ENCLOSURE 4

Final AP1000 Suitable Equivalent Insulation Testing Technical Report - Pre-submittal Meeting

(Non-Proprietary)

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AP1000 Suitable Equivalent Insulation Testing Technical Report – Presubmittal Meeting

Westinghouse Electric Company

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- Public portion of meeting

Purpose and Objective

- **AP1000** ITAACs state that Metal Reflective Insulation (MRI) or a "Suitable Equivalent" will be used for major RCS components, or for all components within the LOCA Zone of Influence or Flood up Level
- Section 6. Engineered Safety Features
  - Suitable equivalent defined as "In order to qualify as a suitable equivalent insulation, testing must be performed that subjects the insulation to conditions that bound the **AP1000** conditions and demonstrates that debris would not be generated"

Purpose of the qualification testing and associated techincal report: demonstrate that non-metallic insulation (NMI) does not produce debris in case of a LOCA

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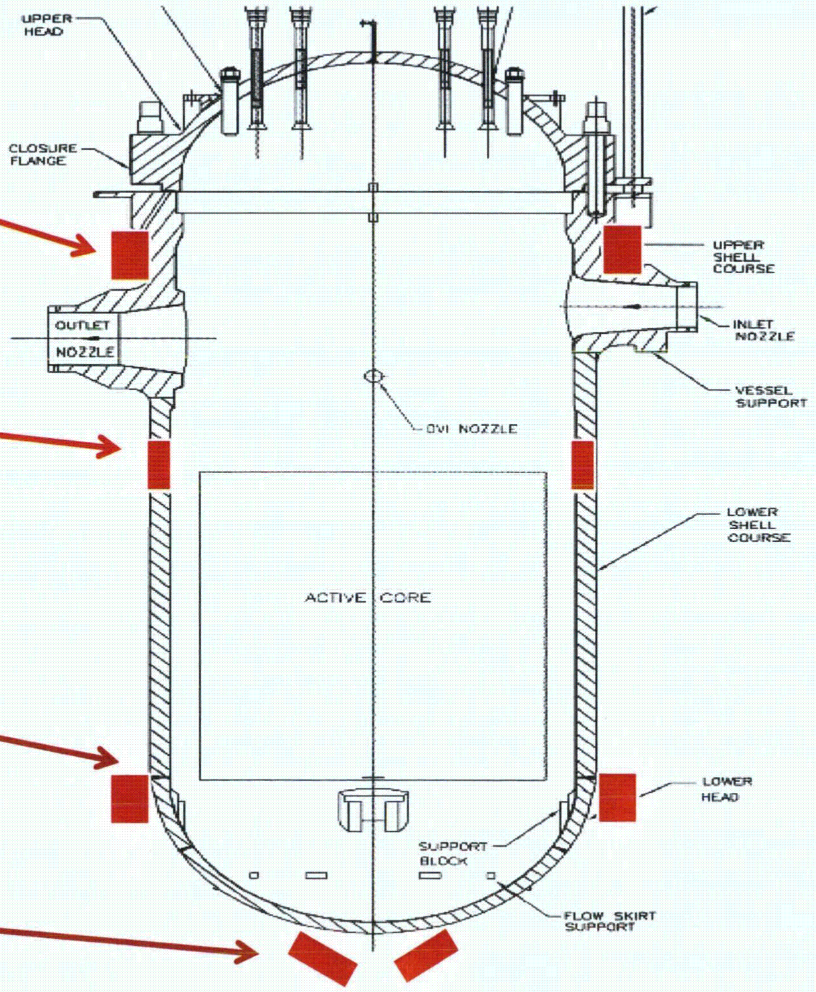
Non-Metallic Insulation Locations

CA31 Neutron Shielding
(105'-2" elevation)

MN20 Upper
Neutron Shielding
(98'-0" elevation)

MN20 Lower
Neutron Shielding
(78'-0" elevation)

MN20 Water
Inlet Doors
(71'-6" elevation)



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Purpose of Non-Metal Insulation

- MN20 & CA31 Neutron Shielding
  - Maintains neutron shielding below operating temperature
  - Reduces heat loss from reactor vessel
  - Insulation required with very limited space available
    - Efficient/thin insulation maximizes shielding volume
    - Metal reflective insulation thickness would be too thick
    - The gap between the shielding and the reactor vessel must be free to provide an ex-vessel cooling steam flow path
- MN20 Water Inlet Doors
  - Buoyant lightweight insulation
  - Reduces heat loss from reactor vessel

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Testing Overview

From Regulatory Guide 1.82:

Such debris can be divided into the following categories:

(1) debris that is generated by the LOCA and is transported by blowdown forces (e.g., insulation, paint),

(2) debris that is generated or transported by washdown, and

(3) other debris that existed before a LOCA (e.g., corrosion material, sludge in a BWR suppression pool) and that may become suspended in the containment sump or suppression pool.

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Testing Overview (cont'd)

- Jet Impingement Testing
  - MN20 Upper neutron shielding and CA31 neutron shielding is located in the Zone of Influence of Reactor Coolant Loop and DVI pipe breaks
- Submergence Testing
  - MN20 and CA31 neutron shielding and Reactor Vessel Insulation System (RVIS) water inlet doors are located below the maximum containment flood up level (110.2 ft)
- To qualify as a suitable equivalent insulation, testing must be performed that subjects the insulation to conditions that bound the AP1000 design conditions and demonstrates that debris would not be generated

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Jet Impingement Testing – RECAP

- Testing required for 'suitable equivalent' verification
- Test facility capable of producing representative LOCA jet
- Test condition scaled to AP1000
  - NRC approved ANSI 58.2
- Test target actual component
- Test target configuration conservative to actual installation
- Jet impingement testing confirms that the Reactor Vessel Neutron Shielding Panels are a suitable equivalent insulation for use in the **AP1000** containment

Test will be conservative to actual plant application

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Submergence Testing – General Procedure

- Autoclaves will be used to expose material test samples to conditions that simulate the temperature, pressure, and chemical make-up of the submergence water during a LOCA.
- Temperature, pressure, and fluid chemical make-up based off of EQ bounding DBA/post-DBA submergence conditions
- Fluid samples will be taken and analyzed for debris
- Post test inspections of the samples will be performed

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Technical Report Format and Content

- WCAP organized as follows:

1 PURPOSE 1-1
2 NMI DESIGN 2-1
2.1 NMI FUNCTIONS 2-1
2.2 NMI DESCRIPTION 2-1
2.3 LOCATIONS IN THE PLANT 2-1
3 DEBRIS PRODUCTION MECHANISMS 3-1
4 JET IMPINGEMENT TESTING 4-2
4.1 TEST OBJECTIVE 4-2
4.2 TEST SETUP 4-2
4.3 ACCEPTANCE CRITERIA 4-2
4.4 RESULTS 4-2
5 SUBMERGENCE TESTING 5-1
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5.2 TEST SETUP 5-1
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5.4 RESULTS 5-1
6 CONCLUSION 6-1

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- Closed portion of meeting

Non-Metallic Insulation Locations (detailed location)

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CA31 Neutron Shielding
(105'-2" elevation)

Upper Neutron Shielding
(98'-0" elevation)

Lower Neutron Shielding
(78'-0" elevation)

Water Inlet Doors
(71'-6" elevation)

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Purpose of Non-Metal Insulation

- MN20 & CA31 Neutron Shielding
  - Maintains neutron shielding below operating temperature [ ][a,c]
  - Reduces heat loss from reactor vessel
  - Insulation required with very limited space available
    - Efficient/thin insulation maximizes shielding volume
    - Metal reflective insulation thickness would be too thick
    - The gap between the shielding and the reactor vessel must be free to provide an ex-vessel cooling steam flow path
- MN20 Water Inlet Doors
  - Buoyant lightweight insulation
  - Reduces heat loss from reactor vessel

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CA31 Neutron Shielding (cont'd)

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CA31 Neutron Shielding (cont'd)

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Purpose

- Reduce radiation streaming from the reactor cavity annulus
- Reduce neutron activation of surrounding materials (cobalt)

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CA31 Neutron Shielding (cont'd)

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MN20 Upper Neutron Shielding

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MN20 Upper Neutron Shielding (cont'd)

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Purpose

- Reduce radiation streaming from the reactor cavity annulus
- Reduce neutron activation of surrounding materials (cobalt)

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MN20 Upper Neutron Shielding (cont'd)

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Upper Neutron Shielding Plant Installed Configuration

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Upper Neutron Shielding Plant Installed Configuration

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Upper Neutron Shielding Plant Installed Configuration

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Upper Neutron Shielding Plant Installed Configuration

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Upper Neutron Shielding Plant Installed Configuration

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Upper Neutron Shielding Plant Installed Configuration

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MN20 Lower Neutron Shielding

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MN20 Lower Neutron Shielding (cont'd)

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Purpose

- Reduce radiation streaming into the lower reactor cavity
- Reduce neutron activation of surrounding materials (cobalt)

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MN20 Lower Neutron Shielding (cont'd)

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MN20 Water Inlet Doors

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MN20 Water Inlet Doors (cont'd)

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Purpose

- Supports in-vessel retention following a severe accident
  - Buoyant doors permit water to access to the region between the reactor vessel and insulation

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Testing Overview

From Regulatory Guide 1.82:

Debris that could affect long-term recirculation cooling can be divided into the following categories:

(1) debris that is generated by the LOCA and is transported by blowdown forces (e.g., insulation, paint),

(2) debris that is generated or transported by washdown, and

(3) other debris that existed before a LOCA (e.g., corrosion material, sludge in a BWR suppression pool) and that may become suspended in the containment sump or suppression pool.

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Testing Overview (cont'd)

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Debris Category	
(1) debris that is generated by the LOCA and is transported by blowdown forces (e.g., insulation, paint),	
(2) debris that is generated or transported by washdown, and	
(3) other debris that existed before a LOCA (e.g., corrosion material, sludge in a BWR suppression pool) and that may become suspended in the containment sump or suppression pool.	

Testing Overview (cont'd)

- Jet Impingement Testing
  - MN20 Upper neutron shielding and CA31 neutron shielding is located in the Zone of Influence of Reactor Coolant Loop and DVI pipe breaks
- Submergence Testing
  - MN20 and CA31 neutron shielding and RVIS water inlet doors are located below the maximum containment flood up level (110.2 ft)
- To qualify as a suitable equivalent insulation, testing must be performed that subjects the insulation to conditions that bound the AP1000 design conditions and demonstrates that debris would not be generated

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Tentative Schedule

- WEC start testing is late January 2014
  - Submergence testing will start January 19 2014
  - Jet Impingement Testing will start early March 2014
- WEC complete testing by March/April 2014
- WEC/NRC conduct Final Pre-submittal Meeting and WEC submits TR in May 2014
- NRC completes Acceptance Review for TR in June/July 2014
  - WEC submit WCAP to China Customers
- NRC submits final SE in November 2014
- WEC submits final TR in December 2014
- Install Non-MRI at Domestic Sites – January 2015

Jet Impingement Testing – General

- Wyle Laboratories in Huntsville Alabama 'High Flow' test facility

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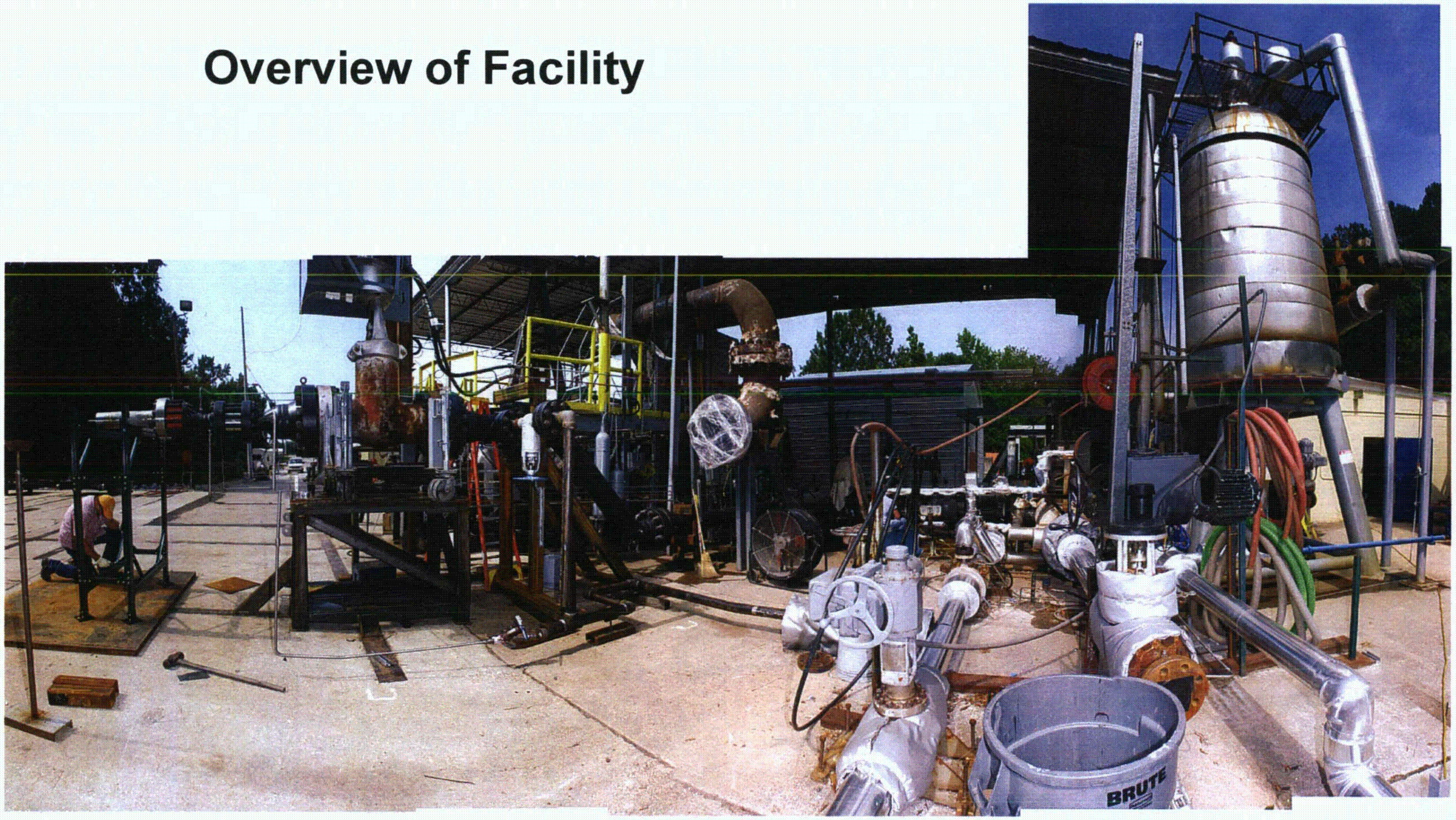
Jet Impingement Testing – Facility

Overview of Facility



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Jet Impingement Testing – Facility (cont'd)

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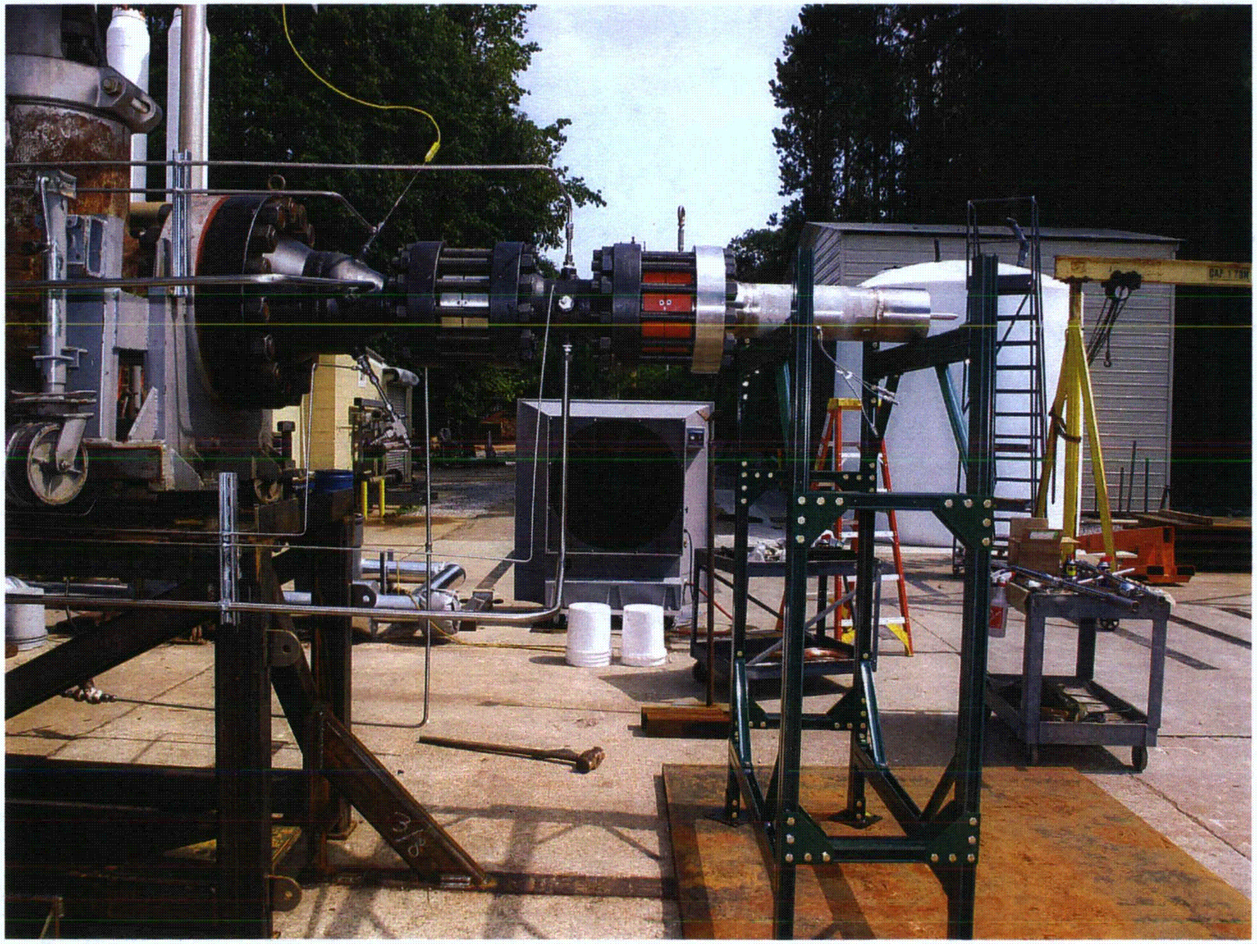
Jet Impingement Testing – General Procedure



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Jet Impingement Testing – General Procedure (cont'd)

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Jet Impingement Testing – General Procedure (cont'd)

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Jet Impingement Testing – Applicability to AP1000

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Jet Impingement Testing – Applicability to AP1000 (cont'd)

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Jet Impingement Target

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Jet Impingement Target (cont'd)

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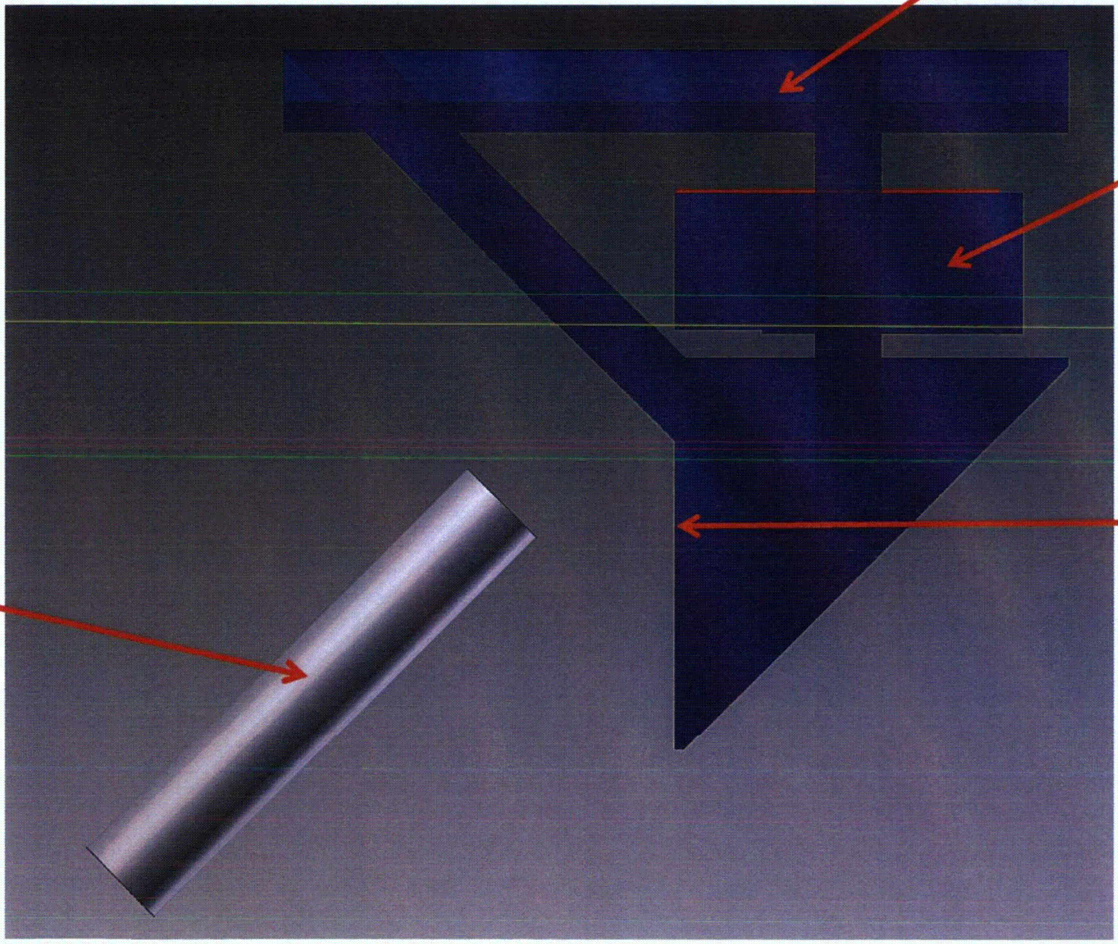
Jet Impingement Target Fixture



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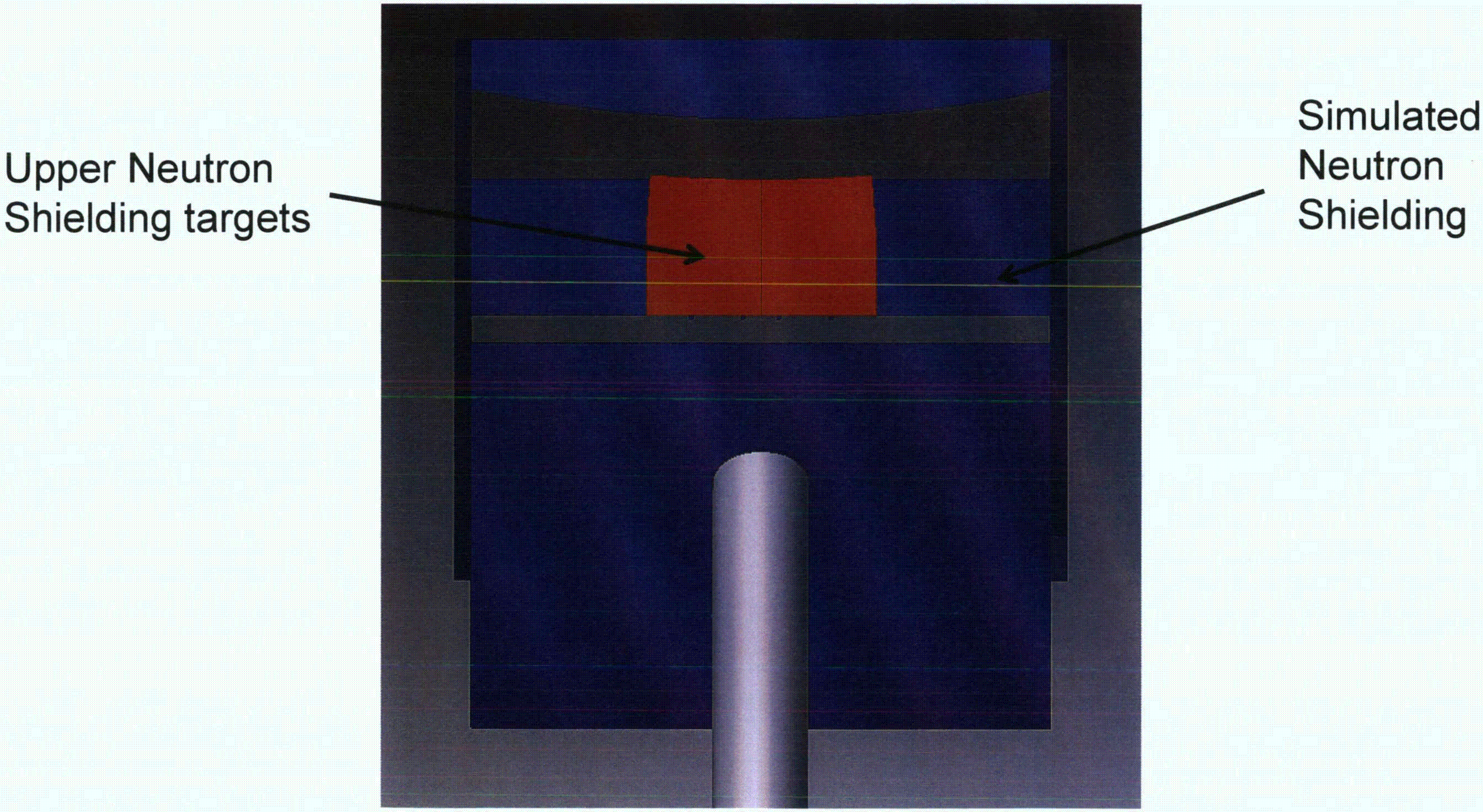
Jet Impingement Target Fixture (cont'd)



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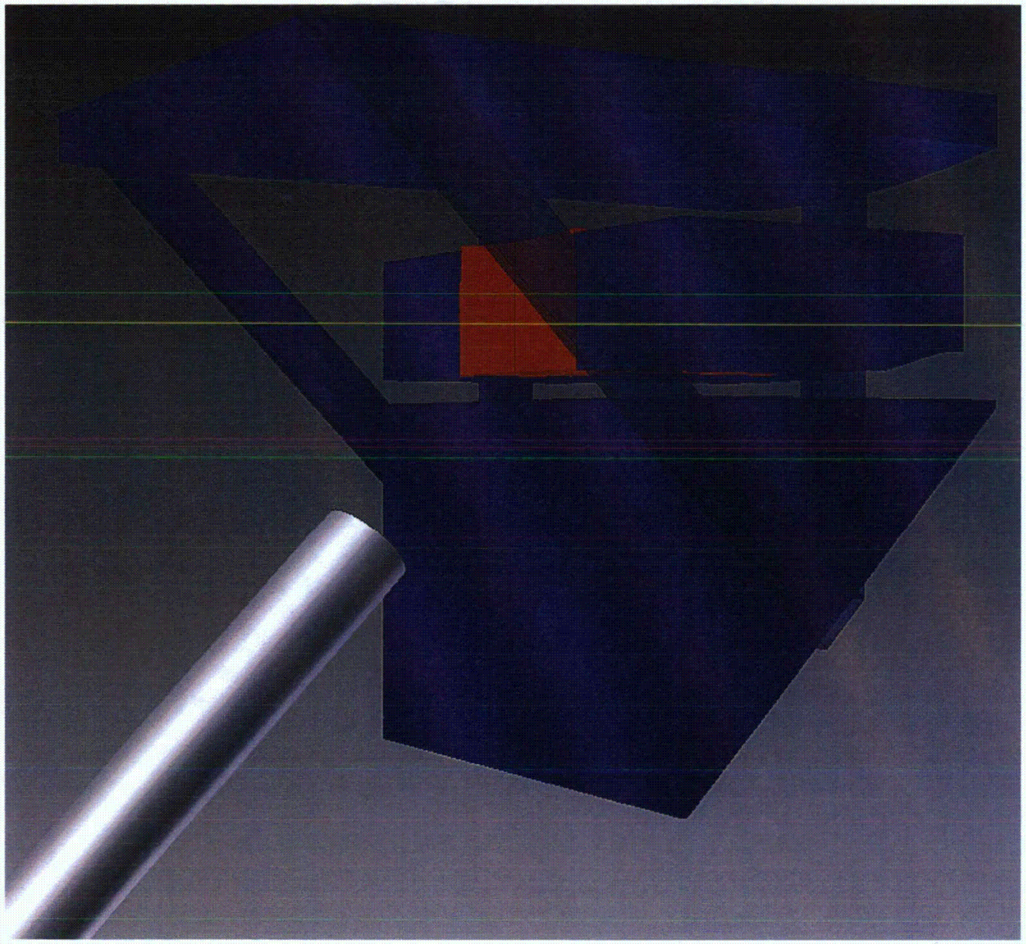
Jet Impingement Target Fixture (cont'd)



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- Temperature, pressure, and fluid chemical make-up based off of EQ bounding DBA/post-DBA submergence conditions
- Fluid samples will be taken and analyzed for debris
- Post test inspections of the samples will be performed

Testing approach aligns with submergence qualification of other AP1000 components

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Submergence Conditions

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Test Samples

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Test Samples (cont'd)

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Test Samples (cont'd)

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Test Samples (cont'd)

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Test Samples (cont'd)

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Test Samples (cont'd)

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Test Samples (cont'd)

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Fluid Analysis

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Suitable Equivalent Qualification

- **AP1000** ITAACs states that MRI or a "Suitable Equivalent" will be used for major RCS components, or for all components within the LOCA Zone of Influence or Flood up Level

- Section 6. Engineered Safety Features
  - Suitable equivalent defined as "In order to qualify as a suitable equivalent insulation, testing must be performed that subjects the insulation to conditions that bound the **AP1000** conditions and demonstrates that debris would not be generated"

Qualification testing will demonstrate that non-metallic insulation does not produce debris in case of a LOCA

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