GSI-191 Resolution Approach of the APR1400

- Overview
- Test Plan
- Conclusion

APR1400 DC

KEPCO E&C

KHNP

Overview

GSI-191 Resolution Approach for the APR1400

Evaluation Methodology

Strainer Design

GSI-191 Resolution Approach for the APR1400

APR1400 Approach

- Application of deterministic method (Strainer test, FA Test)

Clean Plant Criteria	Implementation
No problematic debris materials	-RMI Insulation in ZOI -No Fiber
To prevent problem materials	
1/8" debris bed application	1200 ft^2 (Total Strainer Area)
Paint chip impact	No impact (settle down)
Strainer area after reductions accounting for materials like tags	No impact (Tend to sink)

- Application of 15 g/FA Limit for In-Vessel Downstream Effects is verified by the test

GSI-191 Resolution Approach for the APR1400

- Debris Generation Evaluation Methodology
  - NEI 04-07, NEI 04-07 SER
- Chemical Effects Evaluation Methodology
  - Calculations supported by WCAP-16530-NP-A
- Ex-Vessel Downstream Evaluation
  - Using the component data of reference plant (SKN 3&4)
  - WCAP-16406-P-A

Evaluation Methodology

- GSI-191 Evaluation Methods for the APR1400
  - Break Selection
  - Debris Generation
  - Debris Characterization
  - Debris Transport
  - Strainer Hydraulic Effect and Pump NPSHa
  - Chemical Effect
  - Upstream Effect
  - Downstream Effect
    - Ex-Vessel Downstream Effect
    - In-Vessel Downstream Effect

Evaluation Methodology

❑ GSI-191 Evaluation Methods for the APR1400

Debris Type		Amount	Characterization	Transport
RMI [m^3/ft^3]		3.22 / 114	Small fine / large piece (75%/25%)	No transport
Fibrous Insulation [m^3/ft^3]		0 / 0	-	-
Coating [m^3/ft^3]		0.084 / 3.1	Small fine particle	100% transport to IRWST Sump
Latent Debris	Fiber [kg/lb]	3.4 / 7.5 (13.6 / 30.0)		100% transport to IRWST Sump
	Particle [kg/lb]	42.0 / 92.5 (77.1 / 170.0)		

Evaluation Methodology

❑ Evaluation Summary of Chemical Effect

Component	Quantity (kg)
Aluminum Oxy-hydroxide	179.5
Sodium Aluminum Silicate	8.5
Calcium Phosphate	1.0

❑ Strainer Sizing Basis

The strainer will be designed assuming a theoretical maximum debris bed thickness of 1/8 inch covering the area of a single IRWST strainer (1,200 ft^2) installed and 100% of all transportable material generated during the LOCA. The 2.4 lbs/ft^3 material density for low density fiberglass is assumed for the latent fibrous debris component.

Evaluation Methodology

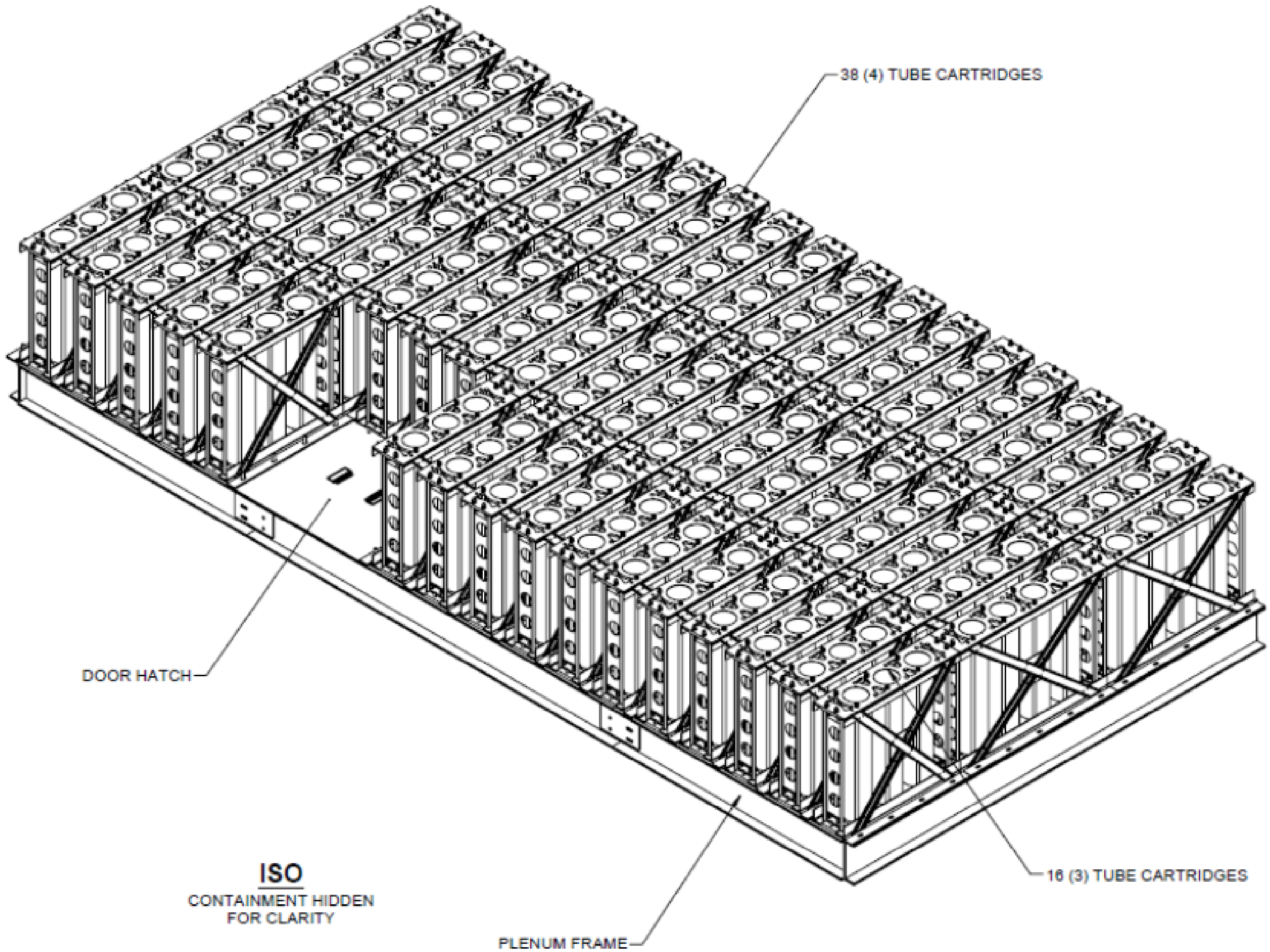
- The IRWST sump strainers head loss will be verified to satisfy the NPSH requirement at the maximum temperature (230°F) by the head loss test. The head loss at 140°F will be conservatively scaled based on the ratio of dynamic viscosity.
- It will be verified by the test that sufficient strainer submergence prevents Strainer Hydraulic Effects (Vortexing, Flashing, and Dearation)
- For NPSH, assumptions are like below
  - Single Active Failure
  - No Containment Overpressure
  - Minimum IRWST Water Level
  - Debris Loaded Strainer Head Loss (2.0 ft Submergence)

Test Plan

In-Vessel Effect Test Plan

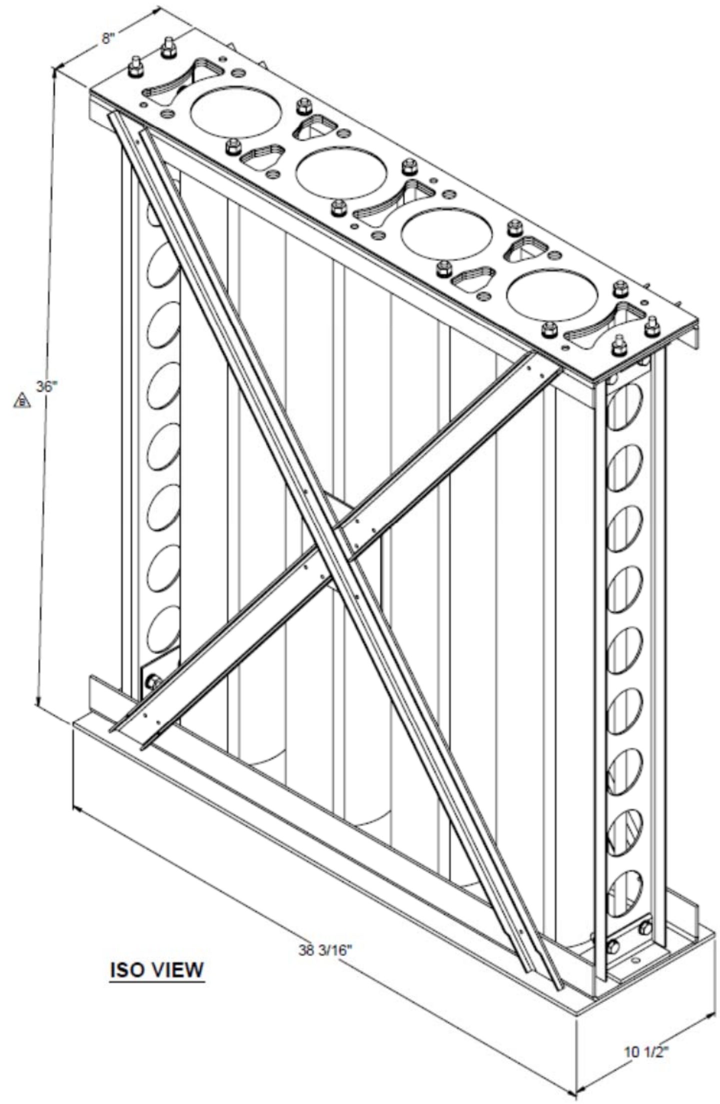
Strainer Test Plan

Strainer Design



Strainer Design (cont'd)

- Mfr. Transco Products Inc.
- Tubular Cartridge Design
- 2.4 mm hole size
- Stainless Steel Materials



Strainer Test Plan

- Two (2) plans under development:
  - Strainer Prototype Head Loss Testing
    1) Clean Strainer Head Loss Test
    2) Debris Head Loss Test including Chemical Effects (Thin-bed Only)
    3) Vortexing Observation at minimum water level
  - Fibrous Debris Bypass Testing

- PURPOSE
  - Verify adequate pressure drop under debris loading and flow rate
  - Obtain mass and characteristics of bypass debris for future in-vessel fuel blockage testing

Strainer Head Loss Test

- Strainer Prototype Head Loss Test Plan (APR1400-K-A-T(NR)-13002 R/0)
  - Test Approach
  - Test Article
  - Test Facility
  - Test Conditions
  - Test Performance
  - Test Termination
  - Test Documentation and Records
  - Quality Assurance Requirements
  - References

Strainer Head Loss Test

- Testing performed in accordance with USNRC March 2008 Supplemental Guidance, “Closure in the Area of Strainer Head Loss and Vortexing”
- Due to the negligible amount of fiber, only a thin-bed test is required – max bed thickness is only 1/8”

Debris Load Summary

	APR1400 Strainer		Test Strainer	
Strainer Surface Area	1200	ft^2	75.1	ft^2
Coatings	3.1	ft^3	38.7[1]	lbs
Latent particulate	170	lbs	10.6	lbs
Latent fiber	30	lbs	1.9	lbs
Chemical load	189	kg	284	gal

Strainer Head Loss Test

- Fibrous debris Preparation method will produce fines (Class 1-3) per Attachment B of NUREG/CR-6224
- Fibrous debris will have a suitable dilution to ensure fibers remain fully dispersed and no agglomeration
- Thin-bed testing will add all particulate first, then fibers, then chemical surrogates to closely represent arrival time of species (this is consistent with the NRC Guidance document)
- Testing will be in a fully agitated tank environment – no settling or “near field effect”
- Chemical surrogates will follow the WCAP-16530-NP recipe for production
- Plot pressure drop as function of time during experiment

Bypass Testing

- Purpose of the bypass testing is to obtain mass and fiber size distribution for fibrous debris bypassing the strainer and entering the recirculation flow path.
- Debris preparation methods for bypass test will be identical to the fines prepared for the head loss testing (i.e., Class 1-3).
- 100% capture of fines will be performed using filter bags downstream of the strainer prototype.
- Only fibrous debris will be included in the test
- The fibrous debris will be batched in two increments starting with 1/16” of inch bed thickness and then another to get to 1/8”.
- Flow rate will be the target design flow rate of 413 gpm.

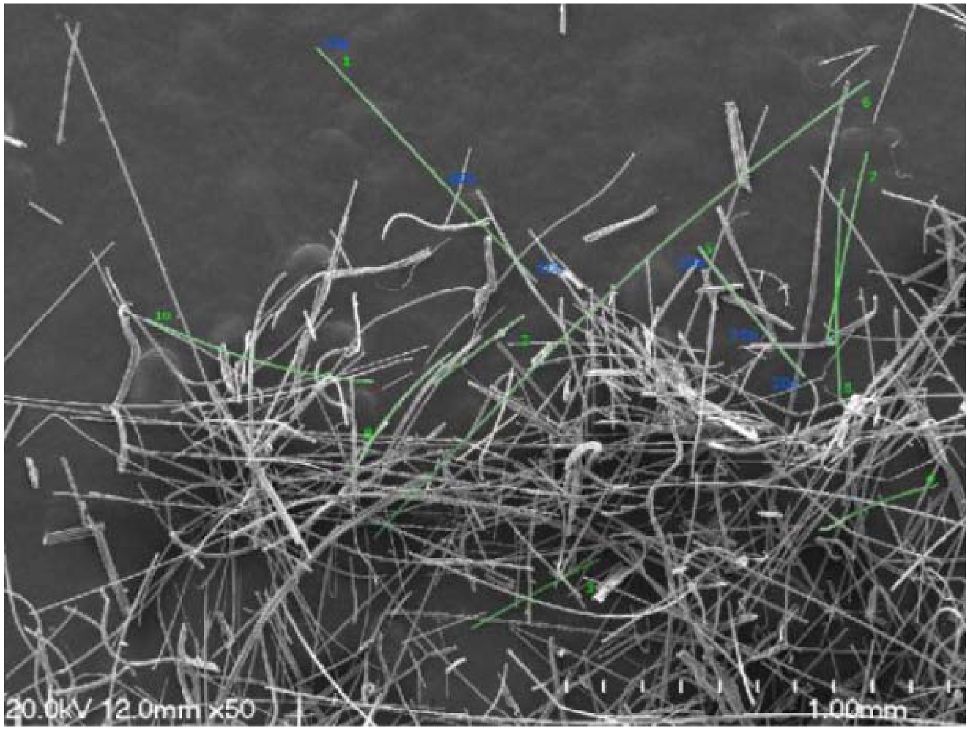
Bypass Testing

Characterization of Fibers

Fibers longer than:	# of Samples	%
0 μm	343	100.00%
500 μm	293	79.30%
1000 μm	162	23.62%
1500 μm	84	4.96%
2000 μm	40	0.87%
2500 μm	19	0.29%

Table 6.1.2 - FE-SEM Fiber Length Measurements

Minimum Length (μm)	131.3
Maximum Length (μm)	4106.3
Average Fiber Length (μm)	1139.9
Number of Measurements	343



Conclusion

Conclusion

- The design and test results of APR1400 IRWST sump strainer fully supports its safety function under post-accident conditions following RG 1.82 Rev.4 requirements.
- The break selection, debris generation, characteristics, transport, head loss are evaluated considering appropriate conservatism.
- Using these data, chemical effect, upstream effect, and downstream effect as well as NPSH of ECCS and CSS pumps are evaluated to verify that these are no significant impact on ECC and CS pumps, and related systems.