ENCLOSURE 4

Westinghouse Non-Proprietary Class 3

APP-MY03-GLY-001-NP Revision 0

Presentations from the April 16th 2008 Meeting Regarding AP1000 Sump Screen Design

F-AP-3.2-1 Rev 4

AP1000 DOCUMENT COVER SHEET

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REVIEWER(S)	SIGNATURE / DATE	
	SIGNATURE / DATE	
VERIFIER(S) ~~K.F. McNamee~~ D.H. Behnke	SIGNATURE / DATE 8/7/08	Verification Method: Independent Review Detailed Review of Revisions

****Plant Applicability**: ☒ All AP1000 plants except: No Exceptions
☐ Only the following plants:

APPLICABILITY REVIEWER** J.A. Speer	SIGNATURE / DATE 8/8/08
RESPONSIBLE MANAGER* C.A. McGinnis	SIGNATURE / DATE for Cindi McGinnis 8/11/08

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April 16, 2008 AP1000 Screen Meeting

- Agenda
  - 9:00 Introduction
  - 9:15 Summary Overview (Schulz)
  - 9:45 Screen Design, Plant Interface (Schulz)
    - 10:00 Screen Design, CCI Background / Experience (CCI)
    - 10:30 Screen Design, AP1000 Drawings (CCI)
  - 11:15 Screen Testing (Andreychek)
  - 12:15 lunch
  - 1:15 Downstream Effects (and other infor from TR-26) (Andreychek)
  - 2:15 LTC Sensitivity Studies (Monahan)
  - 2:45 ITAAC (Schulz)
  - 3:15 RG 1.82 Assessment (Schulz)
  - 3:45 Wrap-up

AP1000 Containment Screen Design Introduction

April 16, 2008

Terry L. Schulz, Consulting Engineer
AP1000 Nuclear Systems Engineering

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- AP1000 Has Important ***DIFFERENCES*** Relative to Operating Plants
  - AP1000 has many design features and characteristics that eliminate or reduce the potential for LTC debris issues
- AP1000 Has Similarities To Operating Plants
  - Allows application of same evaluation methods
    - AP1000 chemicals and materials are used in operating plants (boron, TSP, aluminum, …)
    - AP1000 screen design / vendor are used in many plants
- All Information Discussed Today Is Taken From Reports Sent to NRC
  - Except for LTC sensitivities which will be sent < 4/30/08

AP1000 Differences Overview

- AP1000 Has Many Design Features / Characteristics That Eliminate or Reduce Potential For LTC Debris Issues
  - Fibrous / particulate debris limited by design
    - Fibrous debris is not generated by LOCAs
      - MRI is used in zones of influence of LOCA jets

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    - Debris limited to resident debris, resulting in very low debris loadings
  - Chemical debris limited by design

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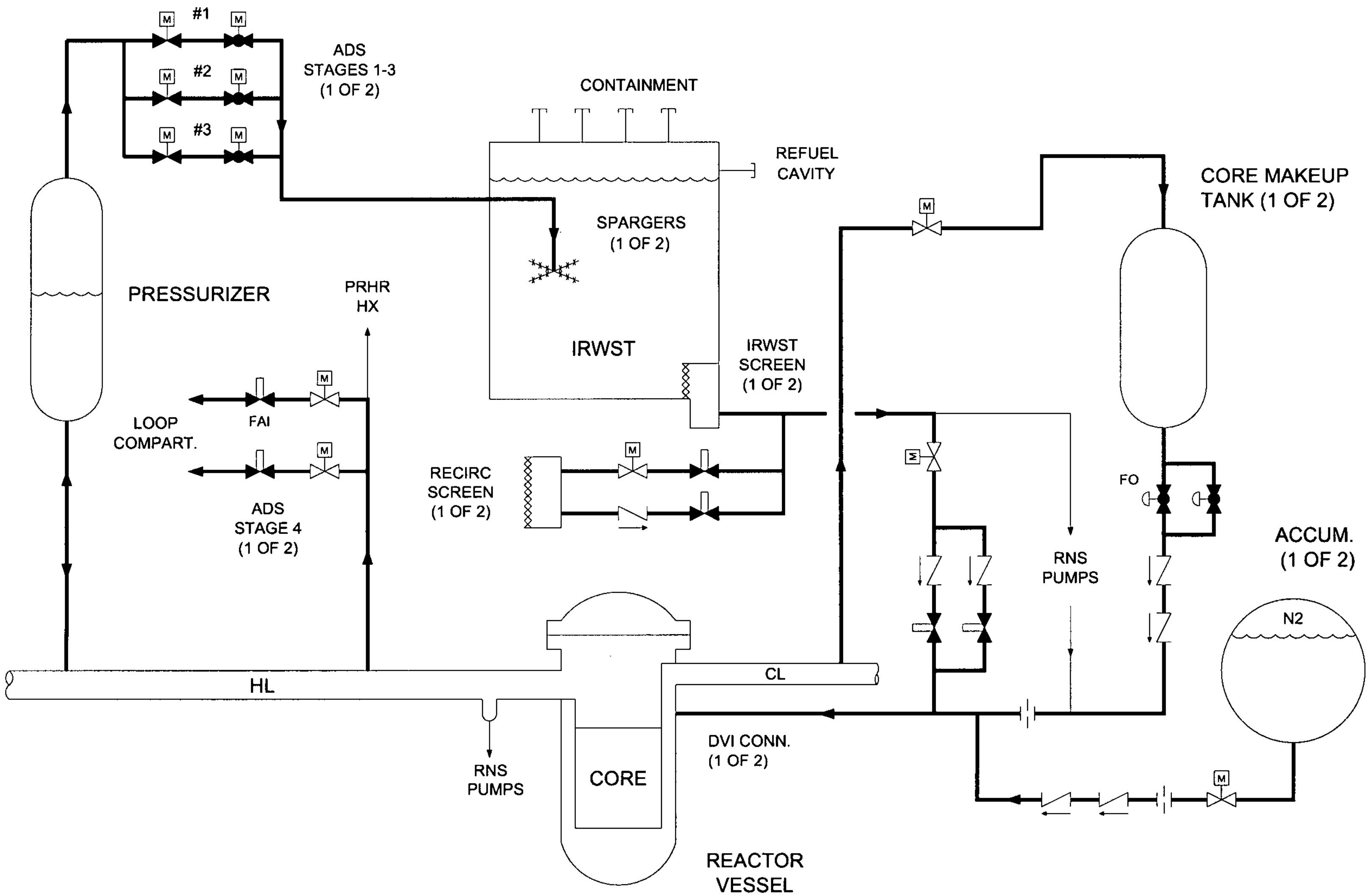
AP1000 Differences Overview

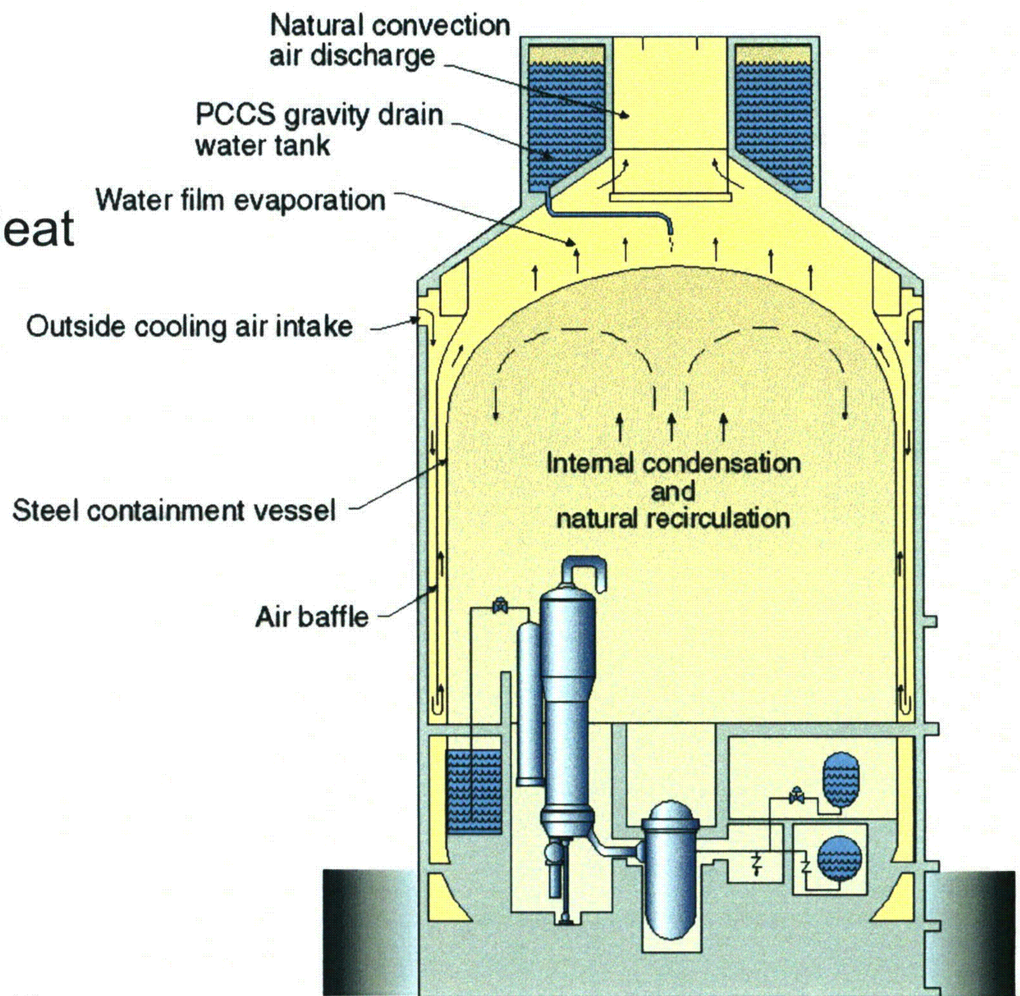
- AP1000 Has Many Design Features / Characteristics That Eliminate or Reduce Potential For LTC Debris Issues (cont)
  - AP1000 does not have Safety Injection pumps
    - High flow SI pumps not used
      - AP1000 SI flows decrease with time, less flow at recirc
    - Chance of downstream effects (in-pipe) adversely affecting system operation greatly reduced
      - No pumps, HX, throttle valves, spray nozzles – reduced vulnerability
  - ADS stage 4 provides significant water carryover
    - Greatly limits chemical concentration increase (boron, TSP, …)
    - Greatly limits deposition on fuel surfaces
  - AP1000 containment cooling equipment has no interface with post LOCA debris

AP1000 Differences Overview
Passive Safety Injection



AP1000 Differences Overview
Passive Containment Cooling System

- No Equipment Located Inside Containment
  - Not impacted by post LOCA debris
- Uses Steel Containment Vessel As Heat Exchanger
  - Water drained onto outside surface
  - Evaporates into natural circ air flow
- PCS Water Storage Tank
  - Provides 72 hr supply of water
    - Afterwards use on/offsite water
    - Air only cooling prevents failure
  - Flow decreases with time
    - 4 standpipes control flow
- 3 Redundant Drain Paths
  - 2 AOV, 1 MOV - Improves PRA reliability



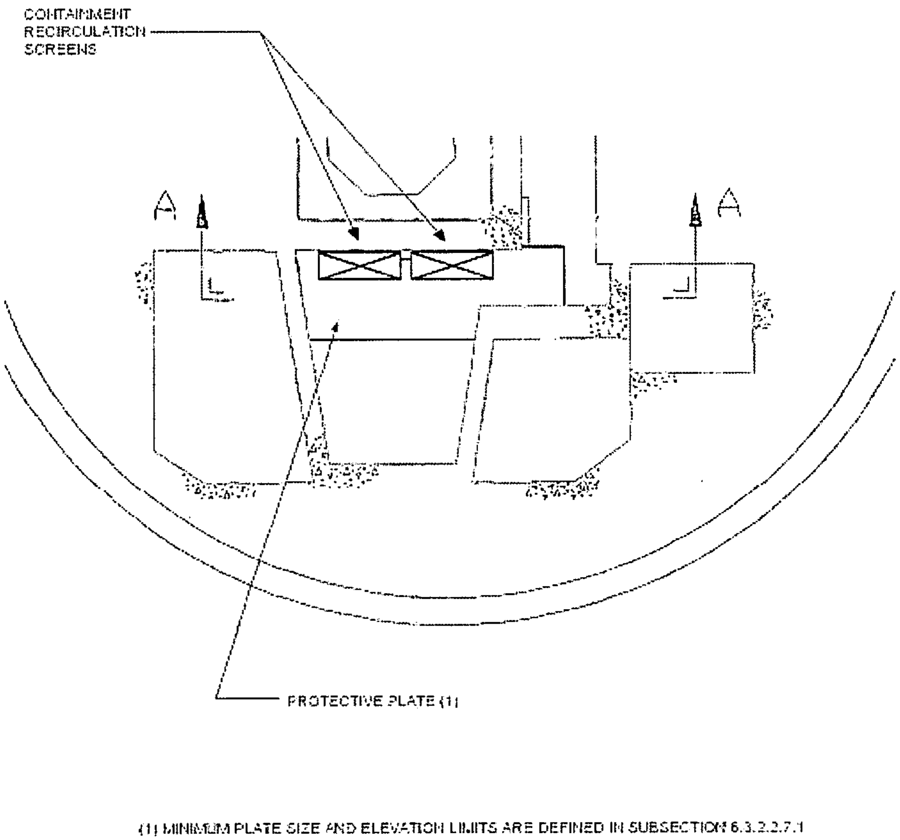
AP1000 Differences Overview

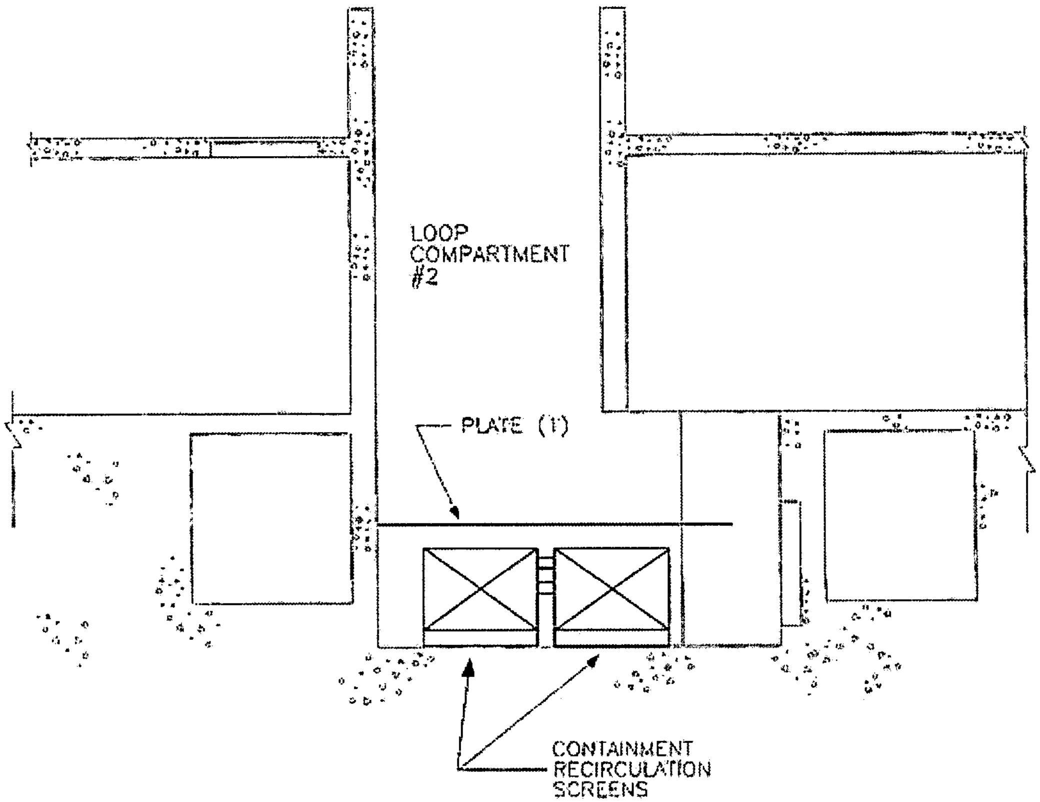
- AP1000 Has Many Design Features / Characteristics That Eliminate or Reduce Potential For LTC Debris Issues (cont)
  - AP1000 has delayed start of recirculation
    - Recirc time for most LOCAs is ~ 4 hr
    - Minimum recirc time for DVI LOCA is ~ 2.5 hr
    - Provides additional settling time
  - AP1000 has no containment spray used during DBA LOCAs
    - Has spray capability using fire pumps
      - Only injection, no recirculation
    - Only used in case of core melt sequence

AP1000 Differences Overview

- AP1000 Has Many Design Features / Characteristics That Eliminate or Reduce Potential For LTC Debris Issues (cont)
  - Containment floods deeper
    - ~ 24 ft above floor at cont recirc screens
    - ~ 13 ft above top of cont recirc screens
    - 2 ft curb provided in front of cont recirc screens
  - Containment recirculation screens protective plate located just above screens
    - Extend out 10' in front of CR screens
    - Prevents debris from falling into water right in front of the screens
    - Heavier debris will settle onto floor before being transported to screens

AP1000 Differences Overview
Containment Recirc. Screens





SECTION A–A

AP1000 Differences Overview

- AP1000 Has Many Design Features / Characteristics That Eliminate or Reduce Potential For LTC Debris Issues (cont)
  - AP1000 screen design provides large screen areas
    - Together with low debris loading, prevent formation of contiguous debris bed => no increase in head loss
      - Confirmed by AP1000 testing
  - AP1000 screen design based on proved screen design
    - "Pocket" geometry more effective than flat screen
    - Provides additional margin
    - Applied to about 45 operating PWRs
      - 20 in US

AP1000 Differences Overview

- Deep Containment Flood Up Can Cover LOCA Break Location
  - Allows part of recirculation flow to bypass screens
  - Very low debris in AP1000 limits amount of debris that could get into the reactor vessel / fuel
    - Not sufficient to from contiguous debris bed => no head loss
    - Have performed T&H analysis with arbitrary large head loss
      - Analyzed 3' and 6' of water head loss across core
      - Downcomer not initially filled, so water level backs up in downcomer
        - » In DCD LTC analysis downcomer not filled by > 6'
        - » Causes no change in flow through core
  - No impact in core cooling

AP1000 Differences Overview

- Long Term Cooling Analysis Demonstrates Adequate Core Cooling With Debris
  - Increase in screen DP has proportional impact on AP1000 recirc flows
    - Characteristic of natural circ system
      - Has no impact on operating plants until pumps stop due to inadequate NPSH
    - AP1000 sensitivity analysis performed with arbitrary increase in screen DP
      - 2 cases analyzed with following head loss additions
        - » 3 ft to core and 6" to CR and IRWST screen head loss
        - » 6 ft to core and 12" to CR and IRWST screen head loss
      - No measurable loss in core cooling margin
        - » Small reduction in recirculation flow rates (case 1 ~4%, case 2 ~11%)
    - Analysis and tests demonstrate contiguous debris bed does not form
      - Head loss will be essentially zero
      - No impact on core cooling

AP1000 Provides Well Documented/Analyzed LTC Design With Large Margins

- Information Presented Today Is Taken From Reports Sent To NRC As Listed Below
  - AP1000 has defined detailed screen design information, reported in APP-GW-GLN-147, Revision 1, submitted 3/3/08
  - AP1000 has performed testing using AP1000 screen design and conditions, reported in WCAP-16914-P, Revision 0, submitted 3/3/08
  - AP1000 has evaluated downstream effects, reported in APP-GW-GLR-079, Revision 3, submitted 2/28/08
  - AP1000 has defined DCD impacts including proposed ITAAC revisions in APP-GW-GLE-002, Revision 0, submitted 2/28/08
  - AP1000 has provided a RG 1.82, Rev 3, assessment / roadmap in letter DCP/NRC2116, submitted 4/9/08
  - AP1000 has performed LTC T&H sensitivities assuming conservative increase in core / screen head losses
    - Analysis complete, will be presented today and submitted by 4/30/08

AP1000
Containment Recirculation and In-Containment Refueling Water Storage Tank Screen Layout

April 16, 2008

Terry L. Schulz, Consulting Engineer
AP1000 Nuclear Systems Engineering

AP1000 Containment Recirculation and IRWST Screen Design Details

OVERVIEW

1. AP1000 Screen Design Interface with Plant
2. AP1000 Screen Manufacturer Experience / Product
3. AP1000 CR and IRWST Screen Detailed Design

AP1000 Screen Design Methodology

- AP1000 screens sized to maximize their areas within the available AP1000 containment space
  - Approx. 5000 ft^2 for CR screens
  - Approx. 1000 ft^2 for IRWST screens
- AP1000 screens use existing structures to aid in the creation of plenums for maximum flow availability
- AP1000 CR screens covered by a protective plate to prevent debris from falling just in front of the screens
- AP1000 IRWST screens protected by the top of the IRWST

AP1000 Containment Recirculation Screens

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AP1000 Containment Recirculation Screens

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AP1000 Containment Recirculation Screens

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IRWST Screens

a,c

IRWST Screens

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Westinghouse AP1000 CR and IRWST Screen Design

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APP-MY03-GLY-001-NP, Rev. 0

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CCI history

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Babcock & Wilcox

Bailey

IMI

ABB

SULZER Valves

BTG Valves

STI

HERION

FLUID KINETICS

NHL

Thompson

1961 - CCI founded

1967 - CCI patents the DRAG® valve

1971 - B&W purchases CCI

1979 - CCI purchases Bailey valves

1981 - IMI acquires CCI

1997 - CCI acquires Sulzer valves

2001 - CCI acquires BTG valves

2002 - CCI acquires STI

2003 - CCI acquires Herion valves

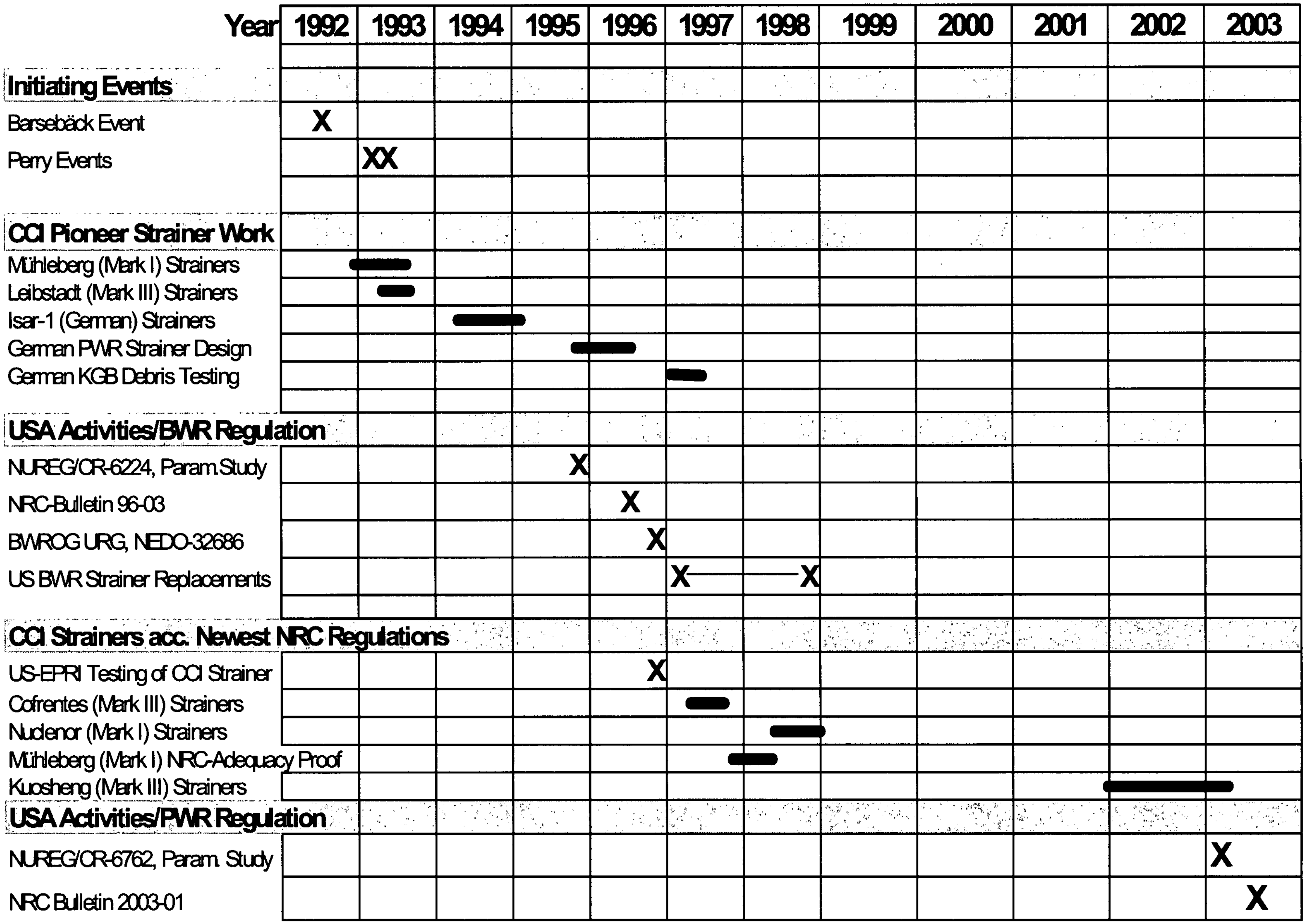
2003 - CCI acquires Fluid Kinetics

2005 - CCI acquires ABB Japan

2005 - Shanghai CCI JV formed

2006 - CCI acquires Truflo **(Newman Hattersley, Thompson Valves)**

Time History of Worldwide Events and ECCS Screen Development by CCI

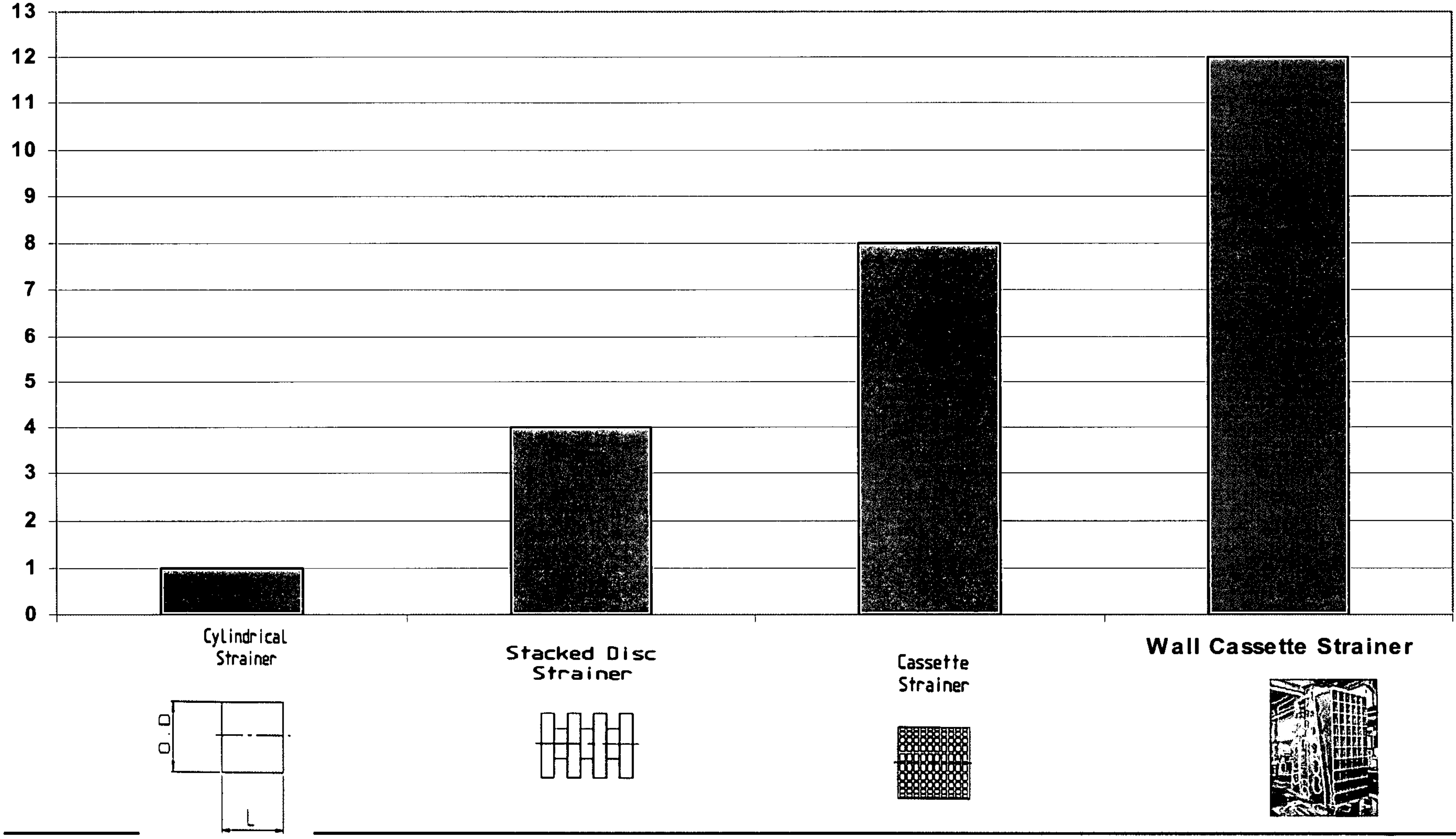


CCI Debris Blockage Mitigation Experience

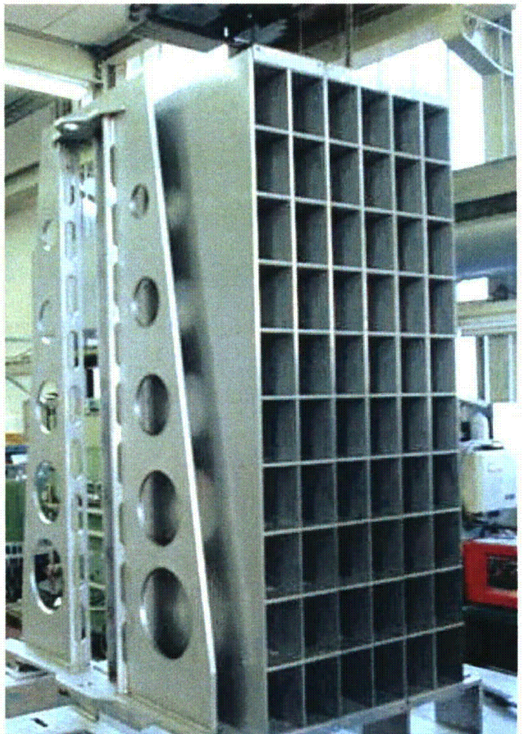
- 1st OEM to deliver upgraded screens following Barsebaeck screen blockage event.
  - 1st OEM to deliver "stacked disk" screens, 1994
  - 1st OEM to develop upgraded screens for PWR, 1995
- EPRI full scale testing of "pocket cassette" screen per BWROG successfully completed in 1996
- 26 BWR screen projects (Switzerland, Germany, Spain, Taiwan, Japan)
- 22 PWR screen projects in progress for EdF
- 20 US PWR Installations

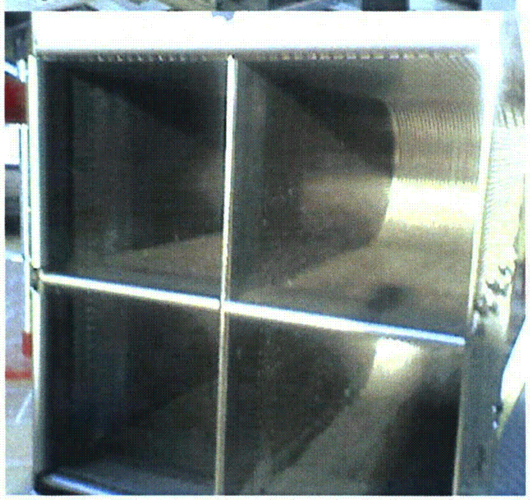
Evolution of CCI Screens

Factors of effective filter area in basic volume



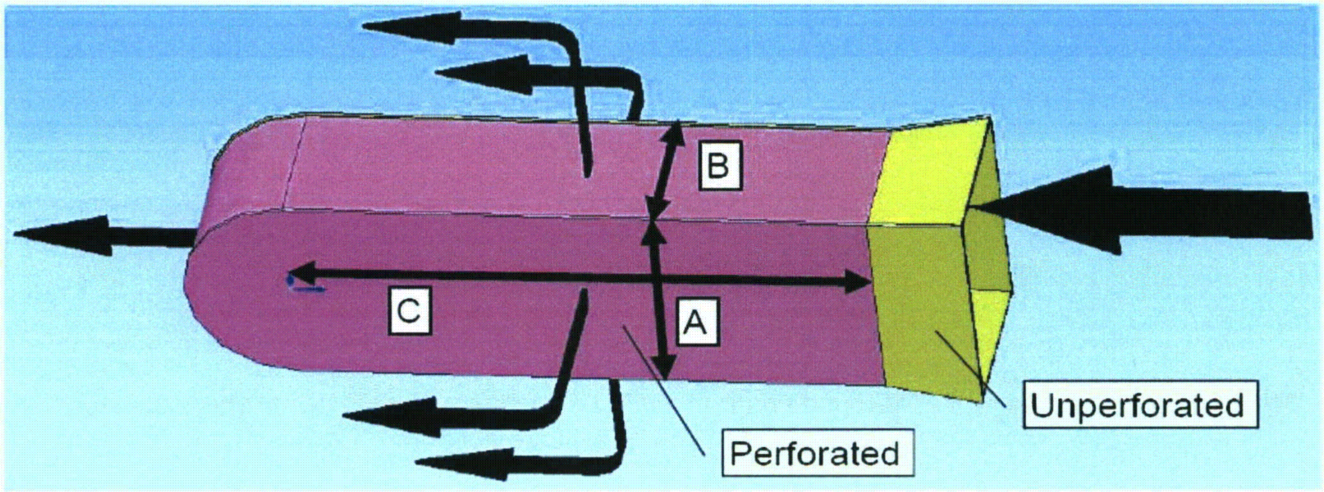
CCI Pocket Cassette Screen Features

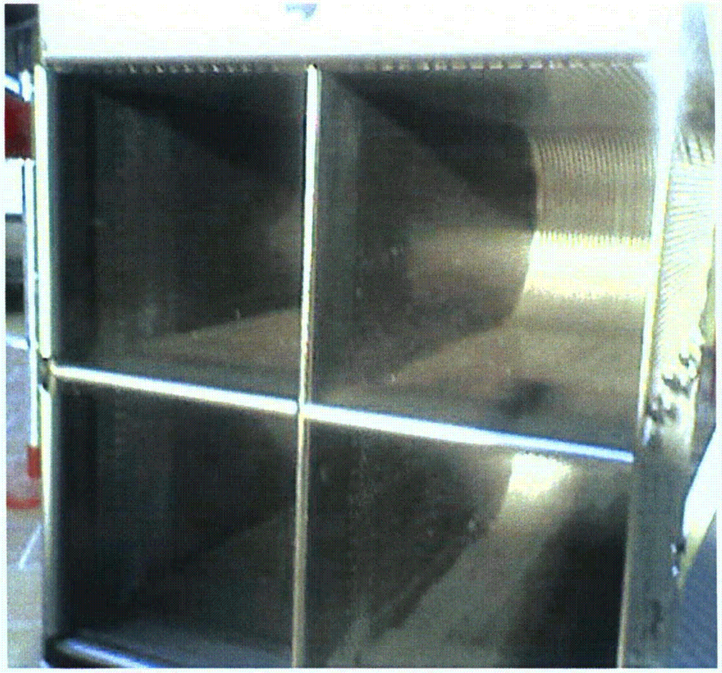


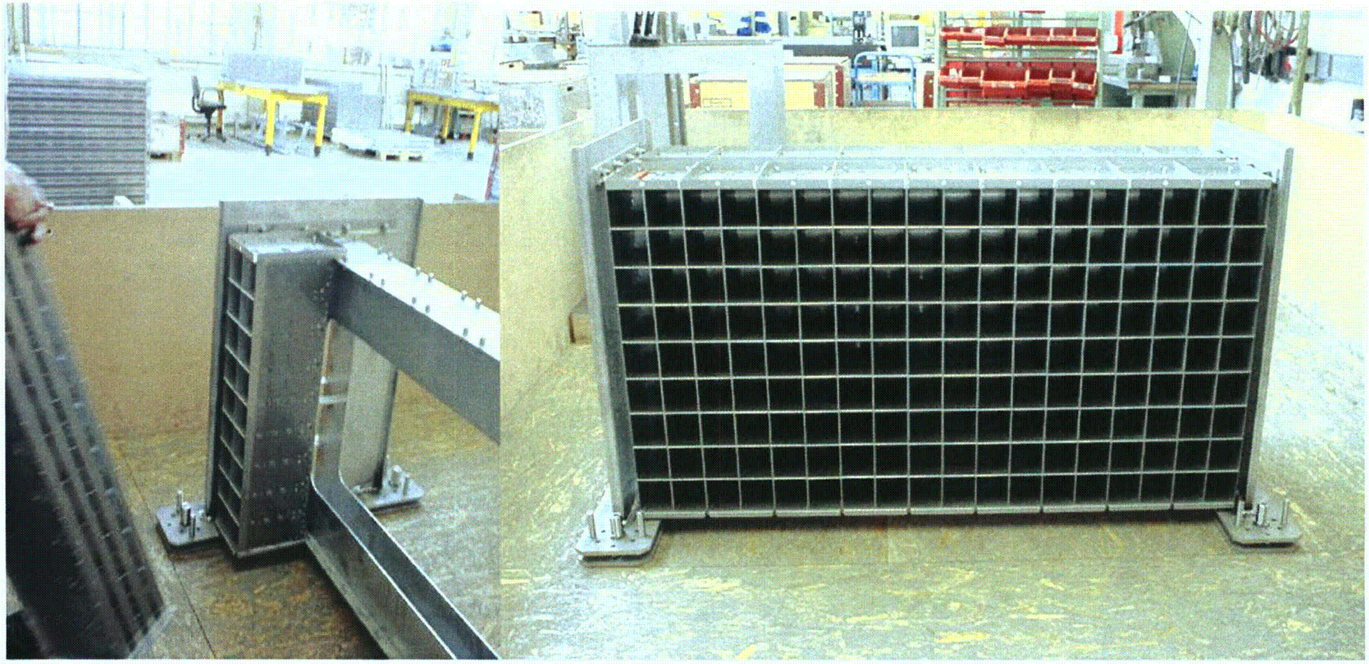


- Passive 4th generation screen, experience since 1993
- No moving parts or related testing
- Rugged design for seismic & LOCA
- Compact modularized design, adapts to unique sump geometry & obstructions, provides convenient installation
- No welding required for installation
- Highest available ratio of inlet surface area-to-volume
- Low screen approach velocity for desired sedimentation effect & convoluted surface for break-up of debris bed build up
- Temporary removal of screen elements for inspection access to ECCS pipe inlets possible

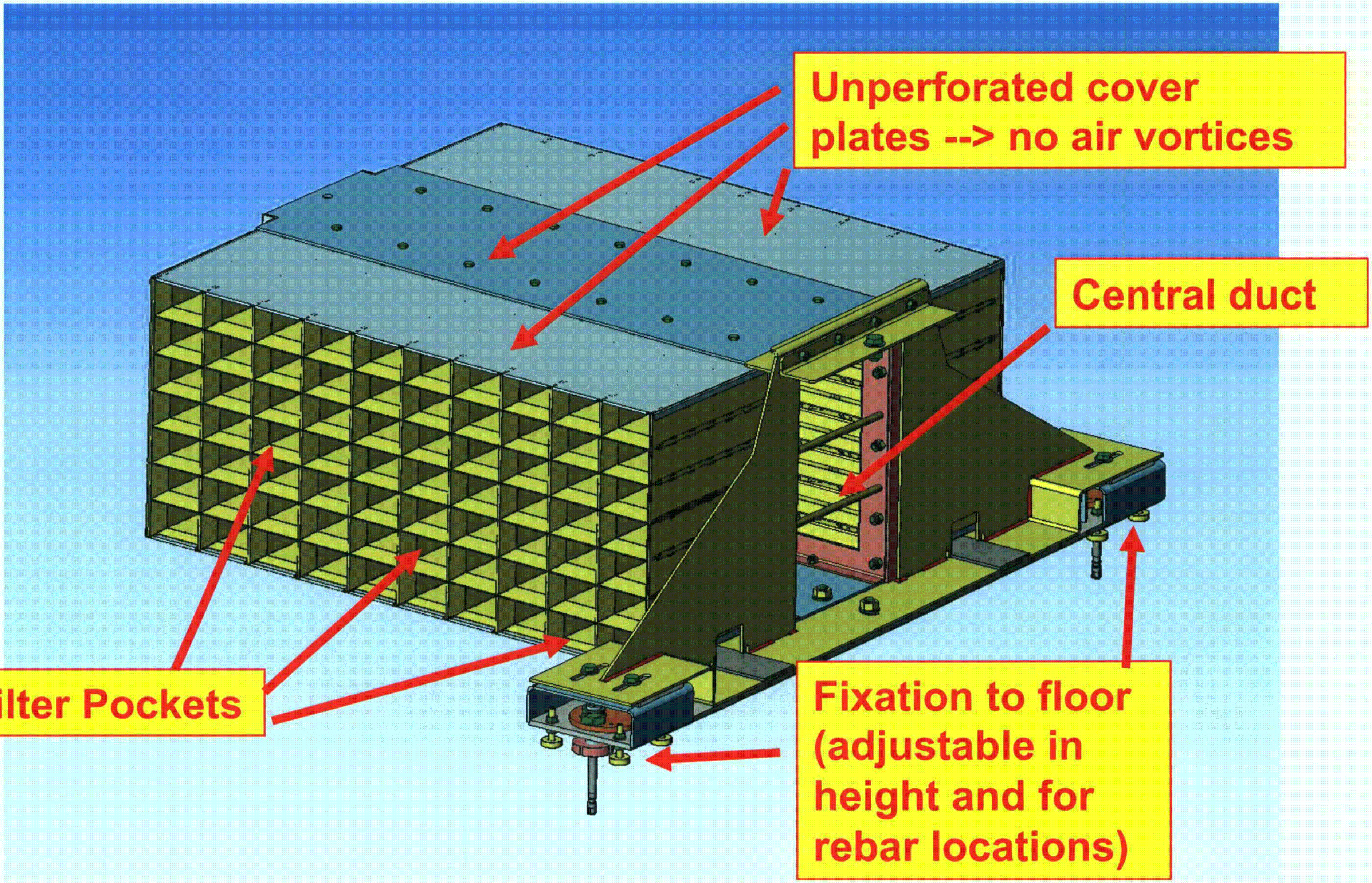
CCI Pocket Screen Design for PWRs



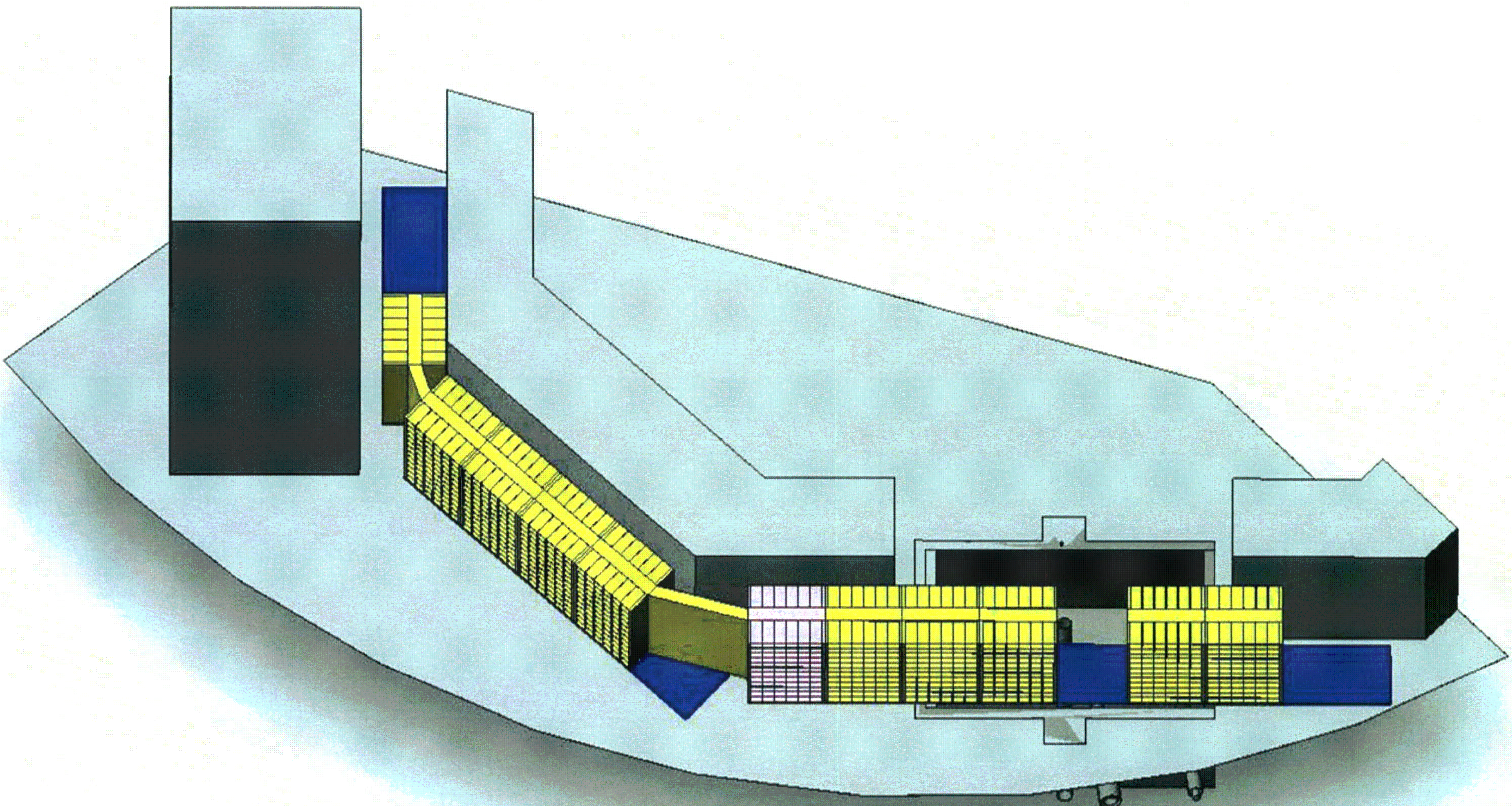




Example Screen Module (Salem)



Example Screen Layout on Containment floor



Calvert Cliffs Mockup

ECCS Sump Strainer

Salem Screen Installation

D.C. Cook Wall Screen Factory Mockup

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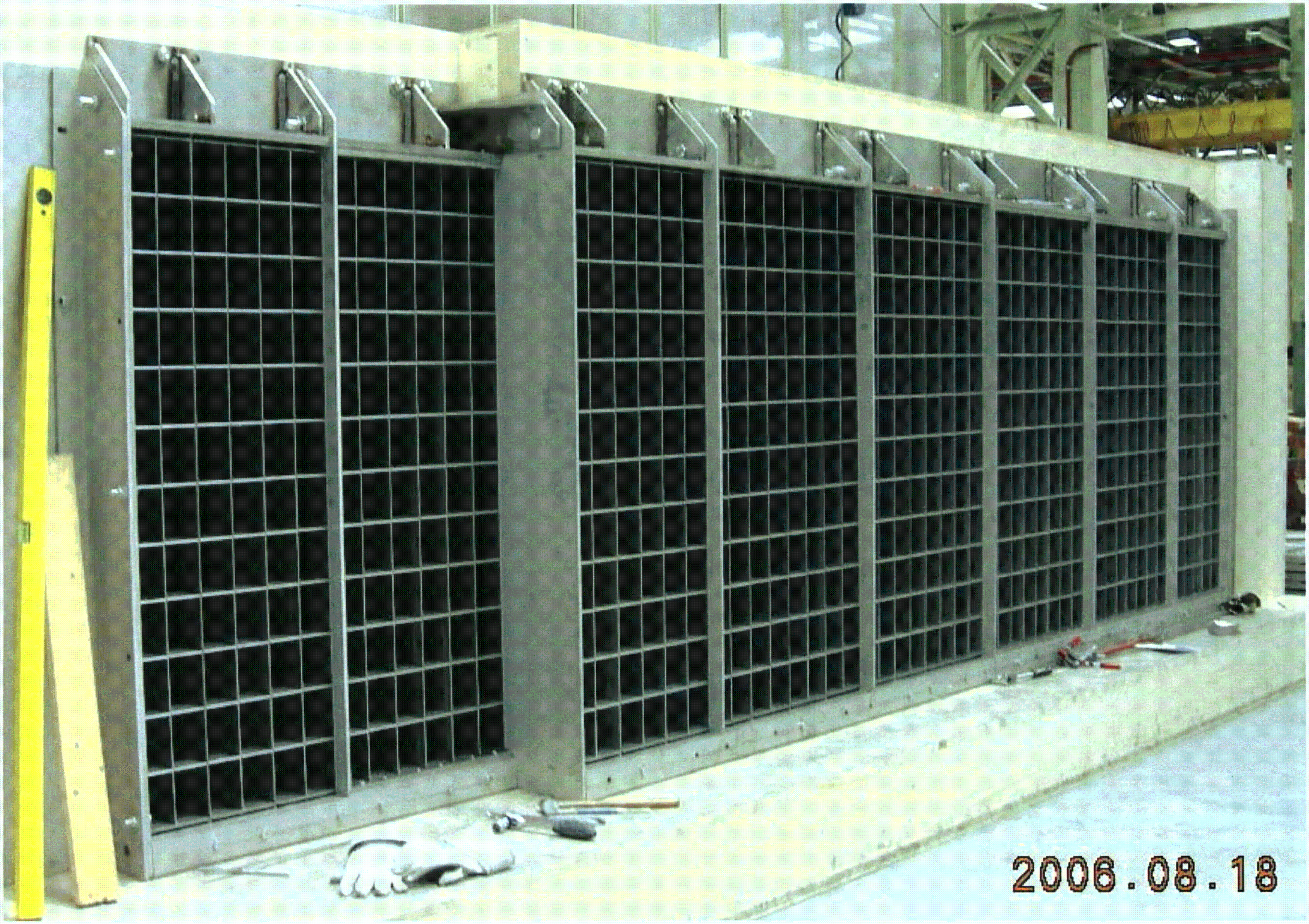

US Nuclear PWR's with CCI Pocket Screens

Owner	Plant	NSSS	Size
Entergy Nuclear South	Arkansas Nuclear One 1	B&W	836
Entergy Nuclear South	Arkansas Nuclear One 2	C-E	858
First Energy Nuclear Operating Company	Beaver Valley 1	Westinghouse	810
Exelon Generation	Braidwood 1	Westinghouse	1120
Exelon Generation	Braidwood 2	Westinghouse	1120
Exelon Generation	Byron 1	Westinghouse	1105
Exelon Generation	Byron 2	Westinghouse	1105
Constellation Nuclear	Calvert Cliffs 1	C-E	825
Constellation Nuclear	Calvert Cliffs 2	C-E	825
American Electric Power	Donald C. Cook 1	Westinghouse	1020
American Electric Power	Donald C. Cook 2	Westinghouse	1090
Duke Power	Oconee 1	B&W	846
Duke Power	Oconee 2	B&W	846
Duke Power	Oconee 3	B&W	846
Arizona Public Service Company	Palo Verde 1	C-E	1243
Arizona Public Service Company	Palo Verde 2	C-E	1243
Arizona Public Service Company	Palo Verde 3	C-E	1243
Constellation Nuclear	R. E. Ginna	Westinghouse	500
PSEG Nuclear LLC	Salem 1	Westinghouse	1106
PSEG Nuclear LLC	Salem 2	Westinghouse	1106

CR & IRWST Screen Design / Assembly on Site

AP 1000 CR Strainer (PXS-MY-02 A+B)

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AP 1000 CR Strainer (PXS-MY-02 A+B)

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AP 1000 CR Strainer (PXS-MY-02 A+B)

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AP 1000 CR Strainer (PXS-MY-02 A+B)

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AP 1000 CR Strainer (PXS-MY-02 A+B)

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AP 1000 CR Strainer (PXS-MY-02 A+B)

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AP 1000 CR Strainer (PXS-MY-02 A+B)

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AP 1000 CR Strainer (PXS-MY-02 A+B)

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AP 1000 IRWST Strainer (PXS-MY-01 A+B)

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AP 1000 IRWST Strainer (PXS-MY-01 A-B)

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AP 1000 IRWST Strainer (PXS-MY-01 A+B)

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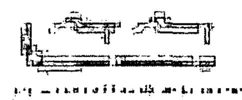
AP 1000 IRWST Strainer (PXS-MY-01 A+B)



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AP 1000 IRWST Strainer (PXS-MY-01 A+B)

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AP 1000 IRWST Strainer (PXS-MY-01 A+B)

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Structural Analysis Performed on AP1000 Screens

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AP1000 Screen Functional Testing

April 16, 2008

Tim Andreychek
Systems & Equipment Engineering-I

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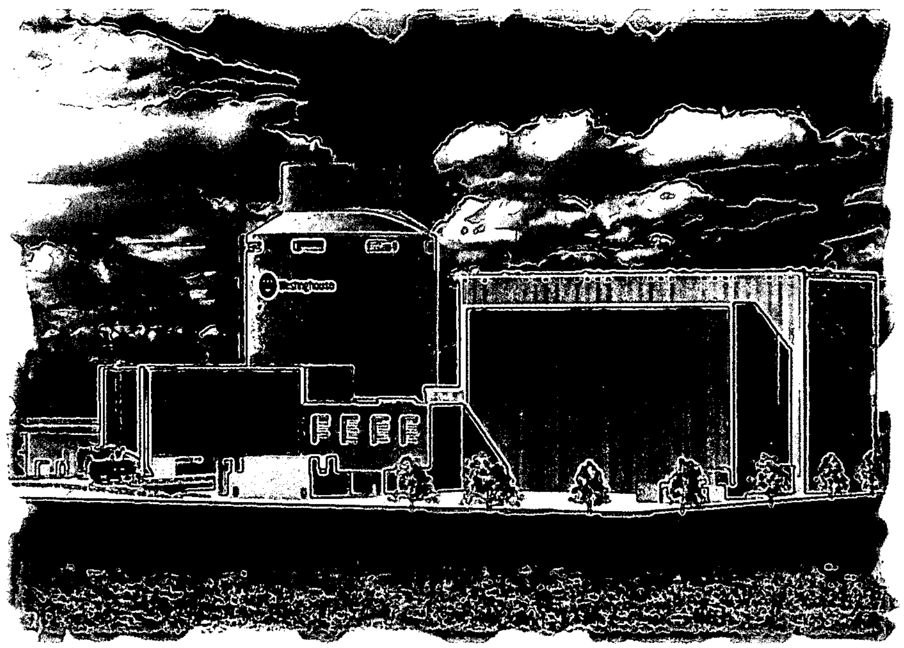
Reason for Testing

- Post-accident sump recirculation
  - Needed to assure long-term core cooling following a LOCA
  - Current a regulatory issue
    - Generic Safety Issue GSI-191
    - Generic Letter GL 2004-02
- AP1000 is also addressing these regulatory issues
  - Using Industry guidance and methods for analysis
  - Recirculation screen testing
    - Confirm performance of an AP1000 recirculation screen design under a spectrum of AP1000-specific debris loadings
      - Resident containment debris
      - Thermal insulation, as appropriate
      - Chemical effects
    - With representative recirculation screen flow rates

The AP1000 Design . . .

- Has some differences from current PWRs
- These differences are important to evaluating long-term core cooling
  - No fibrous thermal insulation
  - Limited (minimal) “problematic” insulation
  - Dense (non-transportable) coatings
  - Limited materials to react with post-accident sump water
- These design differences provide for post-accident recirculation flow under gravity flow conditions associated with the AP1000 design
- These features appropriately accounted for in the test program



Purpose of Test Program

- Use representative post-accident debris loadings to characterize postulated Design Basis Accident (DBA) debris conditions experienced by AP1000 recirculation screens
- Quantify head loss for
  - AP1000 Containment Recirculation Screens and
  - AP1000 In-containment Refueling Water Storage Tank Screens
- Validate the acceptability of a specific screen design for the AP1000

Scaling Considerations

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Scaling Considerations – Screen Area

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Scaling Considerations – Chemical Loading

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General Description of Test

- Hydraulic flume at the Fauske and Associates, Inc. laboratory used
- Debris loadings used

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- Test screen module

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- Flume flow rates

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Instrumentation

- Instrumentation provided for monitoring the following parameters:

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Description of Test Sequence

- Testing took note of industry experience
- Following sequence used:

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Diagram of Flume

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Diagram of Flume

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Diagram of Flume

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Debris Mix for Testing

- Min-K thermal insulation

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- Fibrous resident debris

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- Particulate resident debris

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- Post-accident chemical surrogates

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Debris Loads for AP-1000 Head-Loss Testing

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Test Matrix

- Several clean screen test performed [a,c]

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- Three head loss tests performed

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[a,c]

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AP1000 Head Loss Run Matrix

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Clean Screen Head Loss Test Velocities

a,c

Summary of Debris Added for Head Loss Tests

a,c

Design Basis Test Observations and Data

a,c

Operating Plant Screen Conditions With High Debris Loads Result In Much Higher Head Losses Than AP1000

a,c

Design Basis Test Observations and Data

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1st Sensitivity Test - Observations and Data

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2nd Sensitivity Test – Data and Observations

a,c

2nd Sensitivity Test – Data and Observations

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Test Summary

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Applicability of Test to AP1000-Specific Design

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Applicability of Test to AP1000-Specific Design

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Conclusions

- Measured head loss was comparable for all tests

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- The data from this test program demonstrated the ability of the Recirculation and the IRWST screens to successfully perform their design function under debris loading conditions in excess of that expected for the AP1000 following a postulated LOCA
- The test data and the conclusions above apply to both the Recirculation and IRWST screens
  - Test conditions bound flow and debris conditions for both Recirculation and IRWST screens in recirculation mode following a LOCA
  - The screen geometry for the test is a conservative representation of the design described in TR-147

AP1000 Downstream Effects Evaluation Following a Postulated LOCA

(Technical Report TR26)

April 16, 2008

Tim Andreychek
Systems & Equipment Engineering-I

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Report Contents

- Determines Types / Amounts of Post Accident Debris and Their Transport to Screens / Core
  - Mechanical and chemicals
  - Different break locations
- Assesses Head Loss Across Screens and Core
  - Confirmed in AP1000 screen testing
- Evaluates Downstream Effects
  - Erosion, abrasion, wear and plugging of lines
  - Deposition of chemicals on fuel

AP1000 Debris Sources

- AP1000 design minimizes debris sources

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- Two sources of potential debris applicable to AP1000
  - Resident containment - dirt, dust, lint and other miscellaneous materials inside containment
  - Post-accident chemical effects - chemical products (precipitants) produced due to sump fluid chemically reacting with materials inside containment and producing

AP1000 LTCC Debris Assessment

Known potential contributors to screen plugging considered

- Debris that could be produced by a LOCA
- Resident fibers and particles present in containment prior to the LOCA
- AP1000 features
  - Containment design
  - Equipment locations
  - Containment cleanliness program

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- Generation of chemical precipitants considering
  - Materials used inside AP1000 containment
  - Post-accident water chemistry
  - Applicable research and testing

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Resident Containment Debris Evaluation

- Purpose
  - Estimate amount of resident containment debris consistent with methods of NEI 02-01

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- Containment areas included were consistent
  - Applicable guidance of Regulatory Guide 1.82, Rev 3
  - Relevant aspects of COL Information Item 6.3-2
- Containment categorized into four general types of surfaces:
  - Horizontal surface areas
  - Walls
  - Equipment
  - Piping
- Fundamental assumption
  - The AP1000 owner maintains containment cleanliness consistently with the operating PWR plants sampled

Resident Containment Debris Evaluation

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- Using the described information, an estimate of the mass of each resident containment debris type was made for the AP1000

Effect of Break Locations

- Break locations identified using applicable guidance of NEI 04-07
  - NEI 04-07 break criteria focuses on large amounts and worst case debris compositions

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  - Therefore, break locations evaluated based on transport of maximum amount resident containment debris to recirculation screens and to core

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[ ]

Amount of Resident Containment Debris

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Best Estimate Resident Containment Debris

a,c

Upper Bound Resident Containment Debris

a,c

Summary of Fiber and Particle Containment Debris

a,c

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Post-Accident Chemical Debris

- Materials in containment may dissolve or corrode when exposed to coolant spilled due to a LOCA, resulting in
  - Oxide particulate corrosion products
  - Potential for the formation of precipitants due to changes in temperature and reactions with other dissolved materials
- These chemical products could become another source of debris loading and impact recirculating flow
- Data and methods of WCAP-16530-NP-A, "Evaluation of Post-Accident Chemical Effects in Containment Sump Fluids to Support GSI-191" used to evaluate type and quantity of chemical precipitants that may form in the AP1000 recirculation fluid post-LOCA

Post-Accident Chemical Effects

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Applicability of WCAP-16530-NP-A

- These data and methods are applicable to AP1000 for the following reasons

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- Therefore, the data and calculation methods described in WCAP-16530-NP-A are applicable to the AP1000 design.

Summary of Chemical Debris

- AP1000 has several features that significantly reduces materials available to form chemical precipitants

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[ ]

- For conservatism

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[ ]

- A sensitivity evaluation to assess precipitant from zinc materials

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[ ]

- Evaluation demonstrates AP1000 post-accident chemical debris load significantly lower that for current operating plants

Head Loss Calculations

- Pressure drop due to resident containment debris calculated for
  - Containment Recirculation Screens
  - IRWST Screens
  - Core entrance

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[ ]

- NUREG/CR-6224 correlation used

Applicability of NUREG/CR-6224

- Correlation is conservative for and applicable to AP1000
  - NUREG/CR-6224 head loss correlation developed for containment sump screens with contiguous fiber beds
    - Several types of fibrous materials used to construct the beds used to develop the correlation, including fiberglass
    - Vertical loop head loss data used to develop the correlation

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- Therefore, NUREG/CR-6224 head loss correlation is not only applicable, but its application to the AP1000 design is conservative

Description of Head Loss Calculations

- Two resident containment debris loading cases evaluated:

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- Results are summarized on next slide

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Summary of Head Loss Calculations

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Conclusions from Head Loss Calculations

- For the Containment Recirculation Screens and the IRWST Screens:

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- For the Core:

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- Therefore, resident debris in containment and the formation of post-accident chemical products in the AP1000 containment are evaluated to have **NO** adverse impact on the performance of the PXS

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Downstream Effects Evaluation

- "Downstream effects": effects of debris passing through through recirculation screens on systems, structures and components downstream of the recirculation screens
- These effects are evaluated for operating plants to support closure of Generic Safety Issue GSI-191 using data and methods and developed by the PWR Owners Group
- Two evaluations were performed for the AP1000
  - The first was for effects of debris on systems and components outside the core
  - The second was to evaluate the potential chemical deposition on fuel cladding surfaces due to boiling in the core following a LOCA

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[ ]

Ex-Vessel Downstream Effects Evaluation Method

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- Evaluation data and methods for ex-vessel downstream effects outlined in Revision 1 of WCAP-16406-P-A:
  - The fuel blockage evaluation as described in Section 5
  - Valve evaluations for plugging and erosive wear described in Sections 7 and 8 and Appendix F
    - Valve screening criteria are generically applicable to valves in the long-term core cooling recirculation flow path of PWRs in general

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- AP1000 design features eliminate need for downstream effects evaluations of some components identified in Revision 1 of WCAP-16406-P-A:
  - Pump evaluations, heat exchangers, and orifice evaluations
  - Settling of debris in instrumentation lines
  - Containment Spray System (CSS)
- Thus, data and methods identified in Revision 1 of WCAP-16406-P-A are applicable to the AP1000 design where applicable design features exist

Ex-Vessel Downstream Effects Evaluation Method

- Evaluation included each valve and associated piping in the recirculation path of the PXS
  - Evaluation method and acceptance criteria are described in WCAP-16406-P-A
  - Equipment in the post-LOCA flow path identified using current P&IDs for the AP1000 PXS
- Two tables presented on the following two slides list the components that are in the AP1000 long term core cooling flow path
  - The table immediately following this slide describes the containment recirculation flow path equipment
  - The table following it describes the IRWST injection flow path
- The results of the evaluation demonstrates that the AP1000 PXS equipment utilized for recirculation is acceptable for the expected debris loading in the recirculating fluid resulting from a postulated LOCA

Ex-Vessel Downstream Effects Evaluation Summary

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Ex-Vessel Downstream Effects Evaluation Summary

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In-Vessel (Core) Downstream Effects Evaluation Method (LOCADM)

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- The effect of chemical reactions within the coolant that could lead to deposition of material within the core was evaluated
  - The purpose of the evaluation was to demonstrate acceptable AP1000 long term core cooling performance
  - The evaluation accounted for the unique features of the AP1000 design
- The method developed and documented in WCAP-16793-NP were used to perform the evaluation
  - This evaluation method was developed to be generically applicable to all PWRs

In-Vessel (Core) Downstream Effects Evaluation Method (LOCADM)

- Several features unique to the AP1000 reduce the amount of materials that could contribute to formation of chemical precipitants

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Applicability of LOCADM to AP1000

- The data and methods of WCAP-16793-NP are applicable to the AP1000 for the following reasons:

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Core Deposition Acceptance Criteria

Two Acceptance Criteria are identified for this evaluation

- From Section A4 of WCAP-16793-NP, the acceptance criterion
  - Maximum cladding temperature maintained during periods when the core is covered will not exceed a core average clad temperature of 800°F (426.7 C)

  This acceptance basis is applied after the initial quench of the core and is consistent with the long-term core cooling requirements stated in 10 CFR 50.46 (b)(4) and 10 CFR 50.46 (b)(5)
- An additional acceptance criterion is to demonstrate that the total deposition on the limiting clad surface (oxide + crud + precipitate) is less than 50 mils (1270 μm)
  - Based on 50 mil (1270 μm) being the maximum acceptable deposition thickness on adjacent fuel rods before debris would bridge the gap between the adjacent fuel rods

LOCADM Evaluations Performed

- The purpose was to evaluate the impact of post-accident chemical products in the recirculating coolant following a LOCA on
  - Fuel cladding deposition and
  - Clad/oxide interface temperatures
- Three evaluations were performed

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- AP1000 plant specific inputs used to perform the evaluation

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[ ]

Summary of LOCADM Evaluations Performed

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Summary of Evaluations Performed

AP1000 LOCADM calculations demonstrate

- Both acceptance criteria for long-term core cooling achieved

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- Thus, conservative calculation of post-LOCA chemical product deposition on fuel clad surface does not challenge long-term core cooling for the AP1000 design

Overall Summary

For the AP1000 PXS recirculation flow path

- Resident containment debris is the major post-accident debris source term for recirculation
  - A containment cleanliness program similar to ones in affect today will limit this source

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- Head loss calculations demonstrate
  - Small collection of fiber on screens and bottom of core
  - Minimal pressure drop across screens or core

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- Ex-vessel downstream effects evaluation demonstrate all components in PXS system pass
- In-vessel downstream effects evaluation demonstrate no challenge to long-term core cooling

Conclusions

- The PXS and its “pocket” type recirculation screens have been evaluated and tested
- Evaluations demonstrate the PXS system will function as designed under the available post-accident debris loads associated with the AP1000
  - Ex-vessel downstream effects evaluations completed and all affected components “pass” with margin
  - In-vessel downstream effects evaluations completed and acceptance criteria met with margin
  - Calculated head loss across recirculation screens is minimal

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- Based on this information, the AP1000 evaluation of LTC should be acceptable

Long-Term Cooling Analysis Sensitivities

April 16, 2008

Jill Monahan
AP1000 Safety Analysis Interface

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- Sensitivity results presented here are based on calculations that have been technically verified.
- Documentation is in Westinghouse final management review process.
- Final report will be issued to the NRC by April 30, 2008.

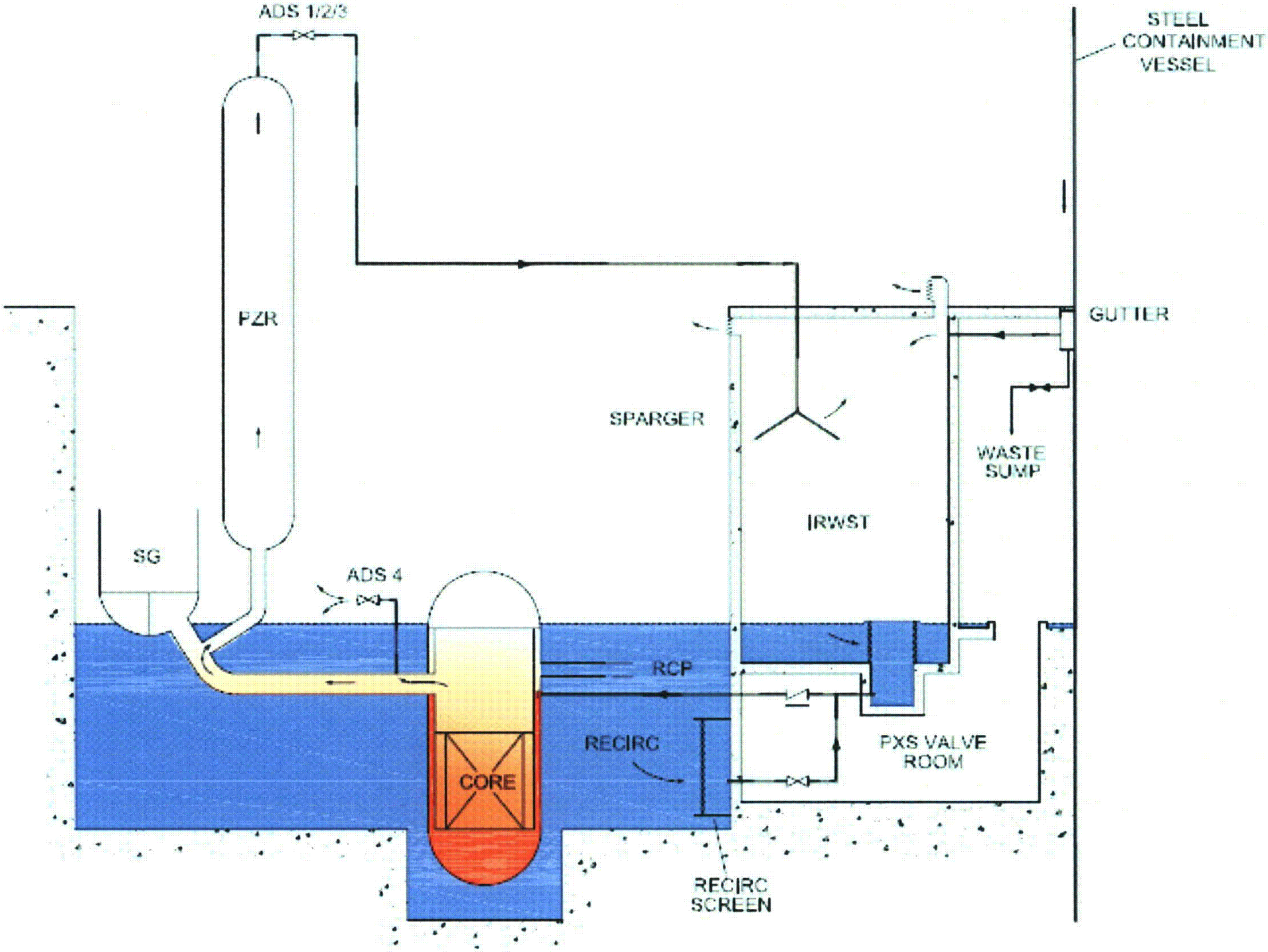
Long-Term Cooling DCD Analysis

- Presented in DCD Section 15.6.5.4C Long-Term Cooling
- Criteria / Purpose
  - The AP1000 safety-related systems are designed to provide adequate cooling of the reactor indefinitely
  - Demonstrate that the passive systems provide adequate emergency core cooling during the IRWST injection / containment recirculation time frame
  - Provide sufficient flow to the reactor vessel to cool the core and to preclude boron precipitation
- Performed Using WCOBRA/TRAC computer code

Long-Term Cooling DCD Analysis

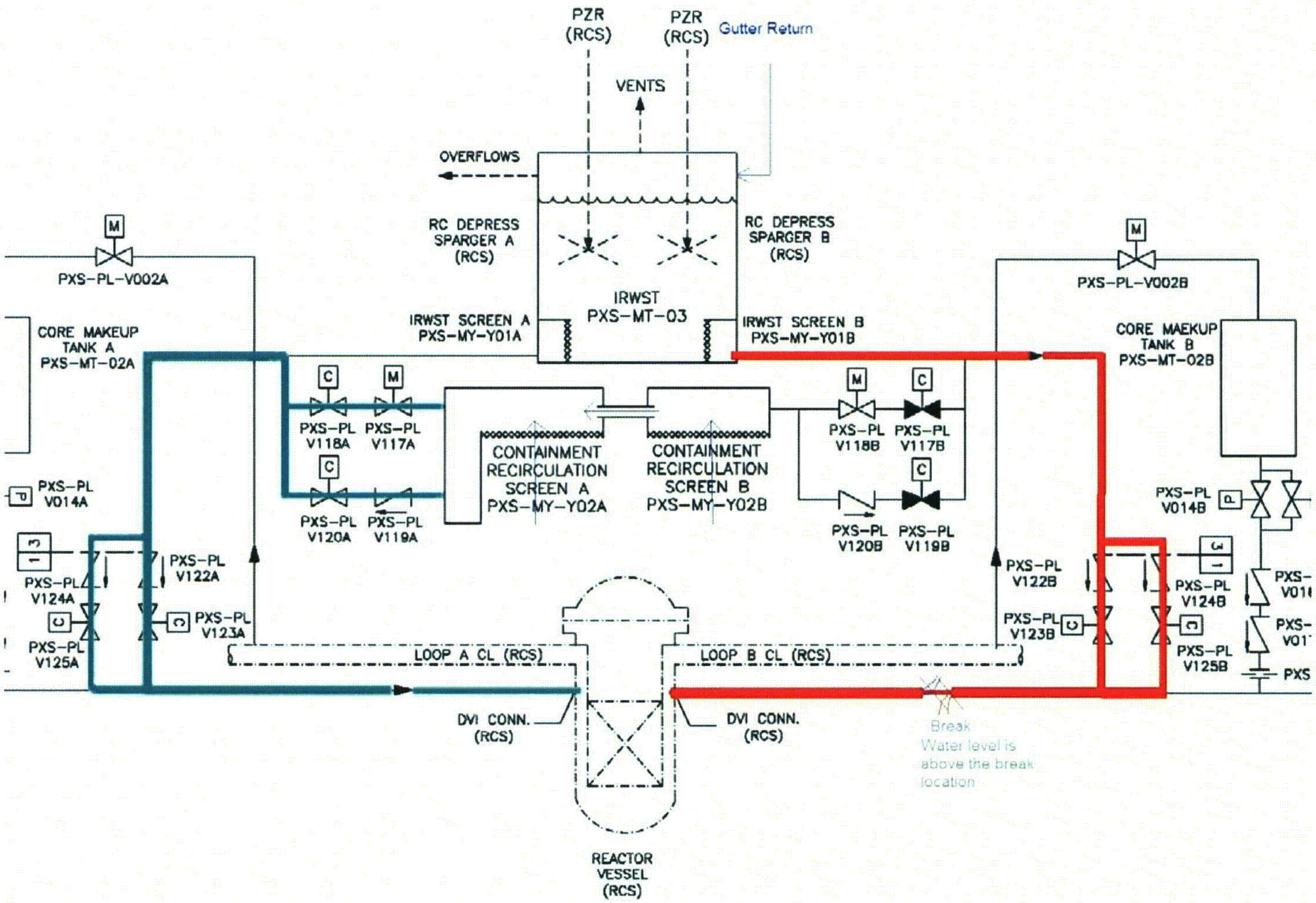
- Double Ended Direct Vessel Injection (DEDVI) Break
  - Most limiting break for long-term cooling
    - One PXS room floods which reduces containment flood level / available liquid driving head for recirculation flow
    - IRWST spills to containment resulting in earliest switchover to recirculation and highest decay heat for to recirculation operation
- Water Sources for Recirculation During DEDVI Break
  - Containment recirculation through CR screens
  - IRWST through IRWST screens
    - Replenished by PCS condensate return via IRWST gutter
  - Containment water flows into LOCA break when level exceeds break elevation

LOCA Long Term Cooling



AP1000

Passive Core Cooling



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Long-Term Cooling DCD Analysis

- Initial conditions based on the end of the SBLOCA transient
- Duration from ~3000 seconds to 10000 seconds
  - Time where IRWST injection is fully established to when Quasi-steady-state recirculation condition has been established
  - Recirculation is initiated at 6500 sec
- Limiting failure is one ADS Stage 4 valve
- Demonstrates no core uncovery and no cladding temperature excursions
- Water carry over through ADS stage 4 valves precludes significant buildup in the core boron concentration

Sensitivities to Debris Loading

- Three areas where debris accumulation might affect system / plant operation
  - Core
  - Containment recirculation screens
  - IRWST screens
- Sensitivities started at 6500 seconds which is time to switchover to containment recirculation (Window mode as described in WCAP-14776, "WCOBRA/TRAC OSU Long-Term cooling Final Validation Report"

Sensitivities to Debris Loading

- Two sensitivity cases performed
  - Case 1 considers a highly conservative increase in pressure drops due to debris blockage
  - Case 2 doubles the pressure drops applied in Case 1
  - Both cases assume a DVI break location in a PXS room
    - As in the DCD, this results in lowest final containment flood level
    - Would result in less debris available for transport into the RCS than calculated in TR-26 for a DVI break in a loop compartment
      - However we have conservatively / non-mechanistically used the TR-26 amount of debris
  - Both cases far exceed any blockage indicated by the testing of the AP1000 screen design
    - WCAP-16914-P indicates no noticeable head loss from the testing

Sensitivities to Debris Loading

- Case 1 Sensitivity
  - Flow resistance of the lower support plate at the core inlet is increased to model a pressure drop of 3 feet at the DCD flow rate of 152 lbm/sec
  - Containment recirculation screen pressure drop is increased by 7 inches at the DCD flow rate of 77.2 lb/sec
    - Objective was to have DP of > 6 inches head loss in sensitivity case
    - Sensitivity case resulted in a DP of 6.8 inches at 73.6 lbm/sec flow
  - IRWST screen pressure drop is increased by 7 inches at the DCD flow rate of 75 lb/sec
    - Objective was to have DP of > 6 inches head loss in sensitivity case
    - Sensitivity case resulted in a DP of 6.8 inches at 72 lbm/sec flow

Sensitivities to Debris Loading

- Case 2 Sensitivity
  - Flow resistance of the lower support plate at the core inlet is increased to model a pressure drop of 6 feet at the DCD flow rate of 152 lbm/sec
  - Containment recirculation screen pressure drop is increased by 14 inches at the DCD flow rate of 77.2 lb/sec
    - Objective was to have DP of > 12 inches head loss in sensitivity case
    - Sensitivity case resulted in a DP of 13.2 inches at 73.6 lbm/sec flow
  - IRWST screen pressure drop is increased by
    - Objective was to have DP of > 12 inches head loss in sensitivity case
    - Sensitivity case resulted in a DP of 13.2 inches at 67.5 lbm/sec flow

Sensitivity Results

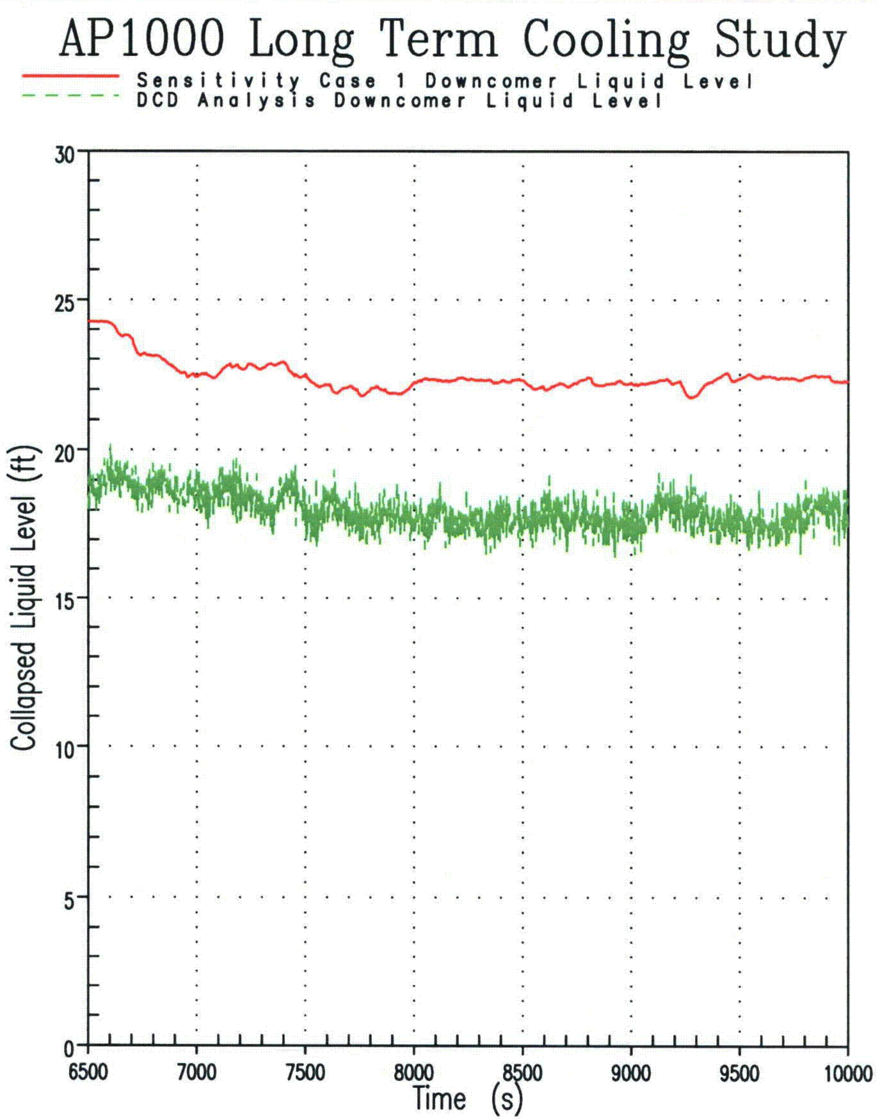
- Containment liquid continues to provide hydraulic head sufficient to drive water into the downcomer through the DVI nozzles
- DVI flow and ADS venting paths provide a liquid flow through the core that enables the core to remain cool and liquid carryover is adequate to preclude concentration of boric acid
- Downcomer level increases with increase core inlet pressure drops
- Cladding temperatures do not appreciably rise above the saturation temperature

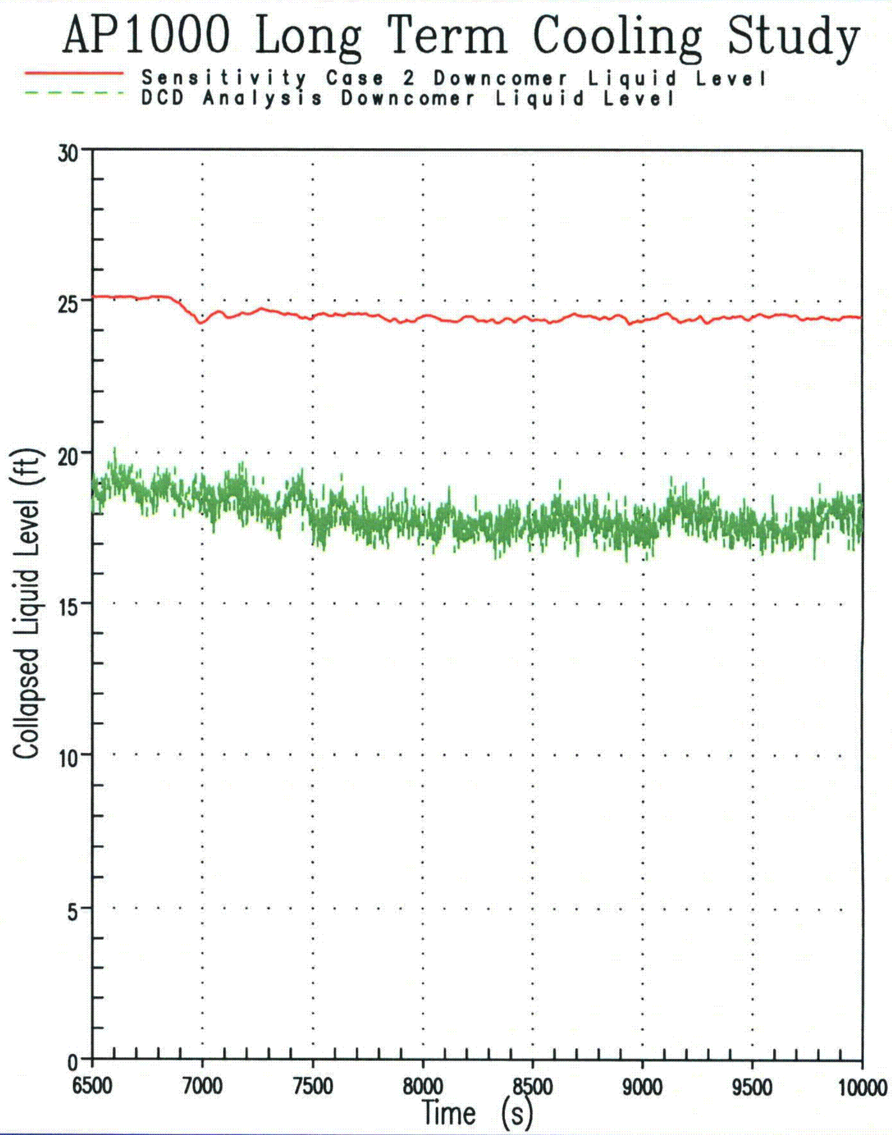
AP1000

Sensitivity Results

- Comparison of DVI line flow rates
  - Intact DVI line
    - 77.2 lbm/sec in the DCD analysis
    - 73.6 lbm/sec in Sensitivity Case 1
    - 69.0 lbm/sec in Sensitivity Case 2
  - Broken DVI line
    - 75.0 lbm/sec in the DCD analysis
    - 72.0 lbm/sec in Sensitivity Case 1
    - 67.5 lbm/sec in Sensitivity Case 2
- The small reduction in recirculation flow rates does not adversely affect core cooling

Sensitivity Results
Collapsed Liquid Level in Downcomer





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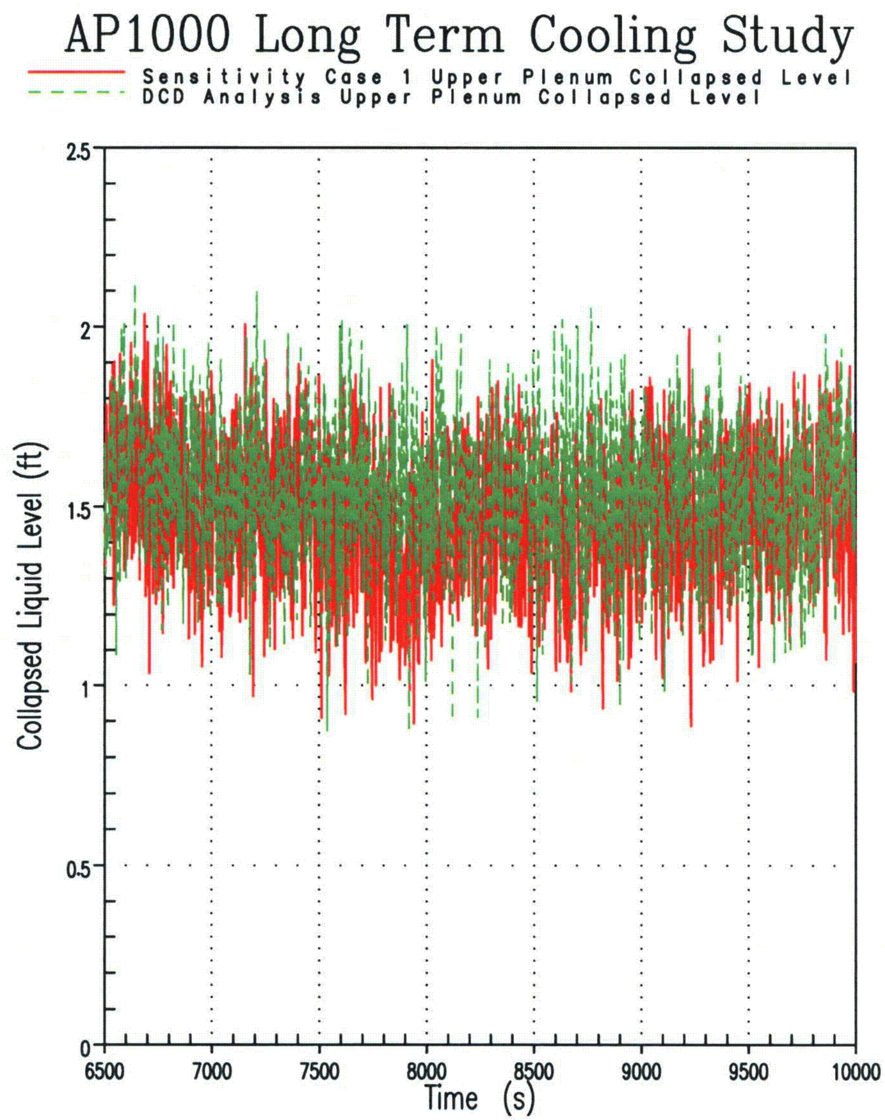
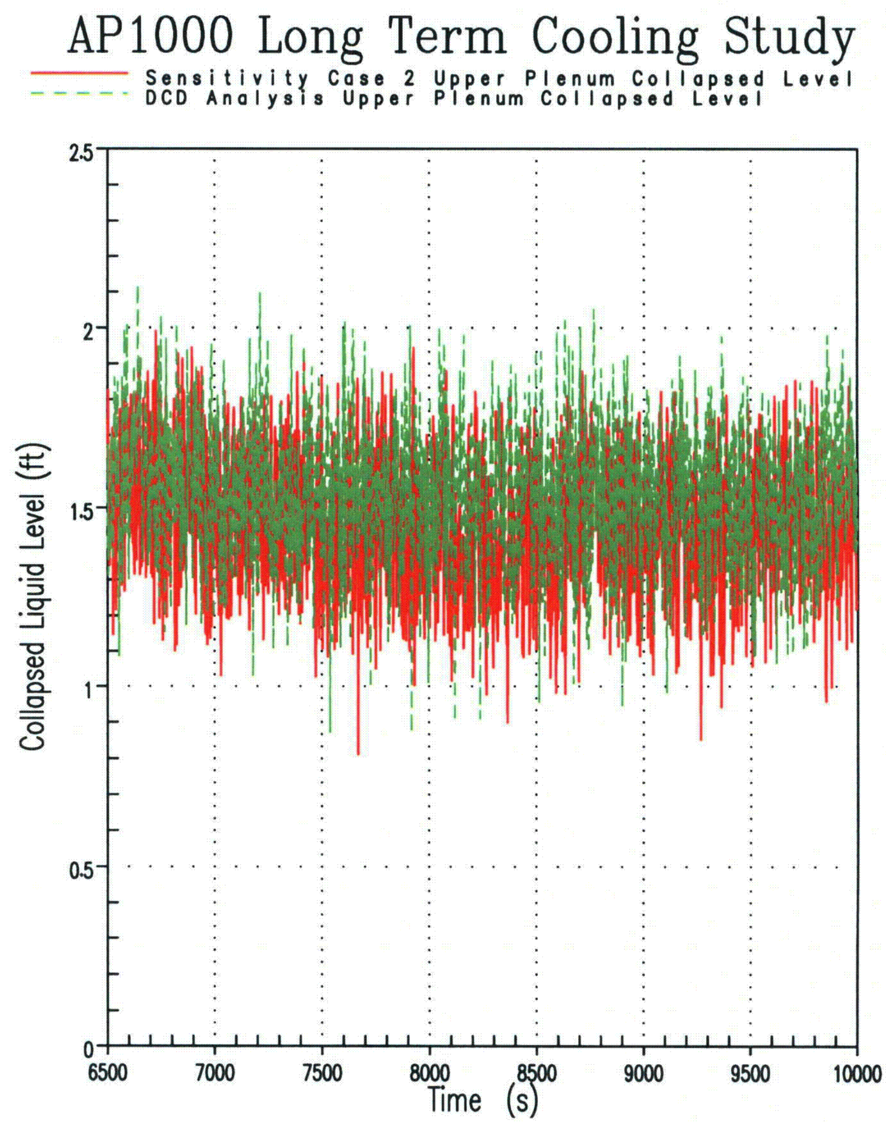
Sensitivity Results
Collapsed Liquid Level in Upper Plenum





LTC Sensitivity Summary

- AP1000 screen testing and analysis shows that there will be no measurable increase in head loss caused by debris
  - DCD LTC analysis unaffected
- LTC sensitivity studies show no loss in core cooling margin even with large arbitrary / non-mechanistic increases in core / screen head losses
  - Testing shows screen DPs about 1/8" water clean and with design basis debris load
    - Testing also shows screen DPs unchanged by doubling resident debris
  - Increasing DPs for core (to 3' & 6') and screens (to 6" & 12") result in small decreases in recirc flows (~4% & ~11%) but no loss in core cooling margin

AP1000 Screen ITAACs

April 16, 2008

Terry L. Schulz, Consulting Engineer
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AP1000 Screen ITAACs

- Proposed Revisions to AP1000 ITAACs Related to Screens
  - CR and IRWST screen areas (revised)
    - Added pocket face & total areas
    - Added total face and revised screen areas
  - Curb heights in front of screens (revised)
    - Added curb height for IRWST screen
  - Protective plate (minor change)
  - Use of SS under protective plate (unchanged)
  - Use of SS enclosures on excore instrumentation (new)
  - Use of MRI insulation (unchanged)
  - Use of high density coatings (unchanged)

ITAAC - Screen and Curb (Revised)

Table 2.2.3-4 (cont.) Inspections, Tests, Analyses, and Acceptance Criteria		
	viii) Inspections of the IRWST and containment recirculation screens will be conducted. The inspections will include measurements of the pockets and the number of pockets used in each screen. The pocket frontal face area is based on a width times a height. The width is the distance between pocket centerlines for pockets located beside each other. The height is the distance between pocket centerlines for pockets located above each other. The pocket screen area is the total area of perforated plate inside each pocket; this area will be determined by inspection of the screen manufacturing drawings.	viii) The screens utilize pockets with a frontal face area of $\geq$ 6.2 in^2 and a screen surface area $\geq$ 140 in^2 per pocket. Each IRWST screen has a sufficient number of pockets to provide a frontal face area $\geq$ 20 ft^2 and a screen surface area $\geq$ 500 ft^2. Each containment recirculation screen has a sufficient number of pockets to provide a frontal face area $\geq$ 105 ft^2 and a screen surface area $\geq$ 2500 ft^2. A debris curb exists in front of the containment recirculation screens which is $\geq$ 2 ft above the loop compartment floor. The bottom of the IRWST screens are located $\geq$ 6 in above the bottom of the IRWST.

ITAAC – Protective Plate (Minor Revision)

Table 2.2.3-4 (cont.)
Inspections, Tests, Analyses, and Acceptance Criteria

Design Commitment	Inspections, Tests, Analyses	Acceptance Criteria
	vii) Inspection of the as-built components will be conducted for plates located above the containment recirculation screens.	vii) Plates located above each containment recirculation screen are no more than 1 ft above the top of the screen and extend out at least 10 ft perpendicular to and at least 7 ft to the side of the screen surface.

ITAAC – Surfaces Under Protective Plate (Minor Rev)
ITAAC – Excore Dector Enclosure (New)

Table 2.2.3-4 (cont.) Inspections, Tests, Analyses, and Acceptance Criteria		
	xiii) Inspections will be conducted of the surfaces in the vicinity of the containment recirculation screens. The surfaces in the vicinity of the containment recirculation screens are the surfaces located above the bottom of the recirculation screens up to and including the bottom surface of the plate discussed in Table 2.2.3-4, item 8.c.vii, out at least 10 feet perpendicular to and at least 7 feet perpendicular to the side of the screen face.	xiii) These surfaces are stainless steel.
	xiv) Inspections will be conducted of the surfaces of the source range, intermediate range, and power range detectors.	xiv) These surfaces are stainless steel.

ITAAC – Use of MRI Insulation (Unchanged)
ITAAC – Use of High Density Coatings (Unchanged

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Table 2.2.3-4 (cont.)
Inspections, Tests, Analyses, and Acceptance Criteria

Design Commitment	Inspections, Tests, Analyses	Acceptance Criteria
	ix) Inspections will be conducted of the insulation used inside the containment on ASME Class 1 lines and on the reactor vessel, reactor coolant pumps, pressurizer and steam generators.	ix) The type of insulation used on these lines and equipment is a metal reflective type or a suitable equivalent.
	x) Inspections will be conducted of the as-built nonsafety-related coatings or of plant records of the nonsafety-related coatings used inside containment on walls, floors, ceilings, structural steel which is part of the building structure and on the polar crane.	x) A report exists and concludes that the coatings used on these surfaces has a dry film density of $\geq$ 100 lb/ft^3.

AP1000 Screen RG 1.82 Assessment

April 16, 2008

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AP1000 RG 1.82 Assessment

- Provided to Assist Review of AP1000 Screen Information
  - RG 1.82 put into table
  - Each item addressed by providing
    - Summary response for AP1000, considering AP1000 differences
    - AP1000 reference for additional information
  - References include
    - DCD sections
    - APP-GW-GLN-147, Revision 1, Technical Report 147, "AP1000 CR and IRWST Screen Design", submitted March 3, 2008
    - WCAP-16914-P, Revision 0, "Evaluation of Debris Loading Head Loss Tests for AP1000 Recirculation Screens and In-containment Refueling Water Storage Tank Screens," submitted March 3, 2008
    - APP-GW-GLR-079, Revision 3, Technical Report 26, "AP1000 Verification of Water Sources for Long-Term Recirculation Cooling Following a LOCA," submitted March 28, 2008
    - APP-GW-GLE-002, Revision 0, "Impacts to AP1000 DCD to Comply with NRC Generic Letter 2004-02", submitted March 28, 2008

AP1000 RG 1.82 Assessment

AP1000 RG 1.82 Assessment Matrix		
Section Number	**Stated Regulatory Position**	**Comparison to the AP1000 Design**
C-1	**PRESSURIZED WATER REACTORS**	The AP1000 is a Pressurized Water Reactor (PWR). Therefore, this section is the appropriate section to perform a comparison between Regulatory Positions stated in the Regulatory Guide, the applicability of those positions to the AP1000 and how the AP1000 design addresses those regulatory positions.
C-1.1	**Features Needed To Minimize the Potential for Loss of NPSH** The ECC sumps, which are the source of water for such functions as ECC and containment heat removal following a LOCA, should contain an appropriate combination of the following features and capabilities to ensure the availability of the ECC sumps for long-term cooling. The adequacy of the combinations of the features and capabilities should be evaluated using the criteria and assumptions in Regulatory Position 1.3.	The AP1000 does not use pumps to provide core or containment cooling during a LOCA. As a result this section does not apply to the AP1000.
C-1.1.1	**ECC Sumps, Debris Interceptors, and Debris Screens**	
C-1.1.1.1	A minimum of two sumps should be provided, each with sufficient capacity to service one of the redundant trains of the ECCS and CSS. Distribution of water sources and containment spray between the sumps should be considered in the calculation of boron concentration in the sumps for evaluating post-LOCA subcriticality and shutdown margins. Typically, these calculations are performed assuming minimum boron concentration and minimum dilution sources. Similar considerations should also be given in the calculation of time for Hot Leg Switchover, which is calculated assuming maximum boron concentration and a minimum of dilution sources.	1. The AP1000 provides for two separate containment recirculation (CR) screens. Each screen is associated with one Passive Core Cooling System (PXS) subsystem. In order to increase margins the two screens have an interconnection between them so that in case one PXS subsystem does not draw recirculation water both screens are available to support the one functioning PXS subsystem. The screen testing performed for the AP1000 (Reference 2) demonstrates that the screens have significant margin. 2. The AP1000 does not have a containment spray system that would be used during a design basis LOCA. Therefore issues associated with containment spray are not applicable to the AP1000 design. The AP1000 does have a non-safety containment spray feature. This feature is only permitted to be used during a severe accident. 3. Boric acid dilution evaluation for the AP1000 has previously demonstrated acceptable boric acid concentrations in both the recirculating pool volume and the reactor vessel post-accident. Refer to DCD section 15.6.5.4C.4. Note that because of the effectiveness of ADS stage 4 in carrying over water from the RCS, the AP1000 does not have Hot Leg Switchover.

AP1000 RG 1.82 Assessment

AP1000 RG 1.82 Assessment Matrix		
Section Number	**Stated Regulatory Position**	**Comparison to the AP1000 Design**
C-1.1.1.2	To the extent practical, the redundant sumps should be physically separated by structural barriers from each other and from high-energy piping systems to preclude damage from LOCA, and, if within the design basis, main steam or main feedwater break consequences to the components of both sumps (e.g., trash racks, sump screens, and sump outlets) by whipping pipes or high-velocity jets of water or steam.	The AP1000 CR screens are separate screens that are located next to each other in one of the AP1000 loop compartments. This location is dictated by the location of the PXS sub-compartments and the large size of the screens The location of these screens has been evaluated to demonstrate that they are not impacted by whipping pipes or high-velocity jets of water or steam. DCD subsection 3.6.4.1 states that an evaluation was performed (APP-GW-GLR-074) to determine the method of protection to be used for safety-related targets located in the vicinity of postulated high-energy pipe breaks. DCD Table 3.6-3 shows that the PXS CR screens in Room 11202 are protected by pipe whip restraints from the effects of three postulated pipe breaks in Rooms 11302 and 11602. Note that all of these breaks are secondary side breaks and the CR screens are not expected to be used during non-LOCA accidents; however for plant design margin it is assumed that the CR screens do have to be protected from such breaks. Due to a recent design change, the heat exchanger (HX) that is used to remove heat from the reactor coolant pump (RCP) was changed from an internal HX to an external HX. As a result, there are now two 3" pipes that connect each RCP motor to its HX. There are 4 potential break locations associated with these lines (per RCP). For three of these break locations, the orientation of the connection and routing of the pipe prevents pipe whip and jet impingement on the CR screens. For the other break location, it is expected that pipe whip restraints or jet shields will not be required because of the design of the piping and the RCP internals. The RCP has a labyrinth restriction located along the RCP shaft next to the pump casing and the volume of cold water contained in the RCP is small. Following a break of a cooling water line, the labyrinth immediately reduces the pressure in the RCP motor (to less than about 1100 psia) and the break flow (to about 13% of what it would be without the labyrinth). The limited volume of cold water results in a very short duration of cold water jetting; once a two phase mixture starts to flow out the pipe break, the distance to the screens prevents jet impingement damage. Since these RCP lines are not expected to require pipe whip restraints or jet shields they do not need to be added to DCD Table 3.6-3.

AP1000 RG 1.82 Assessment

AP1000 RG 1.82 Assessment Matrix		
Section Number	**Stated Regulatory Position**	**Comparison to the AP1000 Design**
C-1.1.1.3	The sumps should be located on the lowest floor elevation in the containment exclusive of the reactor vessel cavity to maximize the pool depth relative to the sump screens. The sump outlets should be protected by appropriately oriented (e.g., at least two vertical or nearly vertical) debris interceptors: (1) a fine inner debris screen and (2) a coarse outer trash rack to prevent large debris from reaching the debris screen. A curb should be provided upstream of the trash racks to prevent high-density debris from being swept along the floor into the sump. To be effective, the height of the curb should be appropriate for the pool flow velocities, as the debris can jump over a curb if the velocities are sufficiently high. Experiments documented in NUREG/CR-6772 and NUREG/CR-6773 have demonstrated that substantial quantities of settled debris could transport across the sump pool floor to the sump screen by sliding or tumbling.	1. The AP1000 CR screens are located near the floor of the loop compartment. Note that the containment floodup level is significantly higher in AP1000 than in operating plants. This allows for the use of a high curb (24 inch) and still have the water level rise ~10 feet above the top of the screen during post LOCA recirculation operation. This screen curb is very effective in the AP1000 due to the very limited amount of debris and low flows / velocities allowed by the plant design. DCD section 6.3.2.2.7.3 describes these elevations. Reference 1 provides detailed descriptions and drawings of these screens. 2. The In-containment Refueling Water Storage Tank Screens are located at the floor of the tank. A 6 inch curb is provided in front of the screens. The IRWST is a closed tank that contains very limited sources of debris. DCD section 6.3.2.2.7.2 describes these elevations. Reference 1 provides detailed descriptions and drawings of these screens. Reference 3 provides an evaluation of the debris that could be transported to the IRWST Screens. 3. The screens are constructed of perforated stainless steel plate that is used to formed pockets. The structural integrity of this configuration is well in excess of screen-like material that was typically used in PWR sump screens prior to actions taken to close Generic Safety Issue GSI-191 and respond to Generic Letter GL 2004-02. As is the case with current operating plants, the structural integrity of the AP1000 screens precludes the need for trash racks. Reference 1 provides additional discussion of the design of the AP1000 screens.
C-1.1.1.4	The floor in the vicinity of the ECC sump should slope gradually downward away from the sump to further retard floor debris transport and reduce the fraction of debris that might reach the sump screen.	The AP1000 loop compartment is 29 feet from the wall near the reactor vessel to the wall behind the SG. The floor extends 12 foot from the RV wall and then drops 3 foot. The floor under the SG is at this lower elevation to facilitate reactor coolant pump removal. Although the floor in the vicinity of the CR screens is not sloped, the initial spill of water will result in water and any debris flowing away from the screens and into the lower portion of the loop compartment. Also note that the protective plate located above the screens extends out to where the floor drops to the lower level. This plate prevents debris from falling into the recirculation water close to the screens. Reference 1 provides additional information about CR screens and the floor elevations around them.

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Section Number	**Stated Regulatory Position**	**Comparison to the AP1000 Design**
C-1.1.1.5	All drains from the upper regions of the containment should terminate in such a manner that direct streams of water, which may contain entrained debris, will not directly impinge on the debris interceptors or discharge in close proximity to the sump. The drains and other narrow pathways that connect compartments with potential break locations to the ECC sump should be designed to ensure that they would not become blocked by the debris; this is to ensure that water needed for an adequate NPSH margin could not be held up or diverted from the sump.	The AP1000 does not have a containment spray system that would operate during a design basis LOCA and as a result does not have a large amount of water that needs to be drained from the operating deck down to the CR screens. Most of the water that flows to the CR screens will come out of the ADS stage 4 valves. These ADS Stage 4 valves discharge into both loop compartments. As a result, the only passage with significant flow is the corridor that connects the two loop compartments. This corridor is level and more than 8 feet wide. The AP1000 does have three rooms located below the normal post-LOCA containment flood level that do not normally flood. These rooms include the two PXS subsystem rooms and the CVS purification room. These rooms are discussed in the DCD flood hazards analysis (DCD section 3.4.1.2.2.2). These rooms are designed so that they do not normally flood during a LOCA. The rooms drain to the containment sump through redundant series check valves. One of the PXS rooms can initially flood if there is a LOCA of a direct vessel injection (DVI) line in one of these rooms. Such an event is considered in the long term cooling analysis performed in DCD Chapter 15 (DCD 15.6.5.4C). In addition, it is conservatively assumed that leakage will eventually cause all of these rooms to flood. This "wall-to-wall" case is also considered in Chapter 15 (DCD 15.6.5.4C.3).
C-1.1.1.6	The strength of the trash racks should be adequate to protect the debris screens from missiles and other large debris. Trash racks and sump screens should be capable of withstanding the loads imposed by expanding jets, missiles, the accumulation of debris, and pressure differentials caused by post-LOCA blockage under design-basis flow conditions. When evaluating impact from potential expanding jets and missiles, credit for any protection to trash racks and sump screens offered by surrounding structures or credit for remoteness of trash racks and sump screens from potential high energy sources should be justified.	The response to item C-1.1.1.2 discusses the design of the screen relative to whipping pipes and jet impingement. The AP1000 design precludes the generation of missiles inside containment as discussed in DCD section 3.5.1.2. The screen testing demonstrated that they will not see an significant head loss while operating with design basis flow / debris conditions (Reference 2). In addition, the screens will be designed to withstand a significant head loss.
C-1.1.1.7	Where consistent with overall sump design and functionality, the top of the debris interceptor structures should be a solid cover plate that is designed to be fully submerged after a LOCA and completion of the ECC injection. The cover plate is intended to provide additional protection to debris interceptor structures from LOCA-generated loads. However, the design should also provide means for venting of any air trapped underneath the cover.	The top of the cassettes for the AP1000 CR screens is a solid plate that is vented. In addition, the AP1000 employs another plate that extends out 10 feet in front of the CR screens as well as 7 foot to the side. This plate prevents debris from falling into the water just in front of the screens. This plate is discussed in the DCD in subsection 6.3.2.2.7.3 and shown in detail in Reference 1.

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Section Number	**Stated Regulatory Position**	**Comparison to the AP1000 Design**
C-1.1.1.8	The debris interceptors should be designed to withstand the inertial and hydrodynamic effects that are due to vibratory motion of a safe shutdown earthquake (SSE) following a LOCA without loss of structural integrity.	The AP1000 screens are designed to mitigate the inertial and hydrodynamic effects that are due to vibratory motion of a safe shutdown earthquake (SSE) following a LOCA without loss of structural integrity.
C-1.1.1.9	Materials for debris interceptors and sump screens should be selected to avoid degradation during periods of both inactivity and operation and should have a low sensitivity to such adverse effects as stress-assisted corrosion that may be induced by chemically reactive spray during LOCA conditions.	The CR screens for the AP1000 are constructed of stainless steel. This material's ability to withstand degradation during both periods of inactivity and activity is well known. The AP100 has no spray system that will be used during design basis LOCAs to challenge the CR screens.
C-1.1.1.10	The debris interceptor structures should include access openings to facilitate inspection of these structures, any vortex suppressors, and the sump outlets.	The design of the AP1000 screens is presented in Reference 1. This reference includes drawings that show access panels to allow such inspections. Also note that the pockets can be removed in groups if needed to provide additional access.
C-1.1.1.11	A sump screen design (i.e., size and shape) should be chosen that will avoid the loss of NPSH from debris blockage during the period that the ECCS is required to operate in order to maintain long-term cooling or maximize the time before loss of NPSH caused by debris blockage when used with an active mitigation system (see Regulatory Position 1.1.4).	The AP1000 CR screens were designed very conservatively relative to the amount of debris expected in the AP1000. As shown in Reference 3, the calculated head loss is insignificant. This agrees with the AP1000 screen test results (Reference 2). The AP1000 does not use ECCS pumps.
C-1.1.1.12	The possibility of debris-clogging flow restrictions downstream of the sump screen should be assessed to ensure adequate long term recirculation cooling, containment cooling, and containment pressure control capabilities. The size of the openings in the sump debris screen should be determined considering the flow restrictions of systems served by the ECCS sump. The potential for long thin slivers passing axially through the sump screen and then reorienting and clogging at any flow restriction downstream should be considered. Consideration should be given to the buildup of debris at downstream locations such as the following: containment spray nozzle openings, HPSI throttle valves, coolant channel openings in the core fuel assemblies, fuel assembly inlet debris screens, ECCS pump seals, bearings, and impeller running clearances. If it is determined that a sump screen with openings small enough to filter out particles of debris that are fine enough to cause damage to ECCS pump seals or bearings would be impractical, it is expected that modifications would be made to ECCS pumps or ECCS pumps would be procured that can operate long term under the probable conditions.	The AP1000 PXS post LOCA recirculation lines do not use pumps, heat exchangers, throttle valves, spray nozzles or orifices (DCD Section 6.3). As a result, the AP1000 has eliminated many of the potential problems associated with debris passing through the ECCS. As discussed in Reference 3, a downstream effects evaluation was performed for the AP1000 PXS. The results of the evaluation demonstrated that debris-clogging, wear and abrasion have negligible impact on the post-accident operation of the PXS.
C-1.1.1.13	ECC and containment spray pump suction inlets should be designed to prevent degradation of pump performance through air ingestion and other adverse hydraulic effects (e.g., circulatory flow patterns, high intake head losses).	The AP1000 design does not have core or containment cooling pumps. Therefore, this regulatory position does not apply to the AP1000 design. Note that the post LOCA containment flood up water level is about 10 feet above the top of the CR screens.

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Section Number	Stated Regulatory Position	Comparison to the AP1000 Design
C-1.1.1.14	All drains from the upper regions of the containment building, as well as floor drains, should terminate in such a manner that direct streams of water, which may contain entrained debris, will not discharge downstream of the sump screen, thereby bypassing the sump screen.	This issue is addressed in the response to item C-1.1.1.5.
C-1.1.1.15	Advanced strainer designs (e.g., stacked disc strainers) have demonstrated capabilities that are not provided by simple flat plate or cone-shaped strainers or screens. For example, these capabilities include built-in debris traps where debris can collect on surfaces while keeping a portion of the screen relatively free of debris. The convoluted structure of such strainer designs increases the total screen area, and these structures tend to prevent the condition referred to as the thin bed effect. It may be desirable to include these capabilities in any new sump strainer/screen designs. The performance characteristics and effectiveness of such designs should be supported by appropriate test data for any particular intended application.	The AP1000 design uses an advanced strainer design, such as that described in this regulatory position, for its CR screens. Therefore, the AP1000 design complies with this regulatory position. The details of the AP1000 screen design are provided in Reference 1.
C-1.1.2	**Minimizing Debris** The debris (see Regulatory Position 1.3.2) that could accumulate on the sump screen should be minimized.	The AP1000 design greatly reduces the amount of debris generated and transported to the CR screens. The use of insulation that can be damaged by LOCA forces and generate fibrous debris is precluded (DCD subsection 6.3.2.2.7.1 item 3). The CR screens employ protective plates that prevent debris from falling into the water close to the screens (DCD subsection 6.3.2.2.7.3). A cleanliness program is required as discussed in C-1.1.2.1
C-1.1.2.1	Cleanliness programs should be established to clean the containment on a regular basis, and plant procedures should be established for control and removal of foreign materials from the containment.	The AP1000 COL holder is required to define a cleanliness program to limit the debris that might be left in the containment following refueling and maintenance outages (DCD subsection 6.3.8.1). Note that the resident debris analysis presented in Reference 3 uses data from operating plants that have typical cleanliness programs.
C-1.1.2.2	Insulation types (e.g., fibrous and calcium silicate) that can be sources of debris that is known to more readily transport to the sump screen and cause higher head losses may be replaced with insulations (e.g., reflective metallic insulation) that transports less readily and causes less severe head losses once deposited onto the sump screen. If insulation is replaced or otherwise removed during maintenance, abatement procedures should be established to avoid generating latent debris in the containment.	The AP1000 design specifies the use of metal reflective insulation in the containment that are subject to damage by LOCA jet impingement forces (DCD subsection 6.3.2.2.7.1 item 3).

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Section Number	**Stated Regulatory Position**	**Comparison to the AP1000 Design**
C-1.1.2.3	To minimize potential debris caused by chemical reaction of the pool water with metals in the containment, exposure of bare metal surfaces (e.g., scaffolding) to containment cooling water through spray impingement or immersion should be minimized either by removal or by chemical-resistant protection (e.g., coatings or jackets).	Minimizing post-accident chemical effects was considered in the AP1000 design. The largest amount of base metal surface that would react with the AP1000 post LOCA water chemistry is the ex-core instrumentation. DCD Tier 1 Table 2.2.3 Item 8c) xiv) ensures that these sensors are enclosed in stainless steel (Reference 4). Reference 3 presents the results of evaluations of the potential for generating chemical precipitants and also on down stream chemical effects. The results show that the AP1000 has effectively reduced the chemical effects.
C-1.1.3	**Instrumentation** If relying on operator actions to mitigate the consequences of the accumulation of debris on the ECC sump screens, safety-related instrumentation that provides operators with an indication and audible warning of impending loss of NPSH for ECCS pumps should be available in the control room.	Operator action is not relied upon to mitigate the consequences of the accumulation of debris on the post LOCA screens because of the design of the AP1000 passive systems and the aggressive approach to reducing potential debris sources and providing large / advanced design screens. In addition, the AP1000 does not use pumps for post LOCA core or containment cooling.
C-1.1.4	**Active Sump Screen System** An active device or system (see examples in Appendix B) may be provided to prevent the accumulation of debris on a sump screen or to mitigate the consequences of accumulation of debris on a sump screen. An active system should be able to prevent debris that may block restrictions found in the systems served by the ECC pumps from entering the system. The operation of the active component or system should not adversely affect the operation of other ECC components or systems. Performance characteristics of an active sump screen system should be supported by appropriate test data that address head loss performance.	The AP1000 design does not use an active sump screen system. Therefore, this regulatory position is not applicable to the AP1000 design.
C-1.1.5	**Inservice Inspection** To ensure the operability and structural integrity of the trash racks and screens, access openings are necessary to permit inspection of the ECC sump structures and outlets. Inservice inspection of racks, screens, vortex suppressors, and sump outlets, including visual examination for evidence of structural degradation or corrosion, should be performed on a regular basis at every refueling period downtime. Inspection of the ECC sump components late in the refueling period will ensure the absence of construction trash in the ECC sump area.	The design of the AP1000 CR screens and IRWST screens provides for inspection as identified in this regulatory position. Refer to Reference 1 for details of the AP1000 screen design including access features. The AP1000 Technical Specifications contained in DCD section 16.1 (SR 3.5.6.8) require inspection of these screens every 24 months.

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Section Number	**Stated Regulatory Position**	**Comparison to the AP1000 Design**
C-1.2	**Evaluation of Alternative Water Sources** To demonstrate that a combination of the features and actions listed above are adequate to ensure long-term cooling and that the five criteria of 10 CFR 50.46(b) will be met following a LOCA, an evaluation using the guidance and assumptions in Regulatory Position 1.3 should be conducted. If a licensee is relying on operator actions to prevent the accumulation of debris on ECC sump screens or to mitigate the consequences of the accumulation of debris on the ECC sump screens, an evaluation should be performed to ensure that the operator has adequate indications, training, time, and system capabilities to perform the necessary actions. If not covered by plant-specific emergency operating procedures, procedures should be established to use alternative water sources that will be activated when unacceptable head loss renders the sump inoperable. The valves needed to align the ECCS and containment spray systems (taking suction from the recirculation sumps) with an alternative water source should be periodically inspected and maintained.	As discussed in item C-1.1.3 operator actions are not relied upon for the AP1000 to prevent the accumulation of debris on post LOCA screens. This item does not apply to the AP1000.
C-1.3	**Evaluation of Long-Term Recirculation Capability** The following techniques, assumptions, and guidance should be used in a deterministic, plant-specific evaluation to ensure that any implementation of a combination of the features and capabilities listed in Regulatory Position 1.1 are adequate to ensure the availability of a reliable water source for long-term recirculation following a LOCA. The assumptions and guidance listed below can also be used to develop test conditions for sump screens. Evaluation and confirmation of (1) sump hydraulic performance (e.g., geometric effects, air ingestion), (2) debris effects (e.g., debris transport, interceptor blockage, head loss), and (3) the combined impact on NPSH available at the pump inlet should be performed to ensure that long-term recirculation cooling can be accomplished following a LOCA. Such an evaluation should arrive at a determination of NPSH margin calculated at the pump inlet. An assessment should also be made of the susceptibility to debris blockage of the containment drainage flow paths to the recirculation sump; this is to protect against reduction in available NPSH if substantial amounts of water are held up or diverted away from the sump. An assessment should be made of the susceptibility of the flow restrictions in the ECCS and CSS recirculation flow paths downstream of the sump screens and of the recirculation pump seal and bearing assembly design to failure from particulate ingestion and abrasive effects to protect against degradation of long-term recirculation pumping capacity.	Refer to applicable items below.

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Section Number	**Stated Regulatory Position**	**Comparison to the AP1000 Design**
C-1.3.1	**Net Positive Suction Head of ECCS and Containment Heat Removal Pumps**	
C-1.3.1.1	ECC and containment heat removal systems should be designed so that sufficient available NPSH is provided to the system pumps, assuming the maximum expected temperature of pumped fluid and no increase in containment pressure from that present prior to the postulated LOCA. (See Regulatory Position 1.3.1.2.) For sump pools with temperatures less than 212 oF, it is conservative to assume that the containment pressure equals the vapor pressure of the sump water. This ensures that credit is not taken for the containment pressurization during the transient. For subatmospheric containments, this guidance should apply after the injection phase has terminated. For subatmospheric containments, prior to termination of the injection phase, NPSH analyses should include conservative predictions of the containment atmospheric pressure and sump water temperature as a function of time.	Not applicable since the AP1000 has no containment spray or safety injection pumps.
C-1.3.1.2	For certain operating PWRs for which the design cannot be practicably altered, conformance with Regulatory Position 1.3.1.1 may not be possible. In these cases, no additional containment pressure should be included in the determination of available NPSH than is necessary to preclude pump cavitation. Calculation of available containment pressure and sump water temperature as a function of time should underestimate the expected containment pressure and overestimate the sump water temperature when determining available NPSH for this situation.	Not applicable since the AP1000 has no containment spray or safety injection pumps.
C-1.3.1.3	For certain operating reactors for which the design cannot be practicably altered, if credit is taken for operation of an ECCS or containment heat removal pump in cavitation, prototypical pump tests should be performed along with post-test examination of the pump to demonstrate that pump performance will not be degraded and that the pump continues to meet all the performance criteria assumed in the safety analyses. The time period in the safety analyses during which the pump may be assumed to operate while cavitating should not be longer than the time for which the performance tests demonstrate that the pump meets performance criteria.	Not applicable since the AP1000 has no containment spray or safety injection pumps.
C-1.3.1.4	The decay and residual heat produced following accident initiation should be included in the determination of the water temperature. The uncertainty in the determination of the decay heat should be included in this calculation. The residual heat should be calculated with margin.	Not applicable since the AP1000 has no containment spray or safety injection pumps.

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Section Number	**Stated Regulatory Position**	**Comparison to the AP1000 Design**
C-1.3.1.5	The hot channel correction factor specified in ANSI/HI 1.1-1.5-1994 should not be used in determining the margin between the available and required NPSH for ECCS and containment heat removal system pumps.	Not applicable since the AP1000 has no containment spray or safety injection pumps.
C-1.3.1.6	The calculation of available NPSH should minimize the height of water above the pump suction (i.e., the level of water on the containment floor). The calculated height of water on the containment floor should not consider quantities of water that do not contribute to the sump pool (e.g., atmospheric steam, pooled water on floors and in refueling canals, spray droplets and other falling water, etc.). The amount of water in enclosed areas that cannot be readily returned to the sump should not be included in the calculated height of water on the containment floor.	The calculation of NPSH is not applicable to the AP1000 because there are no containment spray or safety injection pumps. AP1000 does use the elevation of water in the containment to drive the recirculation of water back into the RCS. As a result, a similar calculation of minimum containment water level was performed that considered: • Steam in the containment atmosphere • Water pooled on floors • Water film on the inside surface of the containment vessel due to operation of the passive containment cooling system • Water trapped in areas that are not readily returned to the containment • Water that fills one PXS room in case of a LOCA pipe break in that room DCD section 15.6.5.4C provides some discussion of this level.
C-1.3.1.7	The calculation of pipe and fitting resistance and the calculation of the nominal screen resistance without blockage by debris should be done in a recognized, defensible method or determined from applicable experimental data.	The head loss across the PXS recirculation piping system is simple and straight forward. The head loss across the CR screens under clean conditions was determined by test (Reference 2).
C-1.3.1.8	Sump screen flow resistance that is due to blockage by LOCA-generated debris or foreign material in the containment which is transported to the suction intake screens should be determined using Regulatory Position 1.3.4.	The screen head loss was estimated in Reference 3. Testing performed for AP1000 has confirmed that the head across the AP1000 screens will be insignificant with the AP1000 flow / debris conditions (Reference 2).
C-1.3.1.9	Calculation of available NPSH should be performed as a function of time until it is clear that the available NPSH will not decrease further.	Not applicable since the AP1000 has no containment spray or safety injection pumps.
C-1.3.2	**Debris Sources and Generation**	

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Section Number	**Stated Regulatory Position**	**Comparison to the AP1000 Design**
C-1.3.2.1	Consistent with the requirements of 10 CFR 50.46, debris generation should be calculated for a number of postulated LOCAs of different sizes, locations, and other properties sufficient to provide assurance that the most severe postulated LOCAs are calculated. The level of severity corresponding to each postulated break should be based on the potential head loss incurred across the sump screen. Some PWRs may need recirculation from the sump for licensing basis events other than LOCAs. Therefore, licensees should evaluate the licensing basis and include potential break locations in the main steam and main feedwater lines as well in determining the most limiting conditions for sump operation.	Because the AP1000 design eliminates the use of fibrous insulation that can be damaged by LOCA forces (DCD subsection 6.3.2.2.7.1 item 3), the search for the most severe LOCA considers the amount of resident debris that would be transported to each screen. Refer to Reference 3 for additional discussion on debris amounts. The AP1000 does not use the CR screens for non-LOCA accidents.

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Section Number	**Stated Regulatory Position**	**Comparison to the AP1000 Design**
C-1.3.2.2	An acceptable method for estimating the amount of debris generated by a postulated LOCA is to use the zone of influence (ZOI). Examples of this approach are provided in NUREG/CR-6224 and Boiling Water Reactor Owners' Group (BWROG) Utility Resolution Guidance (NEDO-32686 and the staff's Safety Evaluation on the BWROG's response to NRC Bulletin 96-03). A representation of the ZOI for commonly used insulation materials is shown in Figure 3. • The size and shape of the ZOI should be supported by analysis or experiments for the break and potential debris. The size and shape of the ZOI should be consistent with the debris source (e.g., insulation, fire barrier materials, etc.) damage pressures, i.e., the ZOI should extend until the jet pressures decrease below the experimentally determined damage pressures appropriate for the debris source. • The volume of debris contained within the ZOI should be used to estimate the amount of debris generated by a postulated break. • The size distribution of debris created in the ZOI should be determined by analysis or experiments. • The shock wave generated during the postulated pipe break and the subsequent jet should be the basis for estimating the amount of debris generated and the size or size distribution of the debris generated within the ZOI. Certain types of material used in a small quantity inside the containment can, with adequate justification, be demonstrated to make a marginal contribution to the debris loading for the ECC sump. If debris generation and debris transport data have not been determined experimentally for such material, it may be grouped with another like material existing in large quantities. For example, a small quantity of fibrous filtering material may be grouped with a substantially large quantity of fibrous insulation debris, and the debris generation and transport data for the filter material need not be determined experimentally. However, such analyses are valid only if the small quantity of material treated in this manner does not have a significant effect when combined with other materials (e.g., a small quantity of calcium silicate combined with fibrous debris).	This criteria does not apply to the AP1000 in the sense that no debris is generated by the LOCA as a result of the insulation design approach (DCD subsection 6.3.2.2.7.1 item 3). There is a zone of influence identified in this section of the DCD that used just to determine that there is no fibrous insulation damaged by a LOCA.

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Section Number	**Stated Regulatory Position**	**Comparison to the AP1000 Design**
C-1.3.2.3	A sufficient number of breaks in each high-pressure system that relies on recirculation should be considered to reasonably bound variations in debris generation by the size, quantity, and type of debris. As a minimum, the following postulated break locations should be considered. • Breaks in the reactor coolant system (e.g., hot leg, cold leg, pressurizer surge line) and, depending on the plant licensing basis, main steam and main feedwater lines with the largest amount of potential debris within the postulated ZOI, • Large breaks with two or more different types of debris, including the breaks with the most variety of debris, within the expected ZOI, • Breaks in areas with the most direct path to the sump, • Medium and large breaks with the largest potential particulate debris to insulation ratio by weight, and • Breaks that generate an amount of fibrous debris that, after its transport to the sump screen, could form a uniform thin bed that could subsequently filter sufficient particulate debris to create a relatively high head loss referred to as the 'thin-bed effect.' The minimum thickness of fibrous debris needed to form a thin bed has typically been estimated at 1/8 inch thick based on the nominal insulation density (NUREG/CR-6224).	This criteria does not apply to the AP1000 because no debris is generated by the LOCA as a result of the insulation design approach (DCD subsection 6.3.2.2.7.1 item 3). The only variable is the amount of resident debris transported to each screen. The report discusses the most severe LOCAs relative to resident debris transport.
C-1.3.2.4	All insulation (e.g., fibrous, calcium silicate, reflective metallic), painted surfaces, fire barrier materials, and fibrous, cloth, plastic, or particulate materials within the ZOI should be considered a debris source. Analytical models or experiments should be used to predict the size of the postulated debris. For breaks postulated in the vicinity of the pressure vessel, the potential for debris generation from the packing materials commonly used in the penetrations and the insulation installed on the pressure vessel should be considered. Particulate debris generated by pipe rupture jets stripping off paint or coatings and eroding concrete at the point of impact should also be considered.	The only insulation in the ZOI is metal reflective insulation which will not be transported to the AP1000 screens with the low AP1000 flow rates, as discussed in Reference 3. Data presented to the NRC indicates that PWR LOCA jets will not strip off paint. However, this characteristic is not credited in the AP1000. Although the AP1000 uses safety qualified coatings inside containment, other than the coating used on the inside of the containment vessel they are nonsafety in their application and inspections. As a result, it is assumed that they can be stripped off by LOCA jets. Note that as discussed in DCD subsection 6.1.2.1.5 and Table 6.1-2, these nonsafety coatings used inside containment are required to be a minimum density such that in the AP1000 conditions they will settle on to the floor and not be transported to the screens.

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Section Number	**Stated Regulatory Position**	**Comparison to the AP1000 Design**
C-1.3.2.5	The cleanliness of the containment during plant operation should be considered when estimating the amount and type of debris available to block the ECC sump screens. The potential for such material (e.g., thermal insulation other than piping insulation, ropes, fire hoses, wire ties, tape, ventilation system filters, permanent tags or stickers on plant equipment, rust flakes from unpainted steel surfaces, corrosion products, dust and dirt, latent individual fibers) to impact head loss across the ECC sump screens should also be considered.	Refer to the response to item C-1.1.2.1.
C-1.3.2.6	In addition to debris generated by jet forces from the pipe rupture, debris created by the resulting containment environment (thermal and chemical) should be considered in the analyses. Examples of this type of debris would be disbondment of coatings in the form of chips and particulates or formation of chemical debris (precipitants) caused by chemical reactions in the pool.	Refer to the response to item C-1.3.2.4 for a discussion of coating debris. Reference 3 specifically addresses the potential for formation of chemical debris. In addition, the testing performed for AP1000 included chemical debris and demonstrated that they produced no measurable head loss with AP1000 flows / debris amounts (Reference 2).
C-1.3.2.7	Debris generation that is due to continued degradation of insulation and other debris when subjected to turbulence caused by cascading water flows from upper regions of the containments or near the break overflow region should be considered in the analyses.	Because of the approach used in the AP1000 to use metal reflective insulation and that AP1000 does not have a containment spray system this consideration will not generate additional debris in the AP1000. Also see response to item C-1.1.1.5.
C-1.3.3	**Debris Transport**	
C-1.3.3.1	The calculation of debris quantities transported from debris sources to the sump screen should consider all modes of debris transport, including airborne debris transport, containment spray washdown debris transport, and containment sump pool debris transport. Consideration of the containment pool debris transport should include (1) debris transport during the fill-up phase, as well as during the recirculation phase, (2) the turbulence in the pool caused by the flow of water, water entering the pool from break overflow, and containment spray drainage, and (3) the buoyancy of the debris. Transport analyses of debris should consider: (1) debris that would float along the pool surface, (2) debris that would remain suspended due to pool turbulence (e.g., individual fibers and fine particulates), and (3) debris that readily settles to the pool floor.	Because of the approach used in the AP1000 to use metal reflective insulation essentially all of the AP1000 debris is resident debris. In Reference 3 it has been conservatively assumed that all the resident debris located in areas wetted by the initial break discharge or by subsequent flooding will be transported to an AP1000 screen. The only debris assumed not to be transported is metal reflective insulation.
C-1.3.3.2	The debris transport analyses should consider each type of insulation (e.g., fibrous, calcium silicate, reflective metallic) and debris size (e.g., particulates, fibrous fine, large pieces of fibrous insulation). The analyses should also consider the potential for further decomposition of the debris as it is transported to the sump screen.	Refer to the response to item C-1.3.3.1.

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C-1.3.3.3	Bulk flow velocity from recirculation operations, LOCA-related hydrodynamic phenomena, and other hydrodynamic forces (e.g., local turbulence effects or pool mixing) should be considered for both debris transport and ECC sump screen velocity computations.	Refer to the response to item C-1.3.3.1. The long term cooling analysis (DCD DCD 15.6.5.4C) was used to determine the velocities through the screens.
C-1.3.3.4	An acceptable analytical approach to predict debris transport within the sump pool is to use computational fluid dynamics (CFD) simulations in combination with the experimental debris transport data. Examples of this approach are provided in NUREG/CR-6772 and NUREG/CR-6773. Alternative methods for debris transport analyses are also acceptable, provided they are supported by adequate validation of analytical techniques using experimental data to ensure that the debris transport estimates are conservative with respect to the quantities and types of debris transported to the sump screen.	Refer to the response to item C-1.3.3.1.
C-1.3.3.5	Curbs can be credited for removing heavier debris that has been shown analytically or experimentally to travel by sliding along the containment floor and that cannot be lifted off the floor within the calculated water velocity range.	Refer to the response to item C-1.3.3.1.
C-1.3.3.6	If transported to the sump pool, all debris (e.g., fine fibrous, particulates) that would remain suspended due to pool turbulence should be considered to reach the sump screen.	Refer to the response to item C-1.3.3.1.
C-1.3.3.7	The time to switch over to sump recirculation and the operation of containment spray should be considered in the evaluation of debris transport to the sump screen.	Refer to the response to item C-1.3.3.1.
C-1.3.3.8	In lieu of performing airborne and containment spray washdown debris transport analyses, it could be assumed that all debris will be transported to the sump pool. In lieu of performing sump pool debris transport analyses (Regulatory Position 1.3.3.4), it could be assumed that all debris entering the sump pool or originating in the sump will be considered transported to the sump screen when estimating screen debris bed head loss. If it is credible in a plant that all drains leading to the containment sump could become completely blocked, or an inventory holdup in containment could happen together with debris loading on the sump screen, these situations could pose a worse impact on the recirculation sump performance than the assumed situations mentioned above. In this case, these situations should also be assessed.	Refer to the response to item C-1.3.3.1. AP1000 uses hallways and stairwells as flow paths; their blockage is not credible considering the small amount of debris in the AP1000. Refer to the response to item C-1.1.1.5.

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C-1.3.3.9	The effects of floating or buoyant debris on the integrity of the sump screen and on subsequent head loss should be considered. For screens that are not fully submerged or are only shallowly submerged, floating debris could contribute to the debris bed head loss. The head loss due to floating or buoyant debris could be minimized by a design feature to keep buoyant debris from reaching the sump screen.	This consideration does not apply to the AP1000 screens. The post LOCA containment floodup level is about 10 feet above the top of the AP1000 CR screens (DCD 6.3.2.2.7.3).
C-1.3.4	**Debris Accumulation and Head Loss**	
C-1.3.4.1	ECC sump screen blockage should be evaluated based on the amount of debris estimated using the assumptions and criteria described in Regulatory Position 1.3.2 and on the debris transported to the ECC sump per Regulatory Position 1.3.3. This volume of debris should be used to estimate the rate of accumulation of debris on the ECC sump screen.	Reference 3 provides the evaluation of the AP1000 debris amounts and their transport to the AP1000 screens consistent with these criteria as discussed above. The total amount of debris has been assumed to accumulate in the time it takes to pass the containment floodup volume through the screens once.
C-1.3.4.2	Consideration of ECC sump screen submergence (full or partial) at the time of switchover to ECCS should be given in calculating the available (wetted) screen area. For plants in which containment heat removal pumps take suction from the ECC sump before switchover to the ECCS, the available NPSH for these pumps should consider the submergence of the sump screens at the time these pumps initiate suction from the ECC sump. Unless otherwise shown analytically or experimentally, debris should be assumed to be uniformly distributed over the available sump screen surface. Debris mass should be calculated based on the amount of debris estimated to reach the ECC sump screen. (See Revision 1 of NUREG-0897, NUREG/CR-3616, and NUREG/CR-6224.)	The AP1000 CR Screens are fully submerged at the time that they start recirculating water from the containment back into the RCS. The AP1000 does not use pumps for post LOCA core or containment cooling.
C-1.3.4.3	For fully submerged sump screens, the NPSH available to the ECC pumps should be determined using the conditions specified in the plant's licensing basis.	Refer to response for item C-1.3.4.2.
C-1.3.4.4	For partially submerged sumps, NPSH margin may not be the only failure criterion, as discussed in Appendix A. For partially submerged sumps, credit should only be given to the portion of the sump screen that is expected to be submerged, as a function of time. Pump failure should be assumed to occur when the head loss across the sump screen (including only the clean screen head loss and the debris bed head loss) is greater than one-half of the submerged screen height or NPSH margin.	Refer to response for item C-1.3.4.2.

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C-1.3.4.5	Estimates of head loss caused by debris blockage should be developed from empirical data based on the sump screen design (e.g., surface area and geometry), postulated combinations of debris (i.e., amount, size distribution, type), and approach velocity. Because debris beds that form on sump screens can trap debris that would pass through an unobstructed sump screen opening, any head loss correlation should conservatively account for filtration of particulates by the debris bed, including particulates that would pass through an unobstructed sump screen.	Testing has been performed for the AP1000 (Reference 2). This testing included resident debris (fiber and particle) as well as chemical precipitants. This testing demonstrated that there is not enough debris to form a contiguous bed on the AP1000 screens. As a result, the AP1000 screens do not have any measurable head loss with the screen flow rates and debris amounts based on the analysis in Reference 3 and the AP1000 screen testing.
C-1.3.4.6	Consistent with the requirements of 10 CFR 50.46, head loss should be calculated for the debris beds formed of different combinations of fibers and particulate mixtures (e.g., minimum uniform thin bed of fibers supporting a layer of particulate debris) based on assumptions and criteria described in Regulatory Positions 1.3.2 and 1.3.3.	As discussed above the AP1000 does not have a variety of debris types for different break locations. Basically it just has resident debris. As discussed in Reference 3 the amount of debris available is not sufficient to form a contiguous bed on the AP1000 screens. This situation has been confirmed by the AP1000 screen testing (Reference 2). As a result, the AP1000 screens do not have any measurable head loss with the screen flow rates and debris amounts based on the analysis in Reference 3 and the AP1000 screen testing.

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REFERENCES

1. APP-GW-GLN-147, Revision 1, Technical Report 147, "AP1000 CR and IRWST Screen Design", February 2008
2. WCAP-16914-P, Revision 0, "Evaluation of Debris Loading Head Loss Tests for AP1000 Recirculation Screens and In-containment Refueling Water Storage Tank Screens," March 2008
3. APP-GW-GLR-079, Revision 3, Technical Report 26, "AP1000 Verification of Water Sources for Long-Term Recirculation Cooling Following a LOCA," submitted March 28, 2008.
4. APP-GW-GLE-002, Revision 0, "Impacts to AP1000 DCD to Comply with NRC Generic Letter 2004-02", March 2008