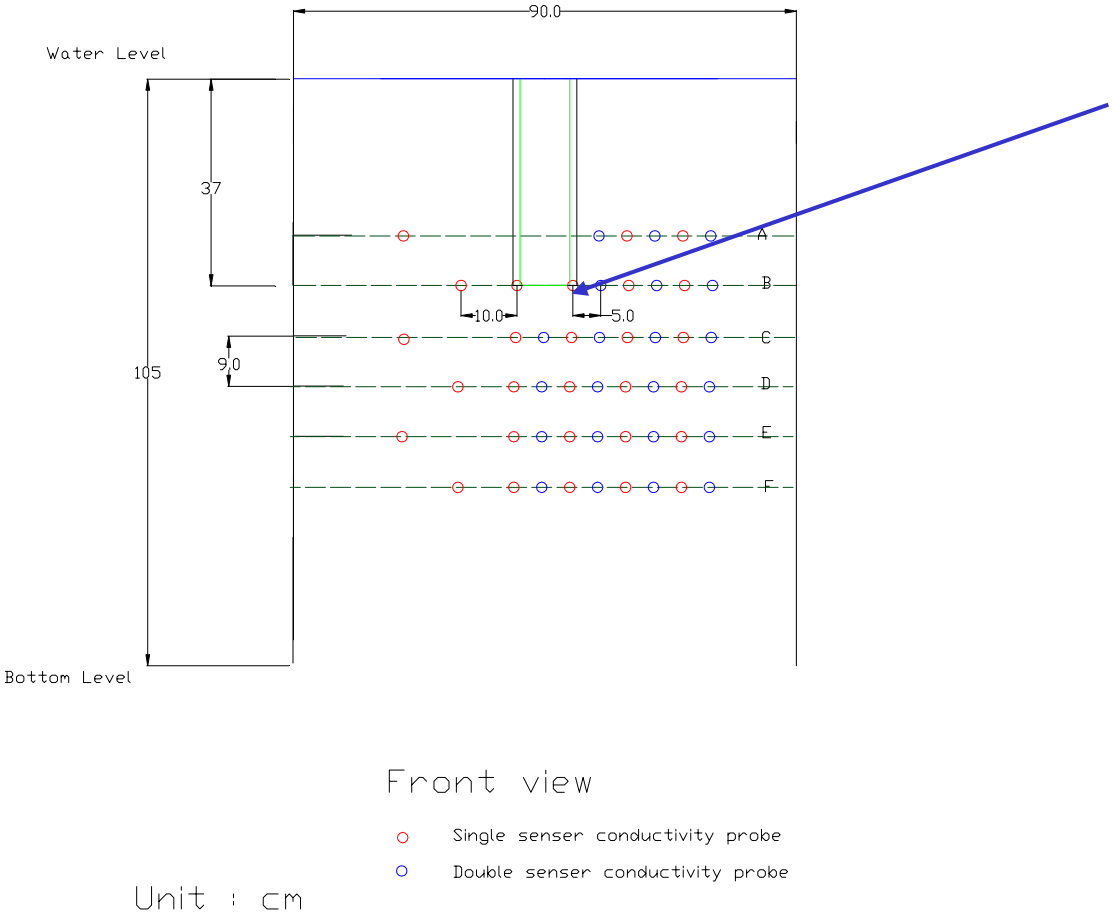


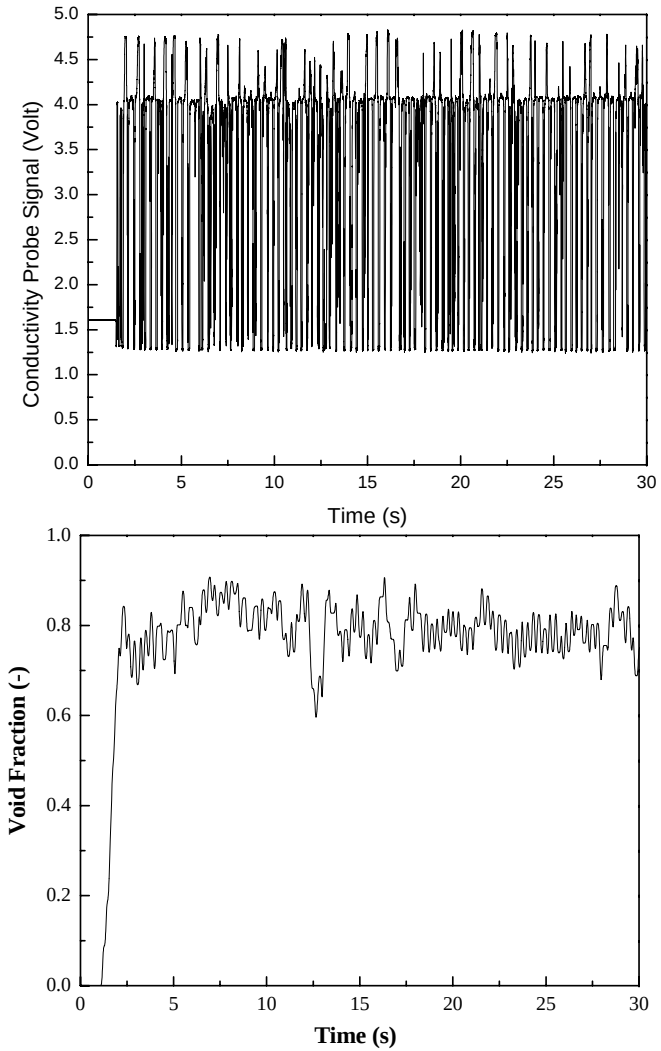




Conductivity Probe Signal

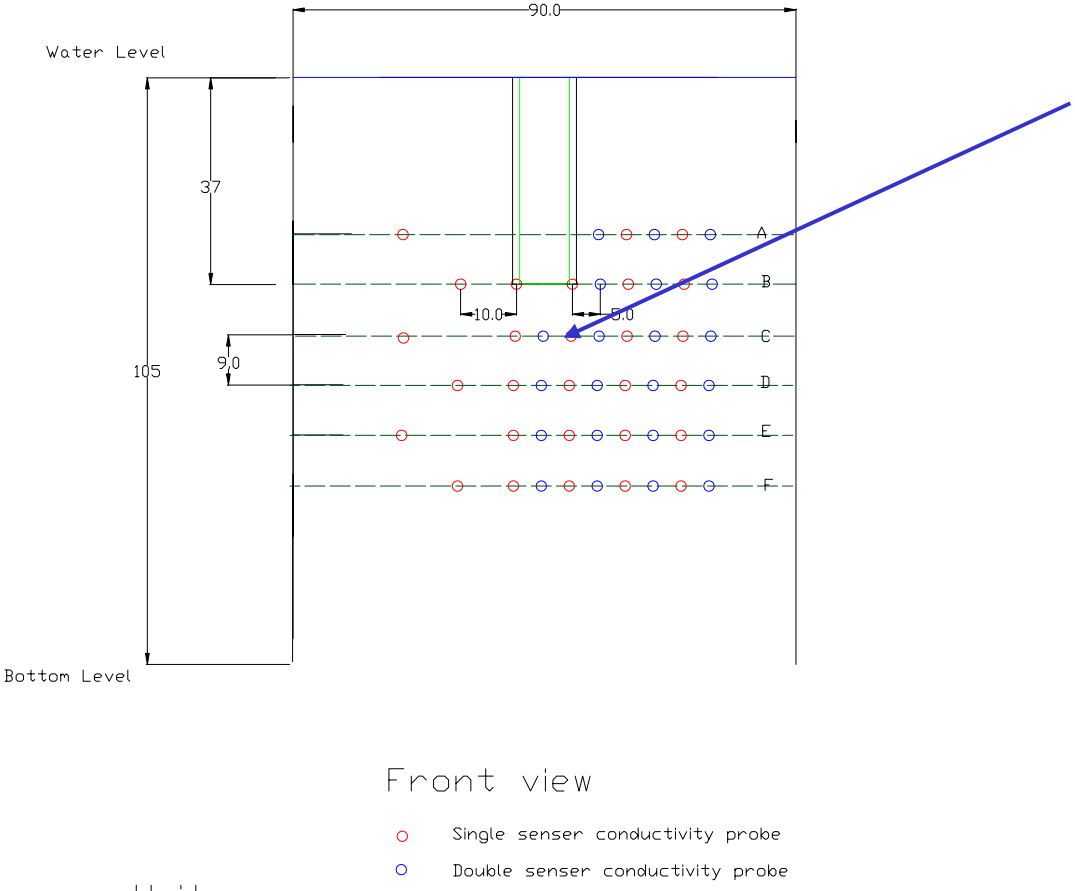
Test No. A1

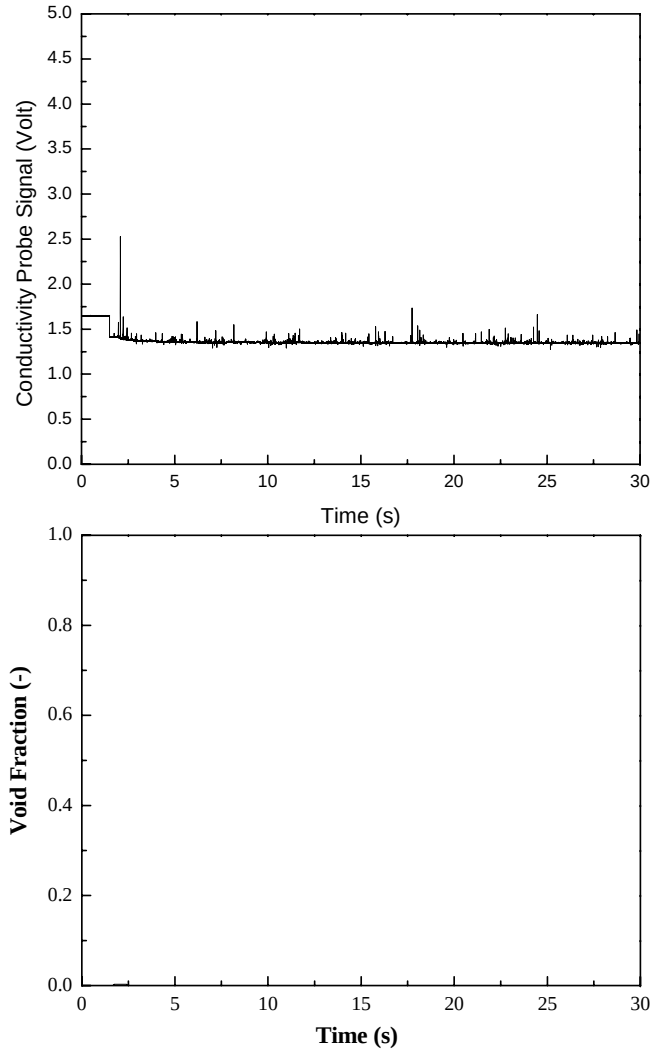




Conductivity Probe Signal

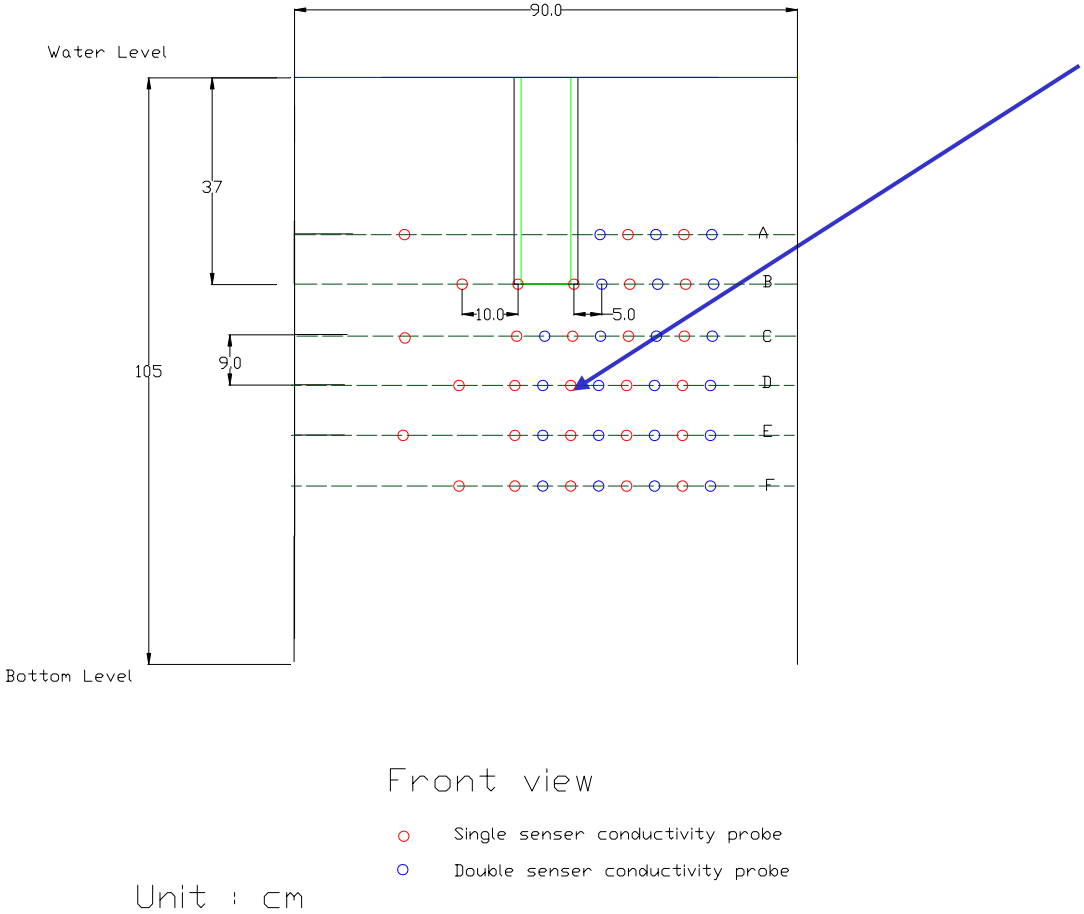
Test No. A1

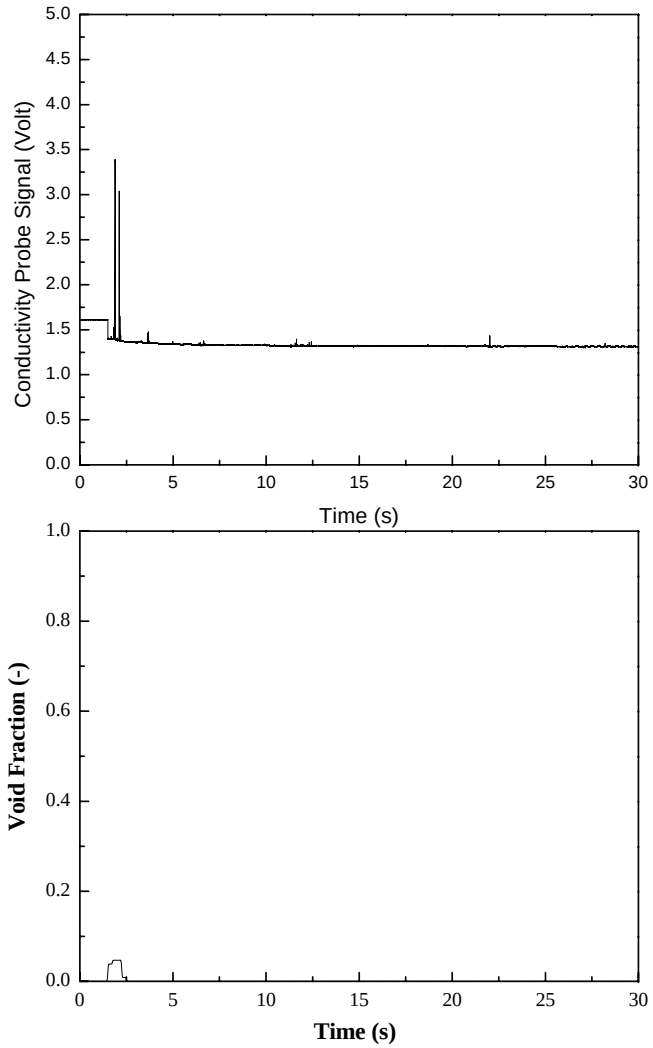




Conductivity Probe Signal

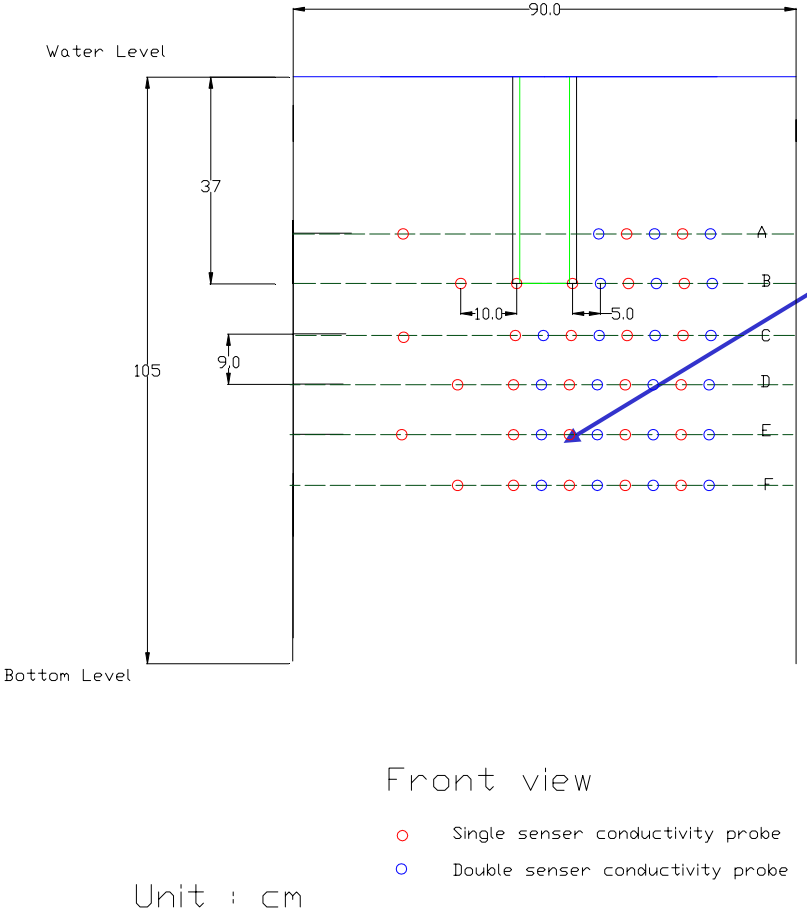
Test No. A1

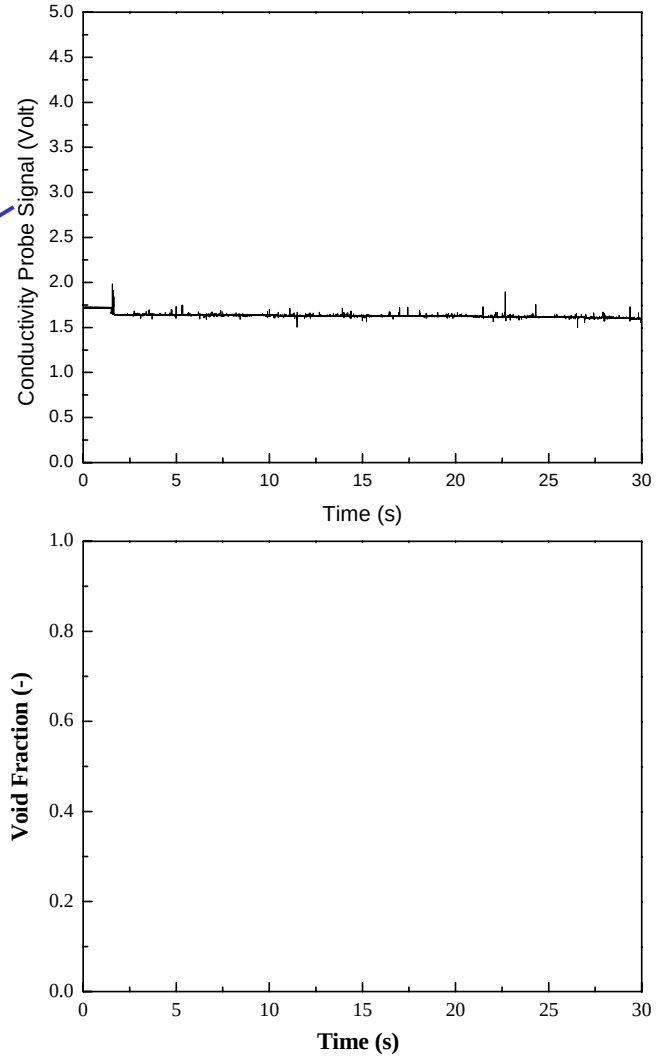




Conductivity Probe Signal

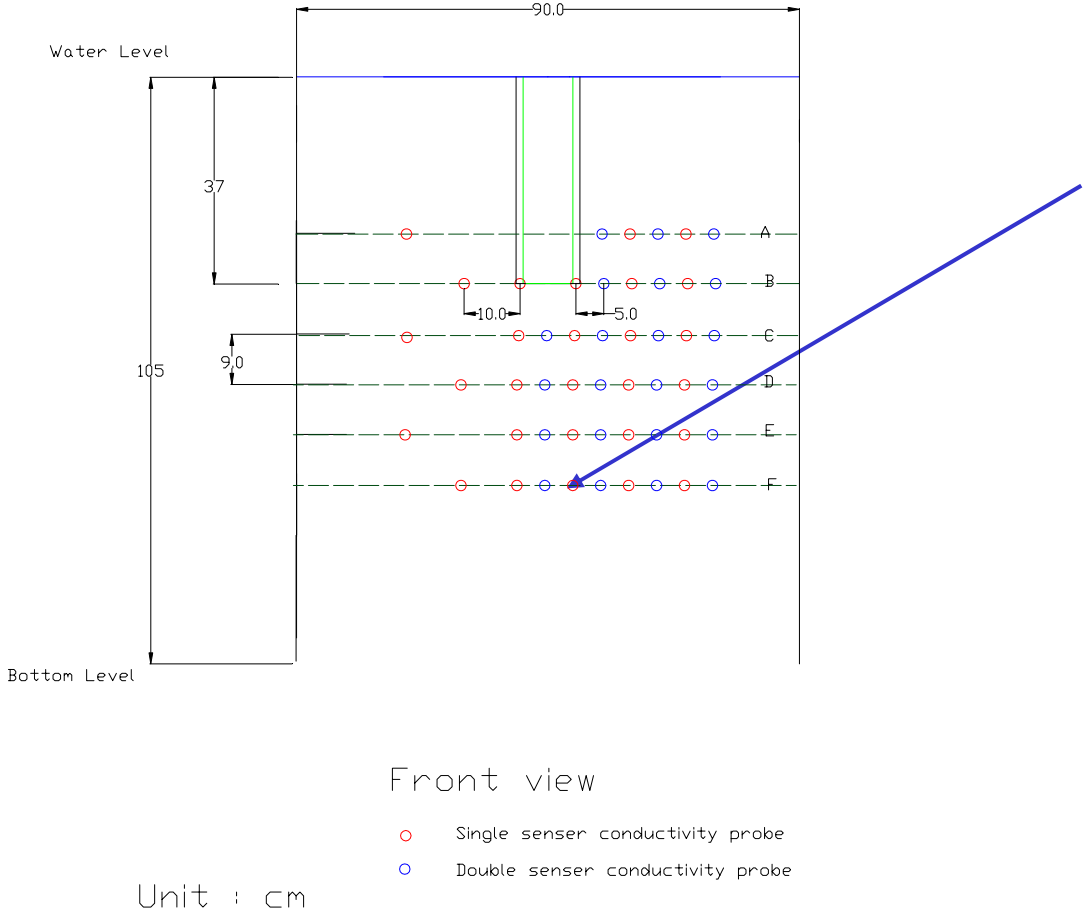
Test No. A1

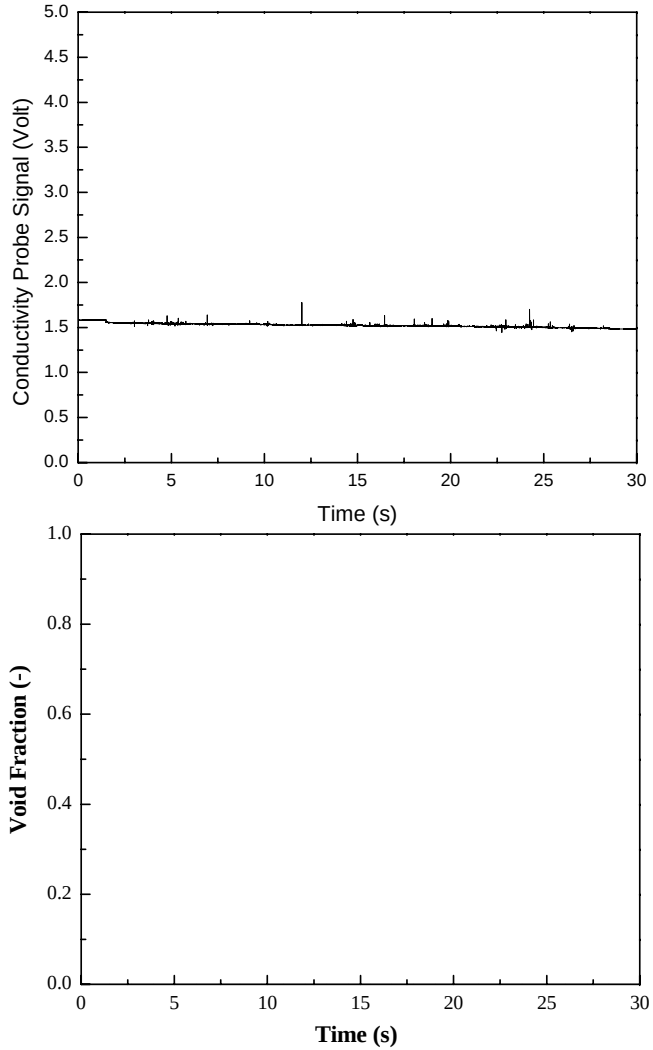




Conductivity Probe Signal

Test No. A1





Summary

- The velocity profile of inlet air and steam at downcomer of MARK I is obtained by RELAP5 calculation.
- Possible alternate inlet boundary condition for air velocity profile is presented.
- Test facility and instrumentation for steady-state tests are characterized by performing the preliminary tests.
- The physical phenomena around the exit of downcomer during blowdown is observed using a high-speed camera.
- Test facility and instrumentation are ready to perform real tests.