U.S.NRC

UNITED STATES NUCLEAR REGULATORY COMMISSION

Protecting People and the Environment

U.S. EPR GSI-191
Public Meeting

U.S. NRC Headquarters

TWFN, Room O-11B2

April 29, 2010

1:00p.m.

Interactions to date

- July 8, 2009 public meeting to discuss technical issues identified by NRC staff
- Several audits on test protocols and specifications
  - Chemical Effects Testing
  - Downstream Effects Testing
  - Sump Strainer Head Loss Testing
- NRC staff witnessed testing
  - Chemical Effects Test (Lynchburg, VA)
  - Downstream Effects Test (Trenton, NJ)
  - Sump Strainer Head Loss Testing (Holden, MA)
- December 2009 sump strainer head loss testing
- January 27, 2010 public meeting on path forward for sump strainer testing
- NRC staff witnessed subsequent sump strainer head loss testing in February 2010.

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Future Interactions

- Submission date of revised technical report and RAI responses is currently TBD
- Potential additional testing on strainer head loss testing and downstream effects
- Audits on supporting documentation
  - Sump strainer test report
  - Downstream effects documentation

U.S. EPR GSI-191 Public Meeting

AREVA NP, Inc. and the NRC
April 29, 2010

EPR™ by AREVA

AREVA

Agenda

Time	Topic	Led By
1:00 PM	Introductory Remarks	NRC/AREVA
1:15 PM	Baseline Evaluation of GSI-191 Related Topics	NRC
1:30 PM	Results of Strainer Head Loss Testing	AREVA
2:00 PM	Discussion of In-Vessel Downstream Effects	AREVA
2:30 PM	Discussion of Remaining Activities	AREVA
3:00 PM	Opportunity for Public Comment	NRC
3:15 PM	Adjourn Public Session	
GSI-191: U.S. EPR Design Certification Proprietary Session		
3:15 PM	Discussion of Proprietary Issues and Content	NRC/AREVA
4:00 PM	Adjourn Closed Session	

U.S. EPR Strainer Performance Head Loss Testing

Fariba Gartland

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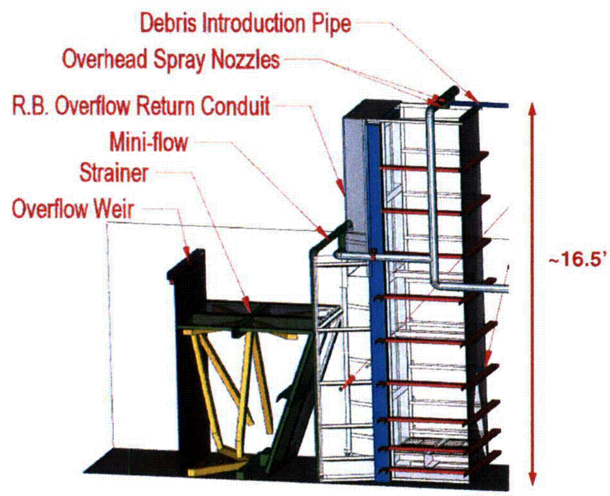
Introduction

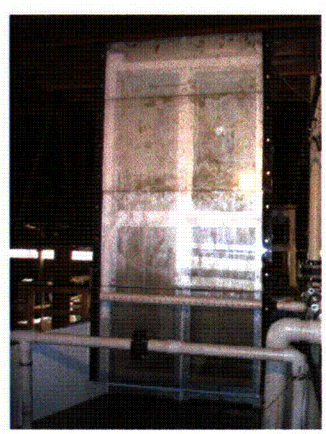
- ▶ Test Facility
- ▶ Test Description
- ▶ Debris
- ▶ Test Results
- ▶ Additional Testing

Test Facility



Test Facility

Top of Submerged Strainer



Top 7' of Retaining Basket

Test Description

- **Design basis test**
  - **100% of the design basis particulate**
  - **100% of the design basis fiber**
  - **Chemical precipitants**
  - **~½ inch coating chips**
    - In addition to 100% of the coatings in particulate form
- **Fiber only sample bypass test**
  - **100% of the design basis fiber**
  - **Samples collected downstream of the strainer**
- **Thin bed test**
  - **100% of the design basis debris**
  - **Fiber batched (1/8 inch thin bed equivalents)**

Debris

Particulate debris

- **Coatings**
  - **Epoxy (acrylic powder surrogate)**
  - **Inorganic zinc (tin powder surrogate)**
  - **Chips were also added (~½ inch)**
- **Microtherm**
- **Latent dirt and dust**

Fibrous debris

- **Fiber from piping**
  - **100% of the design basis fiber source term**
  - **Samples collected downstream of the strainer**
- **Latent fiber**
  - **~70% of the total fibrous debris**
- **Only "fines" utilized in testing**

Debris

Chemical debris

- Calcium phosphate
- Aluminum oxyhydroxide
- Sodium aluminum silicate
  - ALOOH surrogate

Test Results

Testing performed in accordance with March 2008 guidance

Design basis test

- Retaining basket successfully retained debris
- Post test drain down of test apparatus revealed a clean strainer

Thin bed test

- Results similar to the design basis test

Inside retaining basket

Test Results

Fiber only bypass test

- Fiber bypass
  - Conservatively includes debris that re-circulates through the test flume
  - >97% of the sampled fiber was less than 600 μm (0.024 inches) in length

Top of strainer prior to test termination

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Deposition of Debris and Chemical Precipitates on Fuel Rods

Gordon Wissinger

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EPRDM

- Once the ECCS is actuated and suction begins from the IRWST, bypassed materials and ions freed by dissociation of materials upstream of the strainer may reach the reactor vessel
- In the presence of boiling in the core, these materials may be deposited on the fuel rods and build up an insulation layer that could inhibit core cooling by:
  1) degrading the heat transfer from the fuel rod, or
  2) bridging the gap between fuel rods
- An evaluation of the deposition of these chemical precipitates and debris on the fuel rods was performed using the EPR LOCA Deposition Analysis Model (EPRDM) spreadsheet
- This calculation provides a conservative evaluation for up to 30 days following a LOCA of:
  1) The deposition thicknesses on fuel rod surfaces due to chemical and debris deposition, and
  2) The cladding temperatures under the buildup

Acceptance Criteria

- 10 CFR 50.46 requires that, following a LOCA:
  - ◇ Peak cladding temperature (PCT) < 2200°F
  - ◇ Peak local oxidation < 17%
  - ◇ Whole-core hydrogen generation < 1% of cladding
  - ◇ Core remains amenable to cooling
  - ◇ Long-term core cooling (LTCC) is assured
- Objective is to provide LTCC considering debris that might reach the core
- For EPRDM analysis, the LTCC acceptance criterion is further refined:
  - ◇ Clad temperature after core recovery < 800°F
  - ◇ Deposition thickness < 50 mils

Acceptance Criteria

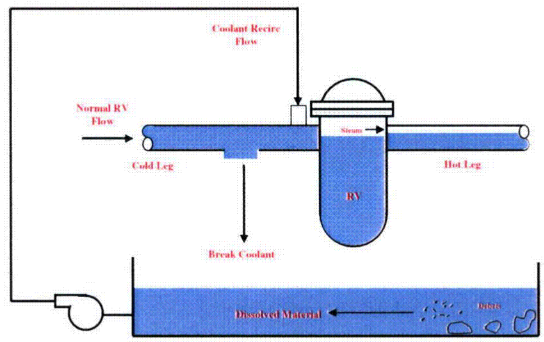
- **Decay heat removal**
  - ◇ The first 3 criteria of 10 CFR 50.46 govern the initial clad temperature excursion following the LOCA
  - ◇ Once the core has been recovered, the cladding temperature should remain near saturation or slightly above, but not be allowed to again reach high temperature
  - ◇ Cladding temperatures at or below 800°F maintain the clad within the temperature range where additional corrosion and hydrogen pickup over a 30 day period will not have a significant effect on cladding properties
  - ◇ Therefore, the cladding and core will not be significantly different than when the core was initially recovered
  - ◇ If the EPRDM simulation of plant specific conditions results in peak cladding temperatures below 800°F, the LTCC acceptance criteria within 10 CFR 50.46 is satisfied

Acceptance Criteria

- **Deposition thickness**
  - ◇ LTCC requires that sufficient flow reaches the core to remove long-term core decay heat
  - ◇ Deposition on the fuel rods could affect local flow channels and impede decay heat removal
  - ◇ Restricting the total deposition buildup on any rod (including existing oxide and crud layers) provides for an open rod-to-rod gap
  - ◇ The rod-to-rod gap for the U.S. EPR fuel is > 120 mils
  - ◇ If the EPRDM simulation of plant-specific conditions results in a total deposition thickness (including existing oxide and crud layers) below 50 mils (1270 microns), then the rod-to-rod gap will remain open and the acceptance criteria within 10 CFR 50.46 is satisfied

Methodology

- EPRDM is a spreadsheet macro calculation used to determine the effect of fibrous, particulate, and chemical debris that passes through the IRWST baskets and/or sump screens, enters the reactor vessel, and deposits on the fuel rods

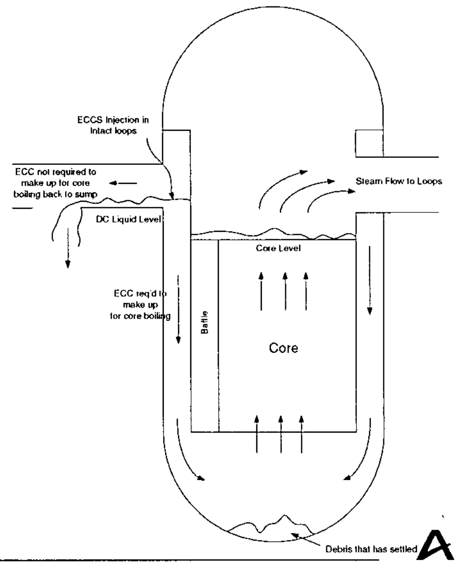


Methodology

- The chemical precipitates formation rate over 30 days is defined by the OLI StreamAnalyzer™ analyses and autoclave testing
  - The following specific chemical compounds were noted to precipitate
    - Sodium Aluminum Silicate ($NaAlSi_3O_8$)
    - Calcium Phosphate ($Ca_3(PO_4)_2$)
    - Aluminum Hydroxide ($Al(OH)_3$)
  - Therefore, the chemical model only considers the release rates of the principal elements guiding the formation of these precipitate compounds:
    - Aluminum
    - Calcium
    - Silicon
- The precipitates formation rate sets the concentration of the IRWST with time
- The ECCS flow transports the precipitates and debris to the RCS and increases the concentration of impurities in the core
  - All fiber generated in containment reaches core within 1 hr
  - Particulate and precipitate concentrations calculated for 30 days

Methodology

- Deposition occurs through the boiling process
- All impurities that reach a boiling site are deposited on the fuel rod
- Conservative core power map with a core exit peak that is consistent with the LOCA LHR limit analyses is used
- Since the deposition process is driven by boiling, increasing the boiling rate will increase the deposition thickness
  - Therefore, a cold leg break with cold side injection is assumed for the entire 30 days
  - Very conservative, because HLI actuates at 60 minutes



Methodology

- When the temperature at the outer surface of the oxide/crud layer is below the boiling point, deposition is assumed to occur via convective deposition rather than by boiling
  - The non-boiling rate of deposit build-up is proportional to heat flux and is 1/80th of that of boiling deposition at the same heat flux
- Flow is not modeled explicitly
  - Instead, a generic heat transfer coefficient of 400 W/m^2-K (70 BTU/hr-ft^2-°F) was assumed for the transfer of heat between bulk coolant within the fuel channels and the surface of the deposits
  - Deposit thermal conductivity = 0.1 W/m-K
- Crud and oxide layers are present at the maximum (end of life) thickness
- Pure steam returns to the IRWST and is condensed

Results

- **Maximum scale thickness < 30 mils**
  - ◇ **Includes initial oxide and crud layers**
  - ◇ **Includes all fiber generated in containment**
- **Maximum cladding temperature < 430°F**

Results

- **Results are very conservative**
  - ◇ **Modeled a cold leg break with cold side injection for 30 days**
    - HLI will be actuated at 60 minutes and significantly reduces core boiling and deposition
  - ◇ **Assume that all fiber generated in containment reaches core within 1 hour**
    - Fiber bypass is not 100% - barrier system will holdup and filter debris
  - ◇ **Predictions of chemical precipitates are conservatively high**
    - Include Al, even though Al is not present in the U.S. EPR containment
  - ◇ **Limiting thermal conductivity used for both crud and oxide layers**
    - Oxide layer thermal conductivity much greater than crud
  - ◇ **Limiting thermal conductivity used for deposition layer**
    - Value used is more than half of the values for material being deposited

Remaining Activities

Fred Maass

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Path to GSI-191 Closure for U.S. EPR Design

▶Remaining Activities

- ◇ANP-10293, Rev. 1 (May 20, 2010)
- ◇RAIs 111, 233, 297, 363 (May 20, 2010)
- ◇Additional testing
- ◇Revise ANP-10293 to reflect results of above