Opening Remarks

September 17, 2008
Mitsubishi Heavy Industries, LTD.

MITSUBISHI HEAVY INDUSTRIES, LTD. UAP-HF-08188-0

Opening Remarks

- Today, MHI will show the NRC our chemical effect test facilities located at MHI Takasago R&D Center. As a part of tour, MHI will explain the test plan, procedure, and preliminarily available results.
- Chemical Effect is one of the GSI-191 issues, "Assessment of Debris Accumulation on PWR Sump Performance", and the NRC has great concerns for its resolution not only for existing plants but also for new plants.
- To respond to this issue, MHI has determined to conduct chemical effect tests. By the tests, impacts of the debris on the following long-term core cooling performance of the standard US-APWR will be evaluated:
  - (1) Impact on strainer debris head loss
  - (2) Impact on downstream evaluation
- Tomorrow at MHI Kobe, a series of technical discussions will be held for sump strainer performance and our plan how to use the chemical effect test results for the assessment.

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Schedule (Sep. 17)

Sept-17, MHI Takasago

10:00 MHI Takasago R&D Center

10:00 ~ 10:20 Greeting and Introduction
10:20 ~ 11:30 Outline of Sump Strainer Chemical Effects Test, Status of the tests and available results
11:30 ~ 12:30 Lab Tour of Sump Strainer Chemical Effects Testing Facility
12:30 ~ 13:30 ***- Lunch -***
13:30 ~ 14:30 Lab Tour of Nuclear Testing Facility
14:30 ~ 14:50 Wrap up

15:00 MHI Takasago Machinery Works

15:00 ~ 16:30 Factory Tour
16:30 Adjourn (Move to Kobe)

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Schedule (Sep. 18)

Sept-18, MHI Kobe Shipyard and Machinery Works

9:00 ~ 12:00 Greeting, MHI Presentations, and Discussions
(1) Introduction
(2) US-APWR Overall Schedule for GSI-191 Closure
(3) Overview of September Technical Report
(4) Bounding Evaluation and Ongoing Chemical Tests
(5) MHI responses to the NRC questions
12:00 ~ 13:00 ***- Lunch -***
13:00 ~ 14:00 Factory Tour
14:00 ~ 16:00 Technical Discussions (Cont'd)
16:00 ~ 16:30 Wrap up
16:30 Adjourn

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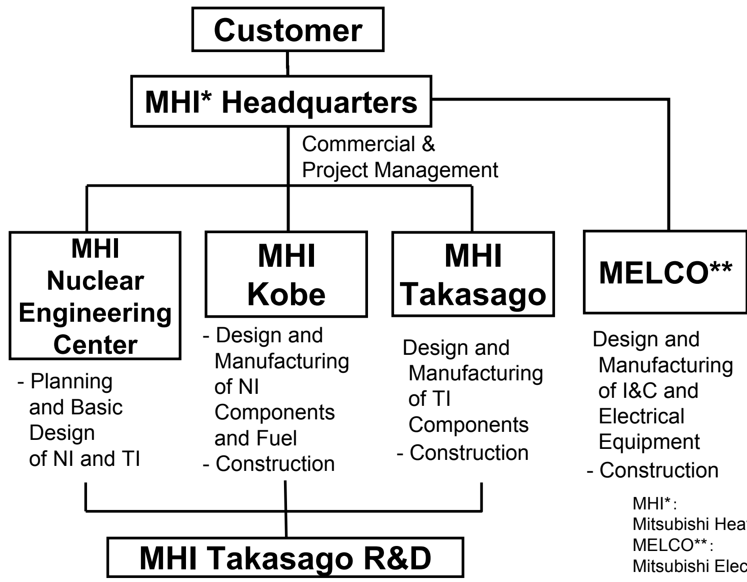
Mitsubishi Nuclear Organization



MHI*: Mitsubishi Heavy Industries
MELCO**: Mitsubishi Electric Corporation

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MHI Responsible Persons for Sump Strainer Issues

Kaname Shibato : Sump Strainer Design (Debris conditions and head loss)

Hiroshi Hamamoto : NPSH Evaluation, Downstream Effects (Ex-Vessel)

Hiroshi Arikawa : Downstream Effects (In-Vessel), Chemical Effects Test

Kazutoyo Murata : Chemical Effects Test

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Participants (Sep. 17)

Yoshiki Ogata	MHI APPD
Yutaka Tanaka	MHI APPD
Kaname Shibato	MHI N-Center
Hiroshi Arikawa	MHI N-Center
Shigemitsu Umezawa	MHI N-Center
Michisuke Nayama	MHI Takasago R&D Center
Koichi Tanimoto	MHI Takasago R&D Center
Kazutoyo Murata	MHI Takasago R&D Center
Sumio Yamauchi	MHI Takasago R&D Center
Kazuo Hirota	MHI Takasago R&D Center
Tadahiko Suzuta	MHI Takasago R&D Center
Ryuichi Matsubara	MHI Takasago R&D Center
Masanori Onozuka	MNES
Robert Choromokos	Consultant (Alion)

MITSUBISHI HEAVY INDUSTRIES, LTD. UAP-HF-08188-6

Participants (Sep. 18)

Yoshiki Ogata	MHI APPD
Yutaka Tanaka	MHI APPD
Kaname Shibato	MHI N-Center
Hiroshi Hamamoto	MHI N-Center
Hiroshi Arikawa	MHI N-Center
Kazutoyo Murata	MHI Takasago R&D Center
Sumio Yamauchi	MHI Takasago R&D Center
Nobuo Ishihara	MHI Takasago R&D Center
Ryuichi Matsubara	MHI Takasago R&D Center
Masanori Onozuka	MNES
Jim Bleigh	PCI
Robert Choromokos	Consultant (Alion)

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Outline of Sump Strainer Chemical Effects Test for US-APWR

Non Proprietary Version

September 17, 2008
Mitsubishi Heavy Industries, LTD.

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Contents

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1.OBJECTIVE for chemical effect test_(1/2)

US-APWR

The objective for chemical effect test is to obtain experimental data under simulated plant conditions on the corrosion products that may form in a post-LOCA environment.

This data will be used

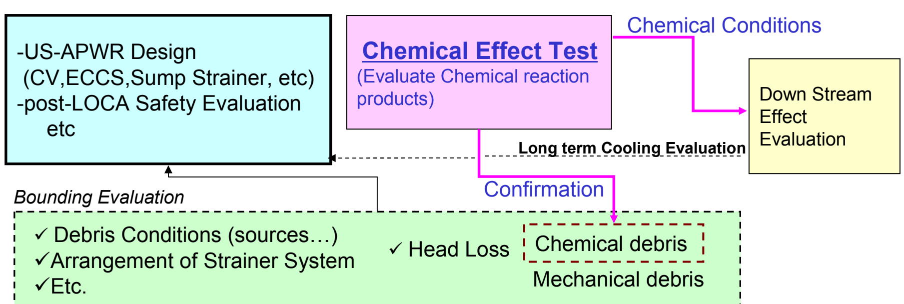
- To determine composition, properties, and amount of chemical reaction products that may impact on debris head losses on the strainers.
- To determine inputs for the downstream chemical effects evaluation to confirm their minimal impact on long term cooling.

1.OBJECTIVE for chemical effect test_(2/2)

US-APWR

Composition of chemical impurities determined by chemical effects testing will be applied

- To confirm chemical debris used in bounding evaluation for strainer design
- To give inputs for chemical precipitant properties and their effect on long term cooling will be evaluated.



2.Test Configuration Outline

US-APWR

To obtain experimental data for corrosion products concentration of system materials, two separate tests (short term and long term) are performed under post-LOCA condition.

- **Autoclave Test (short term)**

  Simulates the temperature transient of the first 100 hours of the post-LOCA

- **Recirculation Test (long term)**

  Simulates the post-LOCA long term environment from 100 hours to 30 days as similar to ICET (The Integrated Chemical Effects Test) experiments published NUREG/CR-6914.

Test performance and Compliance

- **Tests are performed in Takasago R&D Center (TRDC) under the Quality Assurance program of TRDC.**
- **The QA program complies with Appendix-B to 10 CFR Part 50, and Part 21 and is approved by Nuclear Energy Systems Quality and Safety Management Department of MHI.**

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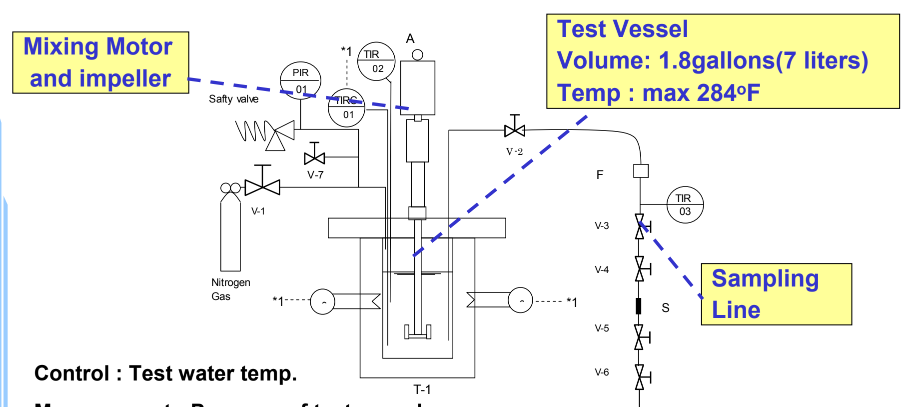
3.Test Apparatus
Autoclave Test apparatus(1/2)

US-APWR

- **Autoclave Test**

  This facility is small size of vessel (stainless steel 316) under high pressure , temp. condition with sampling line, mixing motor.



Control : Test water temp.

Measurement : Pressure of test vessel

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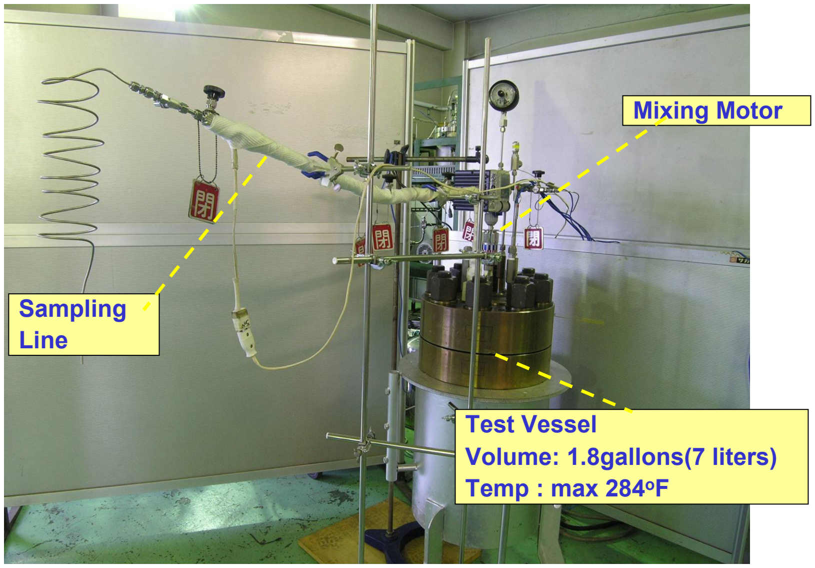
3.Test Apparatus
Autoclave Test apparatus(2/2)

US-APWR



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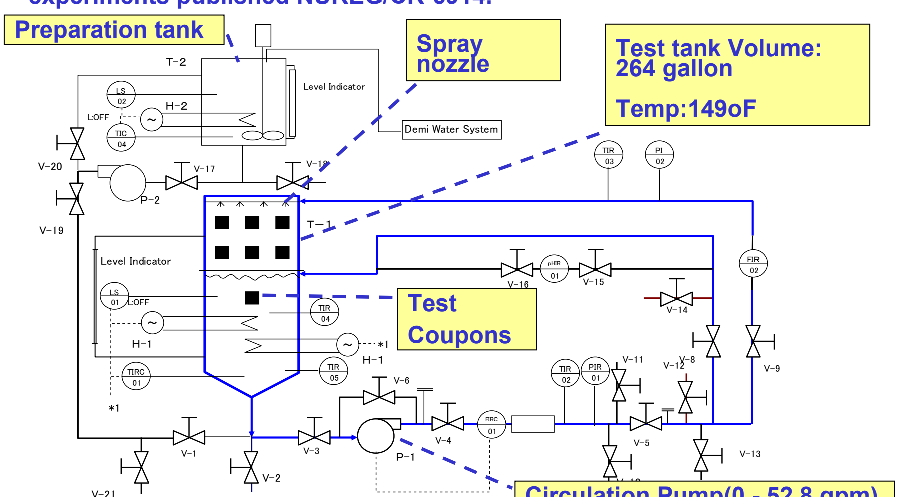
3.Test Apparatus
Recirculation Test apparatus(1/3)

US-APWR

This facility is similar to ICET (The Integrated Chemical Effects Test) experiments published NUREG/CR-6914.



Control : circulation water temp., recirculation flow rate

Measurement : tank water level, pH of circulation water, pressure of test loop

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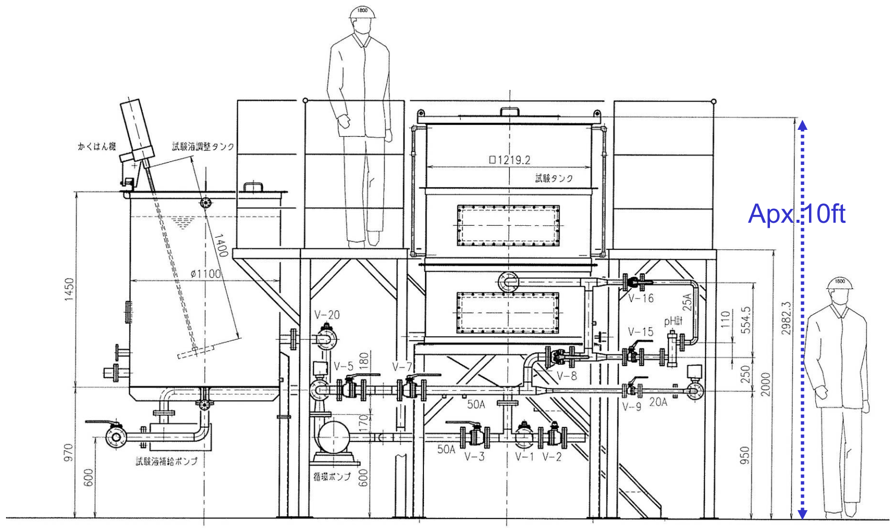
3.Test Apparatus
Recirculation Test apparatus(2/3)



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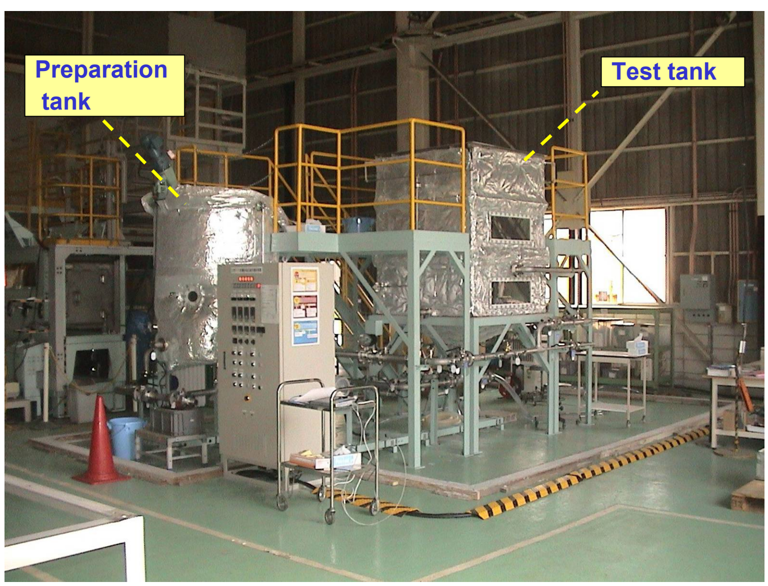
3.Test Apparatus
Recirculation Test apparatus(3/3)



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4.Test Condition(1/8)

US-APWR

Preserve scaling based on the US-APWR parameters

Test material (Test coupons)

- Proportional to surface area/volume assumed in containment and recirculation volume

Fluid pH

- pH is defined by chemical concentration.
- pH conditions (approx. 3 to 8) cover chemical environment during initial 100Hours.
- recirculation test uses a constant pH depending on the mass of NaTB added

Fluid Temperature

- The test profile is established conservatively high to ensure a conservative amount of corrosion and dissolution.

Fluid Rate

- Preserve the ratio of containment spray flow rate to containment cross section area, assumed 30 days spray operation.

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4.Test Conditions (2/8)

US-APWR

Plant Condition

Item		Value	Remarks
Post-LOCA Recirculation Sump Water Volume (Min.)		43930 ft^3	Does not include RCS water volume
RCS Water Volume(Min.)		699000 lbm (approx.11200 ft^3)	Does not include Accumulators water volume
Recirculation Sump Water Boric acid Concentration		4000-4200 ppm B	
RCS Boric acid concentration		0-2250 ppm B	
RCS LiOH Concentration		0 - 3.5 ppm Li	
NaTB Dose Quantity		20 – 22 ton	
Recirculation Sump Water Temperature	Initial	120 ^oF	Maximum temperature includes atmospheric maximum temperature conservatively.
	Max.	284 ^oF	
	Long term.	Less than 149 ^oF	
Recirculation water flow rate (max.)		15960 gpm	Sump water turnover is about 1-2 times per hour.

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4.Test Conditions (3/8)

US-APWR

Plant sump debris sources

Material	Material/Sump Water Ratio	Submerged (%) In pool	Un-submerged (%) Spray zone
Nukon™ insulation	0.0013 ft^3/ft^3	100	0
Concrete particulate	0.003 lbm/ft^3	100	0
Galvanized steel	4.4 ft^2/ft^3	0	100
Aluminum	0.015 ft^2/ft^3	0	100
Concrete	0.019 ft^2/ft^3	0	100
Carbon Steel	0.15 ft^2/ft^3	0	100
Copper	0.39 ft^2/ft^3	0	100

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4.Test Conditions (4/8)

US-APWR

Post-LOCA Sump Water Temperature Profile of short term in plant.

➢Short term Autoclave Test will be performed as simulated transient temperature profile.

[ ]

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4.Test Conditions (5/8)

Post-LOCA Sump Water Temperature Profile of Long term in plant.

➢Long term Recirculation Test was operated at a constant temperature of 149°F which is conservative highly temperature condition for corrosion of materials.

4.Test Conditions (6/8)

Item		Plant condition	Standard Test condition	Remarks
Recirculation sump water boric acid conc.(as B)	**Max.**	**4200ppm**	**3200 ppm**	**(4000ppm×1244m³+0ppm×317m³)／(1244m³+317m³)** More alkaline condition at post-LOCA with mixture of sump water and RCS water, which is conservative for corrosion.
	Min.	**4000ppm**		
RCSBoricacid conc(as B)	**Max.**	**2250ppm**		
	Min.	**0ppm**		
RCS Li conc.	**Max.**	**3.5ppm**	**0.7 ppm**	**(3.5ppm×317m3)/(1244m³+317m³)** More alkaline condition as same as boric acid condition.
	Min.	**0ppm**		
NaTB dose(**max.**)		**22ton**	**14 g/L**	**22ton／(1244m³+317m³)**
HCl conc.(**max.**)		**50-100ppm**	**50,100ppm**	conservatively estimated HCl value that may be generated during 100Hr, 30day post-LOCA

Recirculation sump water volume(min.)：43930ft³(1244m³)

RCS volume(min)：669000lbm(317m³)

4.Test Conditions (7/8)

Autoclave Test

- Run A-2,5 are standard base condition.
- Other runs are valued sensitivity of acid(A-1,4), alkaline(A-3,6) condition.
- Run A-1 to 3 are constant temperature condition.

Run		Temp. (deg F)	Buffering Agent	Boron (ppm B)	NaTB (gram/liter)	HCl (ppm)	Li (ppm Li)	pH*
A-1	Constant Temp.	149	H_3BO_3	4200	0	50	0	3
A-2		**149**	**H_3BO_3+NaTB**	**3200**	**14**	**50**	**0.7**	**8**
A-3		149	H_3BO_3+NaTB	3200	40	50	0.7	8
A-4	Transient Temp.	284	H_3BO_3	4200	0	50	0	3
A-5		**284**	**H_3BO_3+NaTB**	**3200**	**14**	**50**	**0.7**	**8**
A-6		284	H_3BO_3+NaTB	3200	40	50	0.7	8

∗ :pH value is defined by the chemistry concentration, is approximate value.

∗ : conservatively estimated HCl value that may be generated during 100Hr post-LOCA

4.Test Conditions (8/8)

Recirculation Test

- Recirculation test was performed with standard base condition.

Temp (F)	Buffering Agent	Boron (ppmB)	NaTB (gram/liter)	HCl (ppm)	Li (ppm Li)	pH*
149	H_3BO_3+NaTB	3200	14	100	0.7	8

∗ :pH value is defined by the chemistry concentration, is approximate value.

∗ : conservatively estimated HCl value that may be generated during 30 day post-LOCA

∗ : Recirculation flow rate is 200L/min(52.8gpm), which recirculation water turnover is about 10 times per hour.(sump water turnover is 1-2 times per hour)

5.Test Procedures(1/2)

Recirculation Test

✓The cleanliness of the test loop shall be verified using demineralized water. The loop water conductivity (after cleaning) shall be < 5 mS/m and turbidity shall be < 0.3NTU.

✓The preparation (pre-mix) tank shall be filled with demineralized water, heat and chemicals added and adjusted as required for the initial test run conditions temperature(149° F).

✓The sample coupons and other test material (insulation, debris) shall be placed onto the test sample racks inside the test tank.

✓The preparation (pre-mix) conditioned water will be transferred from preparation tank into the test tank .

✓The temperature of the system and flow rates shall be adjusted to the required operating temperature and flow rates. Once established, record the test time and this becomes t = 0.

✓Fluid sampling shall be performed at 24 hour intervals.

5.Test Procedures(2/2)

Autoclave Test

✓The cleanliness of the test loop shall be verified using demineralized water. The loop water conductivity (after cleaning) shall be < 5 mS/m and turbidity shall be < 0.3NTU.

✓The sample coupons and other test material (insulation, debris) shall be placed into the test sample racks and inserted into the test vessel.

✓The preparation (pre-mix) vessel shall be filled with demineralized water and chemicals added and adjusted as required for the initial test run conditions.

✓Transfer the test solution from the pre-mix tank to the autoclave.

✓The autoclave shall be set to operating temperature and establish t = 0 once temperature is achieved. (Temperature profile provided as shown before)

✓Samples shall be obtained every 24 hours during test run except low pH test which samples shall be obtained every 4 hours until 12 hours over.

6.Examination of Test Samples

US-APWR

Masses of all species are accounted for in the experiment.

Test coupons

Coupons used in the test should be weighed and photographed before and after testing.

Fluid Sample

Analyses of fluids shall be performed to characterize dissolved material in the test loop and environments of loop chemistry. For elements whose concentration may vary during a test run, frequent analyses shall be performed. These elements include Al, B, Ca, Cu, Fe, Ni, Si, Mg, Na, and Zn.

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7. Test Results(preliminary)(1/3)

US-APWR

【Tests status】

Recirculation test

- Test operation was finished Sep.11.
- Examination of test samples is in progress.

Photos of coupons after recirculation test.

Autoclave tests

- Run1,4(acidic condition) was done, examination of test sample is in progress.
- Other runs will be performed in Sep.- Oct.

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7.Test Results(preliminary)(2/3)

Recirculation test operation was finished Sep. 11.
Examination of test samples is in progress.

7.Test Results(preliminary)(3/3)

8.Test Schedule

Year	2008								
Month	4	5	6	7	8	9	10	11	12
Test Plan									
Equipment Design									
Manufacturing & Setting									
Chemical Effect Test									
-Measurement System Set up									
-Measurement and Analyses									
-Test Result Assessment and Report Preparation									

9.Summary

- The objective for chemical test is to obtain experimental data under simulated plant conditions on the corrosion products that may form in a post-LOCA environment.
- MHI has elected to perform an ICET experiment, and chemical test for US-APWR was performed.
- Recirculation test was finished and examination is in progress. Autoclave tests are in progress.
- Examination of test sample is under performing, and the results will be reported on November 2008.

Discussion on Sump Strainer Issue
- Introduction-

September 18, 2008
Mitsubishi Heavy Industries, LTD.

Contents

1. Introduction
2. Today's Presentations
3. MHI's Expectations

Introduction

US-APWR

- In MHI letter dated April 16, 2008, our enhanced schedule and plan for Sump Strainer Design was submitted to the NRC.
- The letter stated that all information required for NRC review would be provided by the end of 2008.
- Per the commitment, one technical report was submitted to the NRC in June 2008, and another technical report will be revised and submitted to the NRC by the end of Sept 2008.
- Today, MHI will present the status of our ongoing activities, specifically focusing the debris head loss and chemical effects issues.

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Today's Presentation

US-APWR

1. Overall Schedule
   - ✓ Brief explanation of MHI commitment in June 2008.
2. Revision Summary of Technical Report
   - ✓ MUAP-08001 "Sump Strainer Performance" will be revised and submitted to the NRC in Sept 2008.
   - ✓ MHI presents "Summary of the revision".
3. Discussion Items
   - ✓ What is Bounding Evaluation ?
   - ✓ How to use chemical effects test results in bounding evaluation ?
4. MHI responses to NRC questions
   - ✓ MHI responses to 10 questions from the NRC

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Schedule

Sept-18, MHI Kobe Shipyard and Machinery Works

9:00 ~ 12:00	Greeting, MHI Presentations, and Discussions (1) Introduction (2) US-APWR Overall Schedule for GSI-191 Closure (3) Overview of September Technical Report (4) Bounding Evaluation and Ongoing Chemical Tests (5) MHI responses to the NRC questions
12:00 ~ 13:00	***- Lunch -***
13:00 ~ 14:00	Factory Tour
14:00 ~ 16:00	Technical Discussions (Cont'd)
16:00 ~ 16:30	Wrap up
16:30	Adjourn

MHI's Expectations

- **During today's meeting, MHI would like to respond to the NRC questions or concerns to the greatest extent possible. We expect that this presentation will deepen the NRC's understanding of the subjects discussed.**

Discussion on Sump Strainer Issue
- Overall Schedule -

September 18, 2008
Mitsubishi Heavy Industries, LTD.

MITSUBISHI HEAVY INDUSTRIES, LTD. UAP-HF-08191-0

Contents

MITSUBISHI HEAVY INDUSTRIES, LTD. UAP-HF-08191-1

Introduction

US-APWR

- In MHI letter dated April 16, 2008, an enhanced schedule and plan for Sump Strainer Design was submitted to the NRC.
- The commitments are summarized in the following slide;

MHI Commitments

US-APWR

Evaluation Area	MHI Letter dated April 16, 2008
1. Description of Strainer	Sept-2008: Additional detail design information for the disk layer type strainer including drawings.
2. Break Selection	No new assessment.
3. Debris Generation	Sept-2008: The amount of fibrous debris would be reduced further. Re-evaluation would be performed.
4. Debris Characteristics	Sept-2008: The amount of fibrous debris would be reduced further. Re-evaluation would be performed.
5. Debris Head Loss	Sept-2008: Bounding evaluation using existing test data of debris head loss would be performed.
6. NPSH Evaluation	Sept-2008: Re-evaluation would be performed as per the results of debris head loss evaluation.
7. Downstream Effects	Dec-2008: Supplemented with additional details in ex-vessel and in-vessel issues.
8. Upstream Effects	Sept-2008: Supplemented with additional details to improve NRC understanding.
9. Chemical Effects	Jun-2008: Technical report of test plan and procedure. (Done.) Sept-2008: Audit/Observation of the test available. Nov-2008: Technical report for test results.
10. Structural Analysis	Nov-2008: Stress report and drawings

Report Submittal Plan

- Technical Report "Sump Strainer Performance, MUAP-08001-R0" was submitted to the NRC on Feb. 27, 2008.
- This Technical Report covers the entire sump strainer issue for the US-APWR. Rev.1 to this Report will be issued in Sep., 2008. Rev. 2 incorporating results of the chemical effects test and the downstream effects evaluation will be submitted in Dec., 2008.
- Results of the chemical effects test, structural analysis and downstream effects will be described in separate reports to support the Technical Report "Sump Strainer Performance, MUAP-08001"

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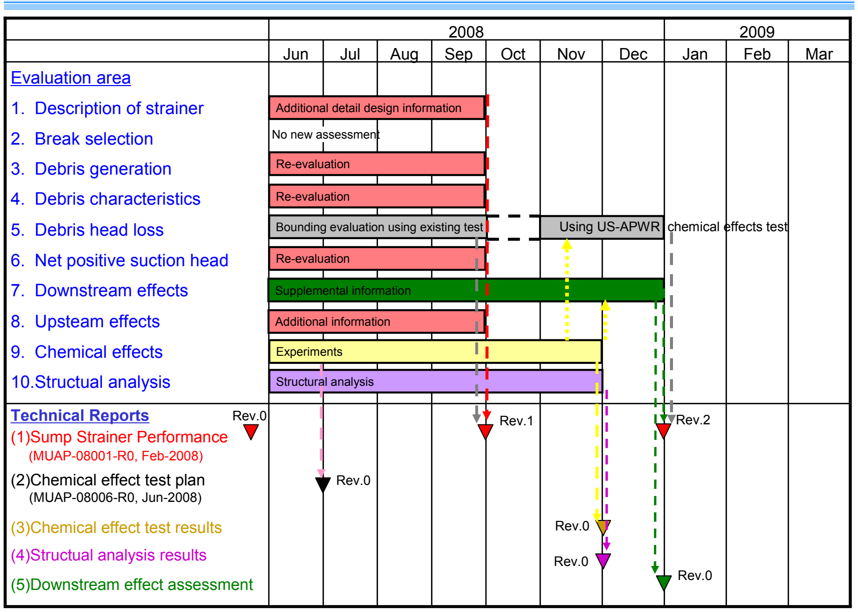
Overall Schedule



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Revision Summary

Technical Report :
MUAP-08001, Sump Strainer Performance

September 18, 2008
Mitsubishi Heavy Industries, LTD.

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Contents

1. Background
2. Overview of Revision
3. Sump Strainer Design
4. Major Changes
5. Ongoing Activities
6. Future Activities

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Background

Current Status and Plan for Sump Strainer Design (based on MHI April 16, 2008 letter) :

- Technical Report "Sump Strainer Performance, MUAP-08001-R0" was submitted to the NRC on Feb. 27, 2008.
- In captioned MHI letter, the report was scheduled to be revised by the end of Sept 2008, incorporating Design Changes and Additional Detail Information of Sump Strainer Design.
- Today, MHI will present the summary of the revision of the technical report prior to formal submittal to the NRC.

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Overview of Revision

Evaluation Area	Overview of Revision 1 ["Sump Strainer Performance", MUAP-08001, Sept-2008]
1. Design Description of Strainer	Further reduction of fibrous insulation, and enlargement of strainer size. Additional information on PCI's Sure Flow Strainer.
2. Break Selection	No significant changes.
3. Debris Generation	Re-evaluation of fiber debris. Miscellaneous debris are considered.
4. Debris Characteristics	No significant changes.
5. Debris Transport	Additional details of debris transportation and re-evaluation are incorporated.
6. Debris Head Loss	Replace NUREG-CR6224 calculation with Bounding Evaluation using CPNPP1/2 design parameter and test data.
7. NPSH Evaluation	No significant changes.
8. Upstream Effect	Additional information regarding water flow path.
9. Chemical Effect Test Plan	Incorporating the summary of test plan*.
10.Downstream Effect	No significant changes. (Evaluation results will be available in Dec-2008.)

* : "Sump Debris Chemical Effects Test Plan", MUAP-08006, Jun-2008

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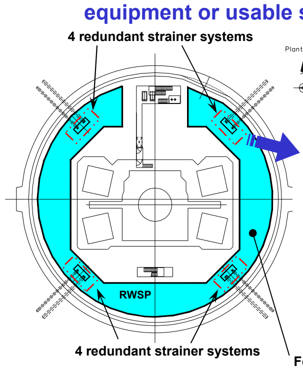
Sump Strainer Design (1/3)

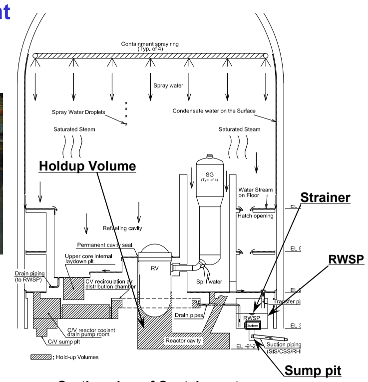
Robust Arrangement of Strainer Systems

- 4 redundant passive strainer systems, with 3,510(ft^2) of surface area of each, are located in RWSP. (PCI Sure Flow Strainer is utilized.)
- Initial water volume of RWSP is 651,000 gallons. No switch over to recirculation required.
- Large foot-print of RWSP allows enlarging each strainer, without impact to equipment or usable space in containment



Plan view RWSP


PCI Sure Flow Strainer



Section view of Containment

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Sump Strainer Design (2/3)

Extremely Low Debris Sources

Amount of fibrous and particulate debris is generally lower than operating plants.

- Use of Reflective Metal Insulation (RMI) is maximized, minimal fibrous insulation is used.
- Insulation made of Cal-Sil is excluded from containment.
- Only qualified protective coatings permitted in containment.

Avoid Using Problematic Chemicals and Substances

New plant can reduce the use of aluminum and other chemical species (such as NaOH).

- Sodium Tetra-borate (NaTB) used as a buffer agent.
- Interior concrete walls are lined with steel with DBA paint. (Exposed concrete is minimized.)

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Sump Strainer Design (3/3)

Conservative Evaluations

US-APWR applies more conservative assumptions than operating plants in the following evaluation areas :

Debris Generation

- All RMI installed on a Reactor Coolant Pipe (31') is considered to fail.
- 10D is assumed for failure of protective coatings.

Debris Transportation

- 100 % Fiber and Latent Debris transport is considered.

Debris Head Loss

- Worst case of 70% debris allocation per sump is considered.

NPSH Evaluation

- Containment overpressure is NOT credited in the evaluation.

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Major Changes (1/3)

Strainer Design

- PCI Sure Flow Strainer (SFS) is utilized for standard US-APWR.
- Strainer surface area has been enlarged to 3,510ft^2 per sump. (Original was 2,150 ft^2/sump)

Debris condition

- Fibrous insulation has been reduced further : 106=>46(ft^3)
- 200ft^2 of Sacrificial Area/sump is considered.

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Major Changes (2/3)

Debris Transportation

- Details of debris transportation and debris allocation patterns for one sump are evaluated.
- 70% of worst allocation/sump is considered.

Debris Head Loss

- Applying Bounding Evaluation Methodology.
- Assumption for chemical composition will be confirmed with the results of the chemical effects tests.
- Need confirmation the results of chemical tests

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Major Changes (3/3)

Chemical Effects Tests Plan

- Incorporating summary of, "US-APWR Sump Debris Chemical Effects Test Plan", MUAP-08006, Jun-2008 .

Downstream Effect

- No significant changes.
- Evaluation details and results will be available by the end of Dec-2008, as committed in MHI Apr-2008 letter.

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Discussion Items

- What is Bounding Evaluation ?
- How to evaluate chemical debris for bounding evaluation using MHI chemical tests results?

These topics will be presented after this presentation.

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Ongoing Activities

- Rev.1 of technical report is drafted, and is in the review process.
- The report will be submitted to the NRC by the end of Sept 2008.

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Future Activities

US-APWR

- MHI plans to submit Rev.2 of technical report by the end of Dec 2008, incorporating the following supplemental information:

  a. Confirmation of chemical debris quantity from the ongoing tests

  b. Summary of the DSE results

The PCI Sure-Flow® Strainer

Debris Allocation & Testing
Bounding Analysis

Non Proprietary Version

Presentation for MHI US-APWR Team
September 18, 2008

The PCI Sure-Flow® Strainer

Overview of PCI Calculation TDI-6032-08 Rev 0

Debris Allocation & Testing
Bounding Analysis

The PCI Sure-Flow® Strainer

Presented by
James M. Bleigh

Performance Contracting, Inc.
Engineered Systems Manager

The PCI Sure-Flow® Strainer

Presentation Contents

- PCI's Relevant Work History
- Objective of this Calculation
- Bounding Guidelines
- Comparing CPNPP 1 & 2 to US-APWR
- Acceptance Criteria
- Conclusions

PCI Sure-Flow® Strainer Work History
Past & Present

17 BWR units operating in the U.S. and Taiwan

- Brunswick 1 & 2
- LaSalle Units 1 & 2
- Quad Cities 1 & 2
- Dresden 1 & 2
- Monticello
- Vermont Yankee
- JA Fitzpatrick
- Nine Mile Point Unit 1
- WPPSS/WNP 2
- Hope Creek
- Pilgrim
- GE Lungmen 1 & 2

PCI Sure-Flow® Strainer Work History
Past & Present

3 BWR units for TEPCo / Japan

TEPCO Kashiwazaki K6
TEPCO Kashiwazaki K3
TEPCO Kashiwazaki K4

PCI Sure-Flow® Strainer Work History
Past & Present

18 PWR units for U.S. PWRs

- Wolf Creek
- Callaway
- Point Beach 1 & 2
- South Texas 1 & 2
- Prairie Island 1 & 2
- Kewaunee
- Palisades
- TVA-Sequoyah 1 & 2
- TVA-Watts Bar 1 & 2
- Comanche Peak 1 & 2
- St. Lucie 2
- Turkey Point 2

PCI Sure-Flow® Strainer Work History
Past & Present

Mitsubishi Heavy Industries, Ltd. of Japan has notified PCI of their intention to award all 24 PWRs. These 24 PWR plants are in various stages of progress at this time.

Of these, Hokkaido Tomari 3 is the first to be designed; and is now in fabrication.

PCI Sure-Flow® Strainer Work History
Past & Present

Mitsubishi Heavy Industries, Ltd.
US-APWR

The US-APWR is currently in the design stage with PCI to support the U.S. NRC licensing application basis.

Debris Allocation & Testing
Bounding Analysis

Objective of this Calculation:

The purpose of this document is to demonstrate that the US-APWR design basis is bounded by the existing Comanche Peak Nuclear Power Plant Units 1 & 2 (CPNPP-1/2) debris head loss tests performed at the Alden Research Laboratory (ARL) in March 2008.

If the CPNPP-1/2 large scale tests at Alden Research Laboratory do in fact bound the US-APWR design basis, then US-APWR specific tests may not have to be performed for the US-APWR postulated debris types and quantities to confirm the NPSh remains acceptable following a LOCA.

Debris Allocation & Testing
Bounding Analysis

Bounding Guidelines:

1. Generally speaking; more "debris mass" per unit area of strainer surface area will bound a debris basis with less debris mass per unit area of screen surface area.
2. This is only true when the recirculation water's approach velocity through the strainer's screen is the same or less than the design basis to which it is compared.

Note: Bounding evaluations are applied to different pipe break locations within a given plant design basis to establish "worse case breaks" and / or between the worse case pipe breaks defined for different plants.

In this calculation, we are comparing the worse case pipe breaks defined for different plants; the US-APWR and CPNPP 1&2.

Debris Allocation & Testing
Bounding Analysis

Bounding Guidelines (continued):

Fibrous Debris

A thin bed of fibers is the only potential "exception" to the general rule that more "debris mass" per unit area of strainer surface area will bound a debris basis with less debris mass per unit area of strainer surface area.

A "thin bed" is generally defined as a mixed fibrous debris bed of ~ 1/8" thick to ~1/4" thick and is a fibrous bed that forms on all strainer surface areas.

Debris Allocation & Testing
Bounding Analysis

Bounding Guidelines (continued):

Fibrous Debris (continued)

For this reason, there are two design conditions to evaluate:

- The "design basis" which is the maximum fiber defined, and
- A "thin bed" of fibers, which could in theory cause a higher head loss if all other design conditions are fixed

Note: The PCI large flume test protocol tested the CPNPP 1&2 design basis for both the maximum fiber design basis; and the thin bed regime. Therefore, the maximum debris head loss presented herein represents the maximum head loss measured for both design conditions.

Debris Allocation & Testing
Bounding Analysis

Bounding Guidelines (continued):

All Other Debris

The following debris types conform to the general guideline for bounding a design basis; meaning, more debris mass per unit area of screen surface area "bounds" a design basis with less debris mass per unit area of screen surface area.

- Particulates from latent debris, coatings, cal sil, other
- Tags, labels, and miscellaneous debris
- Chemical debris precipitates

Debris Allocation & Testing
Bounding Analysis

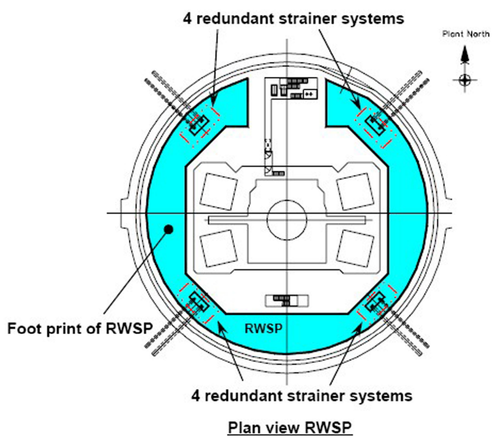
Comparing CPNPP 1 & 2 to US-APWR

Comanche Peak 1 & 2 SFS Arrangement

Debris Allocation & Testing
Bounding Analysis

Comparing CPNPP 1 & 2 to US-APWR

US-APWR SFS Arrangement



Debris Allocation & Testing
Bounding Analysis

Comparing CPNPP 1 & 2 to US-APWR

Design Operating Conditions

[ ]

Debris Allocation & Testing
Bounding Analysis

Comparing CPNPP 1 & 2 to US-APWR

Design Debris Conditions

[ ]

Debris Allocation & Testing
Bounding Analysis

Comparing CPNPP 1 & 2 to US-APWR

Design Debris Conditions

[ ]

Debris Allocation & Testing
Bounding Analysis

Comparing CPNPP 1 & 2 to US-APWR

Design Debris Conditions

[ ]

Debris Allocation & Testing
Bounding Analysis

Comparing CPNPP 1 & 2 to US-APWR

Design Debris Conditions

[ ]

Debris Allocation & Testing
Bounding Analysis

Comparing CPNPP 1 & 2 to US-APWR

Design Debris Conditions

[ ]

Debris Allocation & Testing
Bounding Analysis

Comparing CPNPP 1 & 2 to US-APWR

Mass of Debris per Unit of Screen Surface Area

[ ]

Debris Allocation & Testing
Bounding Analysis

Comparing CPNPP 1 & 2 to US-APWR

Mass of Debris per Unit of Screen Surface Area

[ ]

Debris Allocation & Testing
Bounding Analysis

Comparing CPNPP 1 & 2 to US-APWR

Acceptance Criteria

The Acceptance Criteria for this calculation is defined as the measured debris head loss for CPNPP-1/2 plus the estimated clean strainer head loss (CS HL) for the MHI US APWR is less than the NPSH available for the MHI US-APWR design conditions when adjusted for the plant specific Design Basis temperature.

The maximum CPNPP-1/2 debris head loss measured based on the CPNPP-1/2 Design Basis debris types and quantities including WCAP 16530-NP chemical precipitates is as follows:

[ ]

Total US APWR SFS Head Loss at 120°F =0.805 feet

(*) - Extrapolated by PCI to 30 days of post-LOCA operation, TDI-6004-06 Rev.2.

Total SFS Head Loss adjusted to the US-APWR Design Basis temperature of 70°F = 1.41 feet (i.e., Calculated as 0.805 feet x the dynamic water viscosity factor of 1.75 associated with the Design Basis temperature of 70°F).

Debris Allocation & Testing
Bounding Analysis

Comparing CPNPP 1 & 2 to US-APWR

Acceptance Criteria

The US-APWR has a Design Basis NPSh available of 4.7 feet of water; therefore the testing for CPNPP-1/2 bounds the MHI US-APWR and meets the acceptance criteria defined herein for maintaining a positive NPSh in a post LOCA.

The US-APWR is therefore estimated to have a surplus **NPSh margin of 3.29 feet of water** (4.70 - 1.41) when accounting for head losses due to the strainer, plenum, discharge flow, and design basis debris head losses.

PCI PERFORMANCE CONTRACTING INC ENGINEERED SYSTEMS

Debris Allocation & Testing
Bounding Analysis

US-APWR

Comparing CPNPP 1 & 2 to US-APWR

Conclusions

- The US-APWR is bounded by the CPNPP 1&2 design basis
  - The US-APWR approach velocity through the screen is significantly slower than that of CPNPP 1&2; 0.0035 fps versus 0.0074 fps
  - There is less debris per unit of screen surface area for the US-APWR design basis than the CPNPP 1&2 design basis. Therefore, the measured debris head loss test results from CPNPP 1&2 bounds the US-APWR design basis.

PCI PERFORMANCE CONTRACTING INC ENGINEERED SYSTEMS

Debris Allocation & Testing
Bounding Analysis

US-APWR

Comparing CPNPP 1 & 2 to US-APWR

Conclusions

Using the clean strainer head loss calculated for the US-APWR and the bounding 30 day maximum debris head loss measured for CPNPP 1&2; the US-APWR's Total SFS Head Loss in 70 ºF recirculation water is calculated as shown below:

Head Loss Component	@120°F	@70°F	
[			]
Total US APWR SFS Head Loss	0.805	1.41	feet of water
Viscosity Factor for Temperature		1.75	

Debris Allocation & Testing
Bounding Analysis

Comparing CPNPP 1 & 2 to US-APWR

Conclusions

The US-APWR's NPSh available of 4.7 feet of water at 70 ºF significantly exceeds the total head loss of the SFS arrangement, as shown below:

NPSh Available for US APWR	4.70	feet of water
Total US APWR SFS Head Loss	1.41	feet of water
NPSh Margin Available	3.29	feet of water

Debris Allocation & Testing
Bounding Analysis

Comparing CPNPP 1 & 2 to US-APWR

Conclusions

In conclusion, this calculation confirms the PCI Sure-Flow® Strainers proposed for the MHI US-APWR will have enough NPSh to operate safely following a LOCA event.

Thank you!

This concludes our presentation.

We look forward to discussing our technology with you further!

Using Chemical Effects Test Results in Bounding Evaluation

Non Proprietary Version

September 18, 2008
Mitsubishi Heavy Industries, LTD.

MITSUBISHI HEAVY INDUSTRIES, LTD.

UAP-HF-08193-0

Contents

MITSUBISHI HEAVY INDUSTRIES, LTD.

UAP-HF-08193-1

Approach (1/3)

Chemical Debris in Bounding Evaluation

- US-APWR utilizes bounding evaluation methodology for debris head loss evaluation.
- Current evaluation concluded that CPNPP tests in fact bound the US-APWR design basis, and the MHI US-APWR will have enough NPSH to operate safely following accident.
- In the evaluation, chemical debris for the US-APWR is assumed same as CPNPP1/2, and to be evaluated again upon completion of ongoing chemical effects testing program.

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Approach (2/3)

Existing Efforts in U.S industries

- PWROG TR-WCAP-16530-NP specifies three representative chemical precipitants for PWR plants utilizing any type of buffer agent (NaOH, TSP, NaTB):
  - (1) Aluminum Oxyhydroxide, ALOOH
  - (2) Sodium Aluminum Silicate, NaALSi3O4
  - (3) Calcium Phosphate, Ca3(PO4)2
- Since neither CPNPP1/2 nor US-APWR utilize Trisodium Phosphate (TSP) as buffer agent, ALOOH and NaALSi3O4 are the potential chemical debris for both plants.

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Approach (3/3)

Chemical Debris in Bounding Evaluation

- CPNPP1/2 evaluated that [ ] and [ ] would bound their plant specific chemical debris using TR-WCAP-16530-NP.
- CPNPP1/2 tested [ ] as bounding chemical debris for both ALOOH and NaALSi3O8, because of their similarity for settling and filterability characteristics, as NRC accepted.
- If the US-APWR chemical debris is quantified less than [ ] CPNPP1/2 completely bounds US-APWR.

Note*: Actual amount of ALOOH utilized at CPNPP1/2 test was scaled to accommodate with PCI large flume test facility.

Expected Chemical Debris

Representative Chemical Debris

- US-APWR chemical tests will quantify total “A+B” for comparison.

Chemical Debris	[ ]
(1) Aluminum Oxyhydroxide ALOOH	
(2) Sodium Aluminum Silicate NaALSi3O8	
(3) Calcium Phosphate Ca3(PO4)2	
TOTAL	

Quantification of Chemical Debris

- As described in MHI tests plan "MUAP-08006", following examinations will be performed;
  - Samples taken from both *100hrs Autoclave Test* and *30 days Recirculation Test*, and characterize expected dissolved elements. (e.g. Al, B, Ca, Cu, Fe, Ni, SI, Mg, Na and Zn)
  - Examine Precipitates or Sediment in the test loop.
  - Quantify total mass of each element generated in chemical effects tests.
- Using the result of examinations, representative chemical precipitants (ALOOH, NaALSi3O8) will be quantified by commercial analyzer (i.e. OLI Stream Analyzer™ code).

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Future Actions

- Quantification of chemical debris will be performed after all ongoing tests and examinations are completed.
- After the US-APWR chemical debris are quantified, impacts on current bounding evaluation will be evaluated.
- The evaluation results will be incorporated to Rev.2 of technical report "Sump Strainer Performance, MUAP-08001".

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MHI responses to the NRC questions

September 18, 2008
Mitsubishi Heavy Industries, LTD.

MITSUBISHI HEAVY INDUSTRIES, LTD. UAP-HF-08194-0

Introduction

- The NRC provided ten (10) questions that the staff wants to discuss during the visit to Japan.
- The questions include follow-up questions to the MHI responses to the RAI 45-876.
- Following slides provide MHI responses to them.

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MHI Responses

NRC Question [1]

Follow Up To MHI Response to Question No.06.02.02-1 (Regarding Coatings)

- ✓ The change to DCD Subsection 6.1-2 on p. 6.15, 1st paragraph, eliminates the words "(e.g. inorganic zinc)".
- ✓ If inorganic zinc corrosion inhibiting primer is not being used, identify the type of corrosion inhibiting primer that will be used. Does the type of corrosion inhibiting primer to be used contain metals that could contribute to chemical effects? Does the primer need to be represented in the chemical tests?

MHI Responses

MHI Answer [1]

The US-APWR utilizes DBA epoxy type coating (primer and top-coat) in containment, and prohibits the use of the paints containing zinc or any harmful metals that would potentially contribute to chemical effects.

MHI Responses

NRC Question [2]

Follow Up to MHI Response to Question No. 06.02.02-4. The response indicates the lower temperatures that are more likely to result in formation of precipitates will be realized through the sampling process (cooling) to identify precipitates.

a. How long will the test solution be held at room temperature to allow precipitates (if any) to form and settle out of solution, or will the fluid be run through a filter to capture suspended precipitates? Are precipitates expected to form instantaneously?

b. For the fluid samples taken during the recirculation and autoclave tests, if precipitates are captured by the filters, how will this be correlated to the total amount of precipitate in the tank?

MHI Responses

MHI Answer [2] (1 of 3)

- **Precipitation ratio of the sample fluid is unknown, and it will be relatively difficult to define how to form and settle the solution to provide the precipitants that would impact on strainer head losses, because it would be affected by temperature and cooling duration.**
- **Therefore, MHI is going to examine the sample fluid to identify the concentration of each dissolved element, without filtering or cooling to produce the precipitants.**

MHI Responses

US-APWR

MHI Answer [2] (2 of 3)

Even if the precipitants exist in the sample fluid, they are accounted for as dissolved elements, and total concentrations will be used as the input for a commercial analyzer (i.e. OLI Stream Analyzer) in order to quantify following three representative chemical precipitations that have been identified by PWROG (Note):

- ✓ Aluminum Hydroxide :ALOOH
- ✓ Sodium Aluminum Silicate :NaALSi3O8
- ✓ Calcium Phosphate :Ca3(PO4)2

Note: PWROG TR-WCAP-16530-NP, "Evaluation of Post-Accident Chemical Effects in Containment Sump Fluids to Support GSI-191"

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MHI Responses

US-APWR

MHI Answer [2] (3 of 3)

- **Since the experiment is conducted to produce a conservative release of corrosion products into the recirculation fluid under a higher temperature profile, this approach would be reasonably conservative.**
- **Afterward, the analysis results will be used to confirm the adequacy of the current "bounding evaluation" assuming that the US-APWR chemical precipitants would be bound by CPNPP1/2 chemical precipitants accounted for in their prototypical head loss tests.**

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MHI Responses

NRC Question [3]

What NRC approved industry test reports, in addition to NEI 04-07, will MHI cite or reference to certify the US APWR ECCS sump design?

MHI Responses

MHI Answer [3]

- **For future assessment of chemical effects tests, PWROG document, "TR-WCAP-16530-NP, Evaluation of Post-Accident Chemical Effects in Containment Sump Fluids to Support GSI-191"**
- **Since our evaluations for sump strainer performance including chemical effects and downstream evaluation are ongoing, MHI may refer to additional industry documents, if needed.**

MHI Responses

NRC Question [4]

What other testing and test reports (not presently witnessed or reviewed by the NRC) does MHI plan to cite or reference to certify the US APWR ECCS sump design?

MHI Responses

MHI Answer [4]

- **For future assessment of downstream evaluation (in-vessel), PWROG document, "TR-WCAP-16793-NP, Evaluation of Long-term Cooling Considering Particulate, Fibrous and Chemical Debris in the Recirculating Fluid".**
- **Since our evaluations for sump strainer performance including chemical effects and downstream evaluation are ongoing, MHI may refer to additional industry documents, if needed.**

MHI Responses

US-APWR

NRC Question [5]

Has prototypical head loss testing (scale model testing) to include chemical effects been completed?

MHI Responses

US-APWR

MHI Answer [5]

- A "bounding evaluation" is applied for the US-APWR, instead of design specific head loss testing. The intention of this approach is that if the postulated design of the US-APWR is bounded by the head loss test results of CPNPP1/2, the US-APWR head loss testing may not be needed for the evaluation.
- However, MHI and PCI will do the head loss testing to further confirm the design basis will perform as well as or better than that of the "bounding evaluation".
- The testing is planned to be conducted in early 2009, using the PCI large flume test facility at Alden Research Laboratory.

MHI Responses

NRC Question [6]

What is the ZOI Radius and how was it determined, given that Microporous insulation is allowed in the containment?

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UAP-HF-08194-14

MHI Responses

MHI Answer [6]

Microporous insulation (like Min-k) is not used in the US-APWR containment. Therefore, specific ZOI radius for the insulation was not defined in the debris generation analysis.

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UAP-HF-08194-15

MHI Responses

NRC Question [7]

To what extent does MHI plan to use testing or data from the operating reactors at Comanche Peak Unit 1 and 2 to certify their design?

Please explain how this testing or data applies to the APWR.

MHI Responses

MHI Answer [7]

In separate presentation, MHI/PCI presented details of "bounding evaluation" of the US-APWR strainer using CPNPP1/2 test and design data.

MHI Responses

NRC Question [8]

Does MHI expect the COL applicant to conduct any testing of the sump design as part of the licensing process (COL Action Item)?

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UAP-HF-08194-18

MHI Responses

MHI Answer [8]

No additional plant specific testing is expected to be necessary by the COL applicants, unless they would prefer to apply quite different design deviating from the standard.

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UAP-HF-08194-19

MHI Responses

NRC Question [9]

Are Computational Fluid Dynamic (CFD) models used to analyze debris transport?

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UAP-HF-08194-20

MHI Responses

MHI Answer [9]

- **The US-APWR assumes that all generated debris would be transported to the RWSP, and CFD models were not applied for debris transportation analysis.**
- **As mentioned, MHI and PCI will perform head loss tests using PCI large flume test facility at Alden. For this testing, CFD analysis will be performed to simulate flow characteristics around the sump strainer, and determine the flow channels of the test pool.**

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UAP-HF-08194-21

MHI Responses

NRC Question [10]

How does MHI plan to address in vessel effects due to debris and chemical precipitate?

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MHI Responses

MHI Answer [10] (1/2)

- The following consideration will be taken in evaluating downstream in-vessel effects for long-term core cooling
  - ✓ Cladding temperatures in the core are stable or continuously decreasing
  - ✓ Debris entrained in the cooling water supply will not affect decay heat removal.
- In-vessel downstream effects Technical Report will provide additional details in the following areas:
  - ✓ Chemical Effects on fuel rods *
  - ✓ Blockage at the Core Inlet effect
  - ✓ Local Heating at Grid Spacers
  - ✓ Boric Acid Precipitation effect
  - ✓ Hot leg recirculation

* Evaluate based on the chemical effects test results

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MHI Responses

MHI Answer [10] (2/2)

- Downstream Evaluations including additional information available will be submitted at the end of Dec, 2008.

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