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10 CFR 50.54(f)

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United States Nuclear Regulatory Commission
ATTN: Document Control Desk
Washington, DC 20555-0001

Three Mile Island Nuclear Station, Unit 1
Facility Operating License No. DPR-50
NRC Docket No. 50-289

Subject: Three Mile Island Unit 1 Supplemental Response to NRC Generic Letter 2004-02, "Potential Impact of Debris Blockage on Emergency Recirculation during Design Basis Accidents at Pressurized-Water Reactors"

References:

(1) Generic Letter 2004-02, "Potential Impact of Debris Blockage on Emergency Recirculation During Design Basis Accidents at Pressurized-Water Reactors," dated September 13, 2004

(2) Letter from K. R. Jury (Exelon Generation Company, LLC and AmerGen Energy Company, LLC) to U. S. Nuclear Regulatory Commission "Exelon/AmerGen Response to NRC Generic Letter 2004-02, 'Potential Impact of Debris Blockage on Emergency Recirculation During Design Basis Accidents at Pressurized-Water Reactors,'" dated March 7, 2005

(3) Letter from P. B. Cowan (Exelon Generation Company, LLC and AmerGen Energy Company, LLC) to U. S. Nuclear Regulatory Commission "Exelon/AmerGen Response to NRC Generic Letter 2004-02, 'Potential Impact of Debris Blockage on Emergency Recirculation During Design Basis Accidents at Pressurized-Water Reactors,'" dated September 1, 2005

(4) Letter from P. B. Cowan (Exelon Generation Company, LLC and AmerGen Energy Company, LLC) to U. S. Nuclear Regulatory Commission "Response to Request for Additional Information Regarding NRC Generic Letter 2004-02, "Potential Impact of Debris Blockage on Emergency Recirculation During Design Basis Accidents at Pressurized-Water Reactors" dated July 27, 2005

(5) Letter from C. T. Haney (U. S. Nuclear Regulatory Commission) to Holders of Operating Licenses for Pressurized Water Reactors, "Alternative Approach for Responding to the Nuclear Regulatory Commission Request for Additional Information Letter Regarding Generic Letter 2004-02,' " dated March 28, 2006

(6) Letter from W. H. Ruland (NRC) to A. Pietrangelo (Nuclear Energy Institute), "Revised Content Guide for Generic Letter 2004-02 Supplemental Responses," dated November 21, 2007

(7) Letter from F. Saba (NRC) to C. Crane (Exelon Generation Company, LLC and AmerGen Energy Company, LLC), "Three Mile Island Nuclear Station, Unit 1, Request for Additional information RE: Response to Generic Letter 2004-02, "Potential Impact of Debris Blockage on Emergency Recirculation During Design Basis Accidents at Pressurized-Water Reactors,"" dated February 9, 2006.

(8) Letter from B. W. Sheron (NRC) to A. Pietrangelo (Nuclear Energy Institute), "Nuclear Regulatory Commission Request for Additional Information to Pressurized Water Reactor Licensees Regarding Responses to Generic Letter 2004-02," dated March 3, 2006.

The U.S. Nuclear Regulatory Commission (USNRC) issued Generic Letter (GL) 2004-02 (Reference 1) on September 13, 2004, to request that addressees perform an evaluation of the emergency core cooling system (ECCS) and containment spray system (CSS) recirculation functions in light of the information provided in the GL and, if appropriate, take additional actions to ensure system function. Additionally, the GL requested addressees to provide the USNRC with a written response in accordance with 10 CFR 50.54(f). The request was based on identified potential susceptibility of the pressurized water reactor recirculation sump screens to debris blockage during design basis accidents requiring recirculation operation of ECCS or CSS and on the potential for additional adverse effects due to debris blockage of flowpaths necessary for ECCS and CSS recirculation and containment drainage.

Reference 2 provided the initial AmerGen Energy Company, LLC (AmerGen) response to the GL, followed by the Reference 3 AmerGen response. Reference 4 responded to a request for additional information regarding the Reference 2 response to the GL. References 5 and 8 provided an alternative approach for addressing outstanding requests for additional information (i.e., Reference 7) including the expectation that outstanding requests for additional information responses would be addressed in the Generic Letter 2004-02 Supplemental Response.

Attachment 1 provides the AmerGen Generic Letter 2004-02 Supplemental Response detailing the remaining information to support USNRC verification that the completed corrective actions to address the Generic Letter are adequate. The provided response addresses the actions and methodologies employed at Three Mile Island Unit 1 to resolve the issues identified in GL 2004-02. This response was prepared using the guidelines set forth by the NRC in Reference 5. Outstanding requests for additional information (Reference 7) have been addressed in accordance with References 5 and 8. This information is being provided in accordance with 10CFR50.54(f). There are no regulatory commitments provided in this submittal.

If you have any questions or require additional information, please contact Wendy Rapisarda at (610) 765-5726.

I declare under penalty of perjury that the foregoing is true and correct. Executed on the 28th of December 2007.

Respectfully,

Pamela B. Cowan
Director - Licensing and Regulatory Affairs
AmerGen Energy Company, LLC

Attachment 1 Three Mile Island Unit 1, Supplemental Response to USNRC Generic Letter 2004-02

cc: Regional Administrator, USNRC Region I
Project Manager, NRR, USNRC – Three Mile Island
Senior Resident Inspector, USNRC – Three Mile Island
R. R. Janati, Commonwealth of Pennsylvania
File No. 05049

Attachment 1

Supplemental Response to USNRC Generic Letter 2004-02

Three Mile Island, Unit 1

Attachment 1
Supplemental Response to USNRC Generic Letter 2004-02

ACRONYMS

AECL	Atomic Energy of Canada Limited
AISC	American Institute of Steel Construction
AmerGen	AmerGen Energy Company, LLC
ANSI	American National Standards Institute
ASME	American Society of Mechanical Engineers
AWS	American Welding Society
BS	Building Spray
BWR	Boiling Water Reactor
BWST	Borated Water Storage Tank
CAD	Computer Aided Drafting
CFD	Computational Fluid Dynamics
CFR	Code of Federal Regulations
CF	Core Flood
CFT	Core Flood Tank
CSHL	Clean Strainer Head Loss
CSS	Core Spray System
DBA	Design Basis Accident
DBE	Debris Bypass Eliminator
DCCS	Decay Closed Cooling System
DEG	Double Ended Guillotine
DH	Decay Heat
ECCS	Emergency Core Cooling System
EFW	Emergency Feedwater
EOP	Emergency Operating Procedure
EPRI	Electric Power Research Institute
EQ	Environmentally Qualified
FME	Foreign Material Exclusion
FTC	Fuel Transfer Canal
GL	Generic Letter
GR	Guidance Report
GRP	Geometrical Reflection Positions
GSI	Generic Safety Issue
HELB	High Energy Line Break
HF	Hydrofluoric Acid
HPI	High Pressure Injection
K&L	Keeler and Long, PPG Industries
LB LOCA	Large Break LOCA
LDFG	Low-Density Fiberglass Insulation
LOCA	Loss-of-Coolant Accident
LPI	Low Pressure Injection
LTCC	Long-Term Core Cooling
MU	Make-Up
NaOH	Sodium Hydroxide
NPSH	Net Positive Suction Head
OBE	Operating Basis Earthquake
OTSG	Once-Through Steam Generator
PWR	Pressurized Water Reactor
PZR	Pressurizer
QA	Quality Assurance
RAI	Request for Additional Information
RB	Reactor Building
RBEC	Reactor Building Emergency Cooling
RCP	Reactor Coolant Pumps
RCS	Reactor Coolant System
RFO	Refueling Outage
RMI	Reflective Metal Insulation
ROG	Reactor Operators Group
Rx	Reactor
SB LOCA	Small Break LOCA
SE	Safety Evaluation
SiC	Silicon Carbide
SRSS	Square Root of the Sum of the Squares
SS	Stainless Steel
SSC	System, Structure, and Component
SSE	Safe Shutdown Earthquake
TBE	Thin Bed Effects
TCC	Temporary Configuration Change
TKE	Turbulent Kinetic Energy
TMI Unit 1	Three Mile Island Unit 1
TSCR	Technical Specifications Change Request
TSP	Tri-Sodium Phosphate
UFSAR	Updated Final Safety Analysis Report
URG	Utility Resolution Guidance
USNRC	United States Nuclear Regulatory Commission
ZOI	Zone-of-Influence

Overall Compliance[1]

USNRC Issue 1:

Provide information requested in GL 2004-02, "Requested Information." Item 2(a) regarding compliance with regulations. That is, provide confirmation that the ECCS and CSS recirculation functions under debris loading conditions are or will be in compliance with the regulatory requirements listed in the Applicable Regulatory Requirements section of this generic letter. This submittal should address the configuration of the plant that will exist once all modifications required for regulatory compliance have been made and this licensing basis was updated to reflect the results of the analysis described above.

AmerGen Response to Issue 1:

The recirculation functions for the ECCS and the BS System for TMI Unit 1 are in compliance with the regulatory requirements listed in the applicable Regulatory Requirements section of the subject generic letter under debris loading conditions. The response to USNRC requested information, section 2(b) below, describes the completed corrective actions that ensure this compliance.

Listed below are the conservatisms, detailed throughout this response, which TMI Unit 1 incorporated into their methodology for meeting GL 2004-02:

1. TMI Unit 1 utilizes a bounded loading strategy for testing inputs. The load utilized is a combination of the bounding fiber loads from East D-ring Hot Leg break and the bounding particulate loads from West D-Ring Cold Leg break. (Response Sections 3a.3 and 3o.2.2)

2. TMI Unit 1 utilizes a 7D Zone of Influence on jacketed low-density fiberglass insulation for sump design calculations. WCAP-16710-P (Reference 15) testing confirmed zone of influence could be reduced further to 5D. (Response Section 3b.1)

3. TMI Unit 1 utilizes a latent debris load of 300 lbs versus a walkdown determined value of 192.65 lbs (Response Section 3d.2)

4. TMI Unit 1 utilizes a tags and labels loading of 400 ft^2 versus a walkdown determined value of 332.3 ft^2 (Response Section 3d.2)

5. TMI Unit 1's minimum 15 inch submergence of the top hat modules at minimum credited water level is greater than that used in the testing. Testing was conducted at a submergence of approximately 6 inches above the top hat modules at prototypical plant conditions, and no vortexing was observed for the postulated operating conditions of the TMI sump strainer design. (Response Section 3.f.3)

[1] Attachment 1 was prepared using the guidelines of Reference 5.

General Description of and Schedule for Corrective actions

USNRC Issue 2:

Provide a general description of actions taken or planned, and dates for each. For actions planned beyond December 31, 2007, reference approved extension requests or explain how regulatory requirements will be met as per "Requested Information" Item 2(b). That is provide a general description of and implementation schedule for all corrective actions, including any plant modifications, that you identified while responding to this generic letter. Efforts to implement the identified actions should be initiated no later than the first refueling outage starting after April 1, 2006. All actions should be completed by December 31, 2007. Provide justification for not implementing the identified actions during the first refueling outage starting after April 1, 2006. If all corrective actions will not be completed by December 31, 2007, describe how the regulatory requirements discussed in the Applicable Regulatory Requirements section will be met until the corrective actions are completed.

AmerGen Response to Issue 2:

Based on the results from preliminary debris generation and transport analyses, identified and described below, modifications to the existing debris screens were required to meet the applicable Regulatory Requirements discussed in the generic letter (Reference 1). A majority of the physical changes were performed during the TMI Unit 1 refueling outage, T1R17, in the fall of 2007, as listed below.

1 The sump was divided into a normal “wet” sump and an ECCS “dry” sump.

2 The “box” strainer assembly was replaced with an array of “top hat” strainer modules.

3 The surface area of the strainer was increased from 224 ft^2 to 2580 ft^2.[2]

4 A new trash rack was installed.

5 Configuration changes were made to address upstream flow concerns.
  5.1. Replacement of the door to the entrance of the D-rings
  5.2. Installation of fuel transfer canal drain strainer.

6 The internals of the DH throttle valves have been replaced with a new design that has larger passageways.

7 Piping interferences with the new sump trash rack were modified
  7.1 ¾" Tubing check valve test vent line containing VT-V-24B
  7.2 ¾” FTC leak detection lines from behind the canal liner in the deep end of the canal.
  7.3 Extended valve stem for WDL-V-520

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[2] It was originally reported in Reference 8, that the strainer was intended to be greater than 2750 ft^2. The strainer gross surface area is 2843 sq. ft. This is the total surface area of the strainer. The net strainer surface area is 2580 sq. ft. This is the area of the perforated plate that is capable of taking flow with no blockage by stiffener rings, solid margins, or other structural steel. Subsequent completed testing verified the installed strained size is adequate for the conditions at TMI Unit 1.

8. Normal drain lines were redirected to the new normal sumps
   8.1 4” FTC drain downstream of valve SF-V 31
   8.2 2" Reactor cavity drain line discharging through WDL-V-520
   8.3 Two other 4” embedded RB floor drain lines
   8.4 ½" Leak off drain line from SF-V-24

9. An access ladder was modified to make room for the trash rack.

10. Radiation monitor RM-G-21 was elevated above RB flood level to make room for the strainer and trash rack.

11. The 23 empty TSP baskets were installed in the RB basement. No buffer chemical was installed during T1R17.

12. The RB sump level instruments were modified.

Following T1R17, TMI Unit 1 completed its final physical corrective action associated with the GL 2004-02 Corrective Actions.

1. In accordance with Technical Specification Change Request no. 337 / Technical Specification Amendment no. 263 (References 9 and 7) TMI Unit 1 filled the 23 installed TSP baskets (item 11 above) with the TSP buffer chemical, and isolated the NaOH Tank, containing the removed buffer.

Concurrently the following documents were generated and / or revised to support the GL 2004-02 Actions. All of these documents, and supportive testing, are complete as of December 28, 2007.

1. The Debris Generation Calculation

2. The Debris Transport Calculation (including CFD modeling)

3. The Strainer Head Loss Calculations

4. The Reactor Building Minimum Level During Recirculation Following a LB LOCA Calculation

5. The Downstream Effects Evaluations

6. The NPSH Margin Calculation

7. Emergency Operating Procedures (Revised to throttle LPI flow if high strainer differential pressure is observed)

<u>Specific Information Regarding Methodology for Demonstrating Compliance</u>

<u>USNRC Issue 3a:</u>

Break Selection

The objective of the break selection process is to identify the break size and location that present the greatest challenge to post-accident sump performance.

1. *Describe and provide the basis for the break selection criteria used in the evaluation.*
2. *State whether secondary line breaks were considered in the evaluation (e.g., main steam and feedwater lines) and briefly explain why or why not.*
3. *Discuss the basis for reaching the conclusion that the break size(s) and locations chosen present the greatest challenge to post-accident sump performance.*

<u>AmerGen Response to Issue 3a.1</u>:

<u>Background Information</u>

TMI Unit 1 is a Babcock and Wilcox, two loop, PWR with a large volume dry containment. Each loop contains two RCPs, an OTSG, and associated piping, located within a concrete wall enclosure commonly referred to as a D-ring. The two RCS piping loops are nearly identical with the exception that one loop includes the PZR and the associated piping. The area inside each D-ring is open directly above the 281'-0" basement elevation. The two D-rings are connected by walkways in the basement but, at higher elevations, the refueling cavity and other concrete walls separate the two loops.

<u>Baseline Break Selection</u>

A number of breaks in each high-pressure system that relies on recirculation are considered to ensure that the breaks that bound variations in debris generation by the size, quantity and type of debris are identified. As a minimum, the following break locations are considered:

- Break No. 1: Breaks in the RCS with the largest potential for debris.
- Break No. 2: Large breaks with two or more different types of debris.
- Break No. 3: Breaks in the most direct path to the sump.
- Break No. 4: Large breaks with the largest potential particulate debris-to-insulation ratio by weight.
- Break No. 5: Breaks that generate a "thin bed" – high particulate with 1/8-inch fiber bed.

The controlling breaks at TMI Unit 1 are as follows:

- East D-ring RCS Hot leg break (LB LOCA)
- West D-ring RCS Hot leg break (LB LOCA)
- Nozzle Break at the Reactor Vessel Cavity (LB LOCA)
- 2½-inch letdown line in the vicinity of the containment sump (SB LOCA)

These controlling breaks were assumed to be double-ended guillotine (DEG) and fully offset.

AmerGen Response to Issue 3a.2:

While LOCAs are considered the most probable type of debris generating HELBs that could lead to ECCS sump recirculation, other scenarios were evaluated to ensure that they could not result in debris generation followed by the need for ECCS recirculation as a means of long term core cooling. As long as the RCS remains intact, the intent in PWR design is to provide decay heat removal via the steam generators until the plant can be cooled down, depressurized and placed on the DH Removal system. Therefore, other than for LOCAs, analyses in the UFSAR (Reference 18) do not explicitly describe a sequence of events that show that ECCS recirculation is reached. Rather, the analyses show that DH removal via at least one Steam Generator is established and maintained throughout the event. Specifically, ECCS recirculation is not necessary to maintain long-term decay heat removal for Feedwater Line Break or Main Steam Line Breaks. In addition, it was demonstrated that RB spray is not required in recirculation mode for the Feedwater Line and Main Steam Line Breaks.

AmerGen Response to Issue 3a.3:

With respect to insulation debris generation, the TMI Unit 1 East and West D-rings are very similar with the exception that the East D-ring contains the PZR and associated piping. The PZR is insulated with NUKON, which increases the potential for fiber generation. The RCS hot-leg break near the top of the OTSG and PZR in the East D-ring resulted in the maximum fibrous insulation debris generation. The RCS cold leg break in the West D-ring resulted in the greatest total amount of particulate debris due to the contribution from Thermolag material.

Testing was configured such that fiber and particulate quantities were bounded in both cases by combining the fiber load from the East D-ring hot leg break with the particulate load from the West D-ring cold leg break.

USNRC Issue 3b:

Debris Generation/Zone of Influence (ZOI) (excluding coatings)
The objective of the debris generation/ZOI process is to determine, for each postulated break location: (1) the zone within which the break jet forces would be sufficient to damage materials and create debris; and (2) the amount of debris generated by the break jet forces.

1. *Describe the methodology used to determine the ZOIs for generating debris. Identify which debris analyses used approved methodology default values. For debris with ZOIs not defined in the guidance report (GR)/safety evaluation (SE), or if using other than default values, discuss method(s) used to determine ZOI and the basis for each.*
2. *Provide destruction ZOIs and the basis for the ZOIs for each applicable debris constituent.*
3. *Identify if destruction testing was conducted to determine ZOIs. If such testing has not been previously submitted to the USNRC for review or information, describe the test procedure and results with reference to the test report(s).*
4. *Provide the quantity of each debris type generated for each break location evaluated. If more than four break locations were evaluated, provide data only for the four most limiting locations.*
5. *Provide total surface area of all signs, placards, tags, tape, and similar miscellaneous materials in containment.*

<u>AmerGen Response to Issue 3b.1:</u>

The Debris Generation calculation defines the ZOI as the volume about the break in which the jet pressure is greater than or equal to the destruction damage pressure of the insulation, coatings, and other materials impacted by the break jet. The USNRC SE (Reference 2) concluded that modeling the DEG break ZOI as spherical and centered at the break site or location is an acceptable approach. The radius of the sphere is determined by the pipe diameter and the destruction pressures of the potential target insulation or debris material. Debris sources (insulation, coatings, fixed, etc.) within the ZOI were evaluated in accordance with the GR (Reference 16) and the SE (Reference 2). Table 1 presents the debris sources, ZOI, and method to determine the ZOI used in the analysis.

Table 1. Debris Material ZOI

Debris Source	ZOI	Basis
Transco RMI	2D	USNRC Approved Default Guidance (Reference 2)
Unjacketed NUKON	17D	USNRC Approved Default Guidance (Reference 2)
Jacketed NUKON	7D	WCAP-16710-P[3] (References 15)
ThermoLag 330-1	28.6D	USNRC Approved Default Guidance (Reference 2)
Qualified Coatings	5D	WCAP-16568-P [4](Reference 14)
Unqualified Coatings	100% failure	USNRC Approved Default Guidance (Reference 2)

The ZOI applied to jacketed LDFG is based on testing at Wyle laboratories and values given in NEI 04-07 (Reference 16). Westinghouse report WCAP-16710-P (Reference 15) documents the results of the testing. The tests demonstrated the survivability of jacketed NUKON pipe insulation when subjected to jet impingement loads similar to LOCA blow down loads. The WCAP report concluded that the testing demonstrated the acceptability of reducing the ZOI associated with the NUKON from a spherical-equivalent ZOI of 17D to a value of 5D. However, for conservatism, the report suggested that a 7D ZOI be used for sump design calculations, based on independent analysis for TMI Unit 1 conducted by MPR Associates. A review of the test program concluded that the 7D ZOI is applicable to insulation on the PZR side panels and the RCS hot-leg piping. The ZOI applied to NUKON insulation on other areas of the PZR and on the steam generator was based on SE approved guidance of 17D.

Destruction testing was performed by Westinghouse at Wyle Laboratories. Details of the test procedure and results are given in WCAP-16710-P (Reference 15). An independent review of the test program to TMI Unit 1 was conducted. The results of the review are provided in Table 2.

[3] It was originally reported to the NRC by AmerGen in the GL 2004-02 Supplemental Response (Reference 8) dated September 1, 2005, that the NUKON Insulation ZOI was applied using the established criteria in the NRC Generic Letter 2004-02 SE (Reference 2) Table 3-2. The jacketed NUKON ZOI was updated to 7D based on the findings of the WCAP Report, and a MPR Associates Evaluation, for TMI Unit 1 conditions, as listed above, which were generated in 2007.

[4] It was originally reported to the NRC by AmerGen in the GL 2004-02 Supplemental Response (Reference 8) dated September 1, 2005, that the Qualified Coatings ZOI (10D) was applied using the guidance in NEI 04-07 (Reference 16). The Qualified Coatings ZOI was updated to 5D based on the findings of the WCAP 16568-P report, with subsequent evaluation for applicability to TMI Unit 1 conditions, as listed above.

Table 2. The ZOI for NUKON insulation.

Distance	Insulation Type	Damage Level	Basis
< 5D	All NUKON insulation systems	100% Small Fines	No data are available for less than 5D.
5D < x < 7D	NUKON jacketed	60% Small Fines 40% Large Pieces	WCAP-16710-P (Reference 15) recommends a ZOI of 7D for NUKON insulation. No insulation damage from direct jet impingement was observed in the WCAP-16710-P (Reference 15) test at 5D.
> 7D	NUKON jacketed[5]	No damage	WCAP-16710-P (Reference 15) recommends a ZOI of 7D for NUKON insulation.
5D < x < 17D	NUKON insulation systems other than NUKON jacketed	60% Small Fines 40% Large Pieces	NEI 04-07 (Reference 16) recommends 17D for NUKON.
x > 17D	All NUKON insulation systems	No damage	NEI 04-07 (Reference 16) recommends 17D for NUKON.

<u>AmerGen Response to Issue 3b.2:</u>

See response to 3b.1.

<u>AmerGen Response to Issue 3b.3:</u>

See response to 3b.1.

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[5] NUKON Jacketed means the stainless steel jacket is supported in bearing by the NUKON fiberglass insulation blanket.

<u>AmerGen Response to Issue 3b.4:</u>

Table 3. Quantity of Each Debris Type Generated for Each Break Location

Debris Type	**East D-Ring Hot Leg Break**	**West D-Ring Hot Leg Break**	**Nozzle Break in Reactor Cavity**	**Letdown Line Break**
RMI	12,282 ft^2	11,574 ft^2	25,630 ft^2	1,218 ft^2
NUKON®	237.4 ft^3	197 ft^3	0 ft^3	0 ft^3
Qualified Coatings				
K&L E-I-7475 Epoxy	1.7 lb	0 lb	0 lb	0 lb
K&L 4000 Epoxy	390.8 lb	389.3 lb	0 lb	0 lb
K&L D-Series Epoxy	39.1 lb	39.0 lb	0 lb	0 lb
K&L 6548/7107 Epoxy	104.2 lb	45.7 lb	0 lb	0 lb
K&L E-1-1860 Epoxy	46.5 lb	21.1 lb	0 lb	0 lb
Unqualified Coatings				
Unqualified High Heat Aluminum	14.2 lb	7.2 lb	0 lb	0 lb
Unqualified Misc. Alkyd	60 lb	60 lb	60 lb	60 lb
Unqualified Misc. Enamel	29 lb	29 lb	29 lb	29 lb
Unqualified Misc. Epoxy	244 lb	244 lb	244 lb	244 lb
Dirt/Dust	255 lb	255 lb	255 lb	255 lb
Latent Fiber	45 lb	45 lb	45 lb	45 lb
Tape, Tags, Labels	400 ft^2	400 ft^2	400 ft^2	400 ft^2
Thermolag	0 ft^3	5 ft^3	0 ft^3	0 ft^3

<u>AmerGen Response to Issue 3b.5:</u>

The total surface area of signs, placards, tags, tape, and similar miscellaneous materials in containment is less than 400 ft^2.

<u>USNRC Issue 3c:</u>

Debris Characteristics
The objective of the debris characteristics determination process is to establish a conservative debris characteristics profile for use in determining the transportability of debris and its contribution to head loss. Provide the assumed size distribution for each type of debris.

1. *Provide the assumed size distribution for each type of debris.*
2. *Provide bulk densities (i.e., including voids between the fibers/particles) and material densities (i.e., the density of the microscopic fibers/particles themselves) for fibrous and particulate debris.*
3. *Provide assumed specific surface areas for fibrous and particulate debris.*
4. *Provide the technical basis for any debris characterization assumptions that deviate from USNRC-approved guidance.*

AmerGen Response to Issue 3c.1:

Table 4. Debris Characteristics

Debris Source	Bulk Density	Material Density	Characteristic Size
INSULATION/FIBER			
RMI	N/A	N/A	¼" through 6"
NUKON	2.4 lb/ft^3	175 lb/ft^3	7 micron
Latent Fiber	2.4 lb/ft^3	175 lb/ft^3	7 micron
LATENT PARTICULATES			
Thermolag 330-1	43.6 lbs/ft^3	N/A	10 micron
Dirt/Dust	N/A	169 lb/ft^3	17.3 micron
QUALIFIED COATINGS			
K&L E-1-7475 Epoxy	N/A	101.5 lb/ft^3	10 micron
K&L 4000 Epoxy	N/A	114.5 lb/ft^3	10 micron
K&L D-Series Epoxy	N/A	91.65 lb/ft^3	10 micron
K&L 6548/7107 Epoxy	N/A	109.66 lb/ft^3	10 micron
K&L E-1-1860	N/A	101.5 lb/ft^3	10 micron
UNQUALIFIED COATINGS			
Epoxy	N/A	94 lb/ft^3	10 micron
Alkyd	N/A	98 lb/ft^3	10 micron
Enamel	N/A	98 lb/ft^3	10 micron
Aluminum	N/A	96 lb/ft^3	10 micron

The debris sources developed in the debris generation analysis for NUKON insulation are divided into fines, small, large and intact large pieces in the debris generation calculation and are consistent with the SE (Reference 2) approved methodology and transport metrics for that type and size of debris based on NUREGs or USNRC sponsored research. Two approaches for NUKON insulation have been incorporated in the debris generation and transport analysis.

1. NUKON 17D – the destruction of this insulation material is based on an ALION developed 4 size distribution in accordance with the SE (Reference 2) approved methodology outlined in the Appendices of the SE (Reference 2) on the GR. This size distribution was reviewed previously by the USNRC as part of the GSI-191 plant audits.

2. NUKON 7D – the destruction of this insulation is based on GR/SE (References 16/2) Section 3.0 Baseline Methods considering 60% small-fines and 40% large pieces.

Both approaches utilize a debris size distribution consistent with the SE (Reference 2) approved methodology.

AmerGen Response to Issue 3c.2:

The bulk densities of material and destroyed debris are provided in the debris generation calculation and listed in Table 4, above.

AmerGen Response to Issue 3c.3:

The specific surface areas for fibrous and particulate debris are generally used in the prediction of head loss with the NUREG/CR-6224 (Reference 3) correlation. TMI Unit 1 does not use the NUREG/CR-6224 (Reference 3) correlation to determine the debris bed head loss and therefore the specific surface area is not applicable.

AmerGen Response to Issue 3c.4:

The TMI Unit 1 debris generation, transport and head loss analyses have used the debris characterization assumptions provided in the USNRC approved guidance (Reference 2).

USNRC Issue 3d:

Latent Debris
The objective of the latent debris evaluation process is to provide a reasonable approximation of the amount and types of latent debris existing within the containment and its potential impact on sump screen head loss.

1. *Provide the methodology used to estimate quantity and composition of latent debris.*
2. *Provide the basis for assumptions used in the evaluation.*
3. *Provide results of the latent debris evaluation, including amount of latent debris types and physical data for latent debris as requested for other debris under c. above.*
4. *Provide amount of sacrificial strainer surface area allotted to miscellaneous latent debris.*

AmerGen Response to Issue 3d.1:

Walkdowns were performed in the TMI Unit 1 containment in accordance with NEI 02-01 (Reference 17) to document potential debris. The walkdowns included a comprehensive and methodical inventory of potential sump screen debris sources, which could be dislodged due to the dynamic effects of a HELB, post-LOCA environmental effects, and building spray wash down.

Accessible areas of the containment building were reviewed, rather than limiting the walkdowns to selected areas associated with postulated break locations and spray wash down. This approach ensured that potential sources were fully documented.

AmerGen Response to Issue 3d.2:

A latent debris load of 300 lbs was assumed[6]. This value was chosen to bound, and provide margin above, the 192.65 lbs determined by the containment walkdowns performed during the Fall 2005 RFO (T1R16).

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[6] It was originally reported to the NRC by AmerGen in the GL 2004-02 Supplemental Response (Reference 8) dated September 1, 2005, that the latent debris loading was 200 lbs. This number encompassed the amount of latent debris discovered during the 2005 walkdowns (192.65 lbs); however, it was conservatively raised to 300 lbs for testing and calculations.

The surface area due to tags/labels is assumed to be 400 ft^2. This value was chosen to bound and provide margin above the 332.3 ft^2 determined by the containment walkdowns performed during T1R16.

AmerGen Response to Issue 3d.3:

As recommended in the SE (Reference 2), the properties for the latent debris are 15% fiber and 85% particulate. Subsequently, the latent debris source term is 45 lbs fiber and 255 lbs dirt/dust particulate.

AmerGen Response to Issue 3d.4:

The amount of sacrificial strainer surface area is 300 ft^2. This is based upon 400 ft^2 of tags/labels reduced by 25% due to overlap as permitted in the SE (Reference 2).

USNRC Issue 3e:

Debris Transport
The objective of the debris transport evaluation process is to estimate the fraction of debris that would be transported from debris sources within containment to the sump suction strainers.

1. *Describe the methodology used to analyze debris transport during the blowdown, washdown, pool-fill-up, and recirculation phases of an accident.*
2. *Provide the technical basis for assumptions and methods used in the analysis that deviate from the approved guidance.*
3. *Identify any computational fluid dynamics codes used to compute debris transport fractions during recirculation and summarize the methodology, modeling assumptions, and results.*
4. *Provide a summary of, and supporting basis for, any credit taken for debris interceptors.*
5. *State whether fine debris was assumed to settle and provide basis for any settling credited.*
6. *Provide the calculated debris transport fractions and the total quantities of each type of debris transported to the strainers.*

AmerGen Response to Issue 3e.1:

Debris transport determines the fraction of debris generated that is transported from debris sources (break location) to the sump screen. The results from the Debris Generation Calculation are used to identify debris types and quantity resulting from HELB LOCA and certain small LOCA scenarios. These results are inputs to the Debris Transportation Calculation.

The four major debris transport modes as defined in the Debris Transportation Calculation are:

1. Blowdown Transport - the vertical and horizontal transport of debris to all areas of containment by the break jet.

2. Washdown Transport - the vertical (downward) transport of debris by the containment sprays and break flow.

3. Pool Fill-up Transport - the transport of debris by break and containment spray flows from the BWST to regions that may be active or inactive during recirculation.

4. Recirculation Transport - the horizontal transport of debris from the active portions of the recirculation pool to the sump screen by the flow through the ECCS.

The methodology used in the debris transportation analysis is based on the NEI 04-07 (Reference 16) GR for refined analyses as modified by the USNRC's SE (Reference 2), as well as the refined methodologies suggested by the SE (Reference 2) in Appendices III, IV, and VI. The specific effect of each transport mode was analyzed for each debris type generated, and a logic tree was developed to determine the total transport to the sump screen. The purpose of this approach is to break a complicated transport problem down into specific smaller problems that can be more easily analyzed.

The basic methodology used for the TMI Unit 1 transport analysis, is shown below:

1. Based on many of the containment building drawings, a three-dimensional model was built using CAD software.

2. A review was made of the drawings and CAD model to determine transport flow paths. Potential upstream blockage points including screens, fences, grating, drains, etc. that could lead to water holdup were addressed.

3. Debris types and size distributions were gathered from the debris generation calculation for each postulated break location.

4. The fraction of debris blown into upper containment was determined based on the relative volumes of upper and lower containment.

5. The quantity of debris transported to inactive areas or directly to the sump screen was calculated based on the volume of the inactive and sump cavities proportional to the water volume at the time these cavities are filled.

6. A CFD model was developed to simulate the flow patterns that would occur during recirculation.

7. A graphical determination of the transport fraction of each type of debris was made using the velocity and TKE profiles from the CFD model output, along with the determined initial distribution of debris.

8. The recirculation transport fractions from the CFD analysis were input into the logic trees.

9. The quantity of debris that could experience erosion due to the break flow or spray flow was determined.

10. The overall transport fraction for each type of debris was determined by combining each of the previous steps in the logic trees.

AmerGen Response to Issue 3e.2:

There are no assumptions or methods that deviate from the approved guidance (Reference 2) in the areas of debris transport.

There is no specific guidance in the areas of refined transport analyses provided by the USNRC. The USNRC audited several of the debris transport analyses performed by Alion Science & Technology during the GSI-191 plant audits and provided feedback on the methods employed. The TMI Unit 1 analysis is consistent with those analyses previously audited by the NRC in support of GSI-191.

AmerGen Response to Issue 3e.3:

The CFD calculation for recirculation flow in the TMI Unit 1 containment pool was performed using Flow-3D Version 9.0 Windows installation using an Alion Science and Technology modified subroutine. Flow-3D is a commercially available general-purpose computer code for modeling the dynamic behavior of liquids and gasses influenced by a wide variety of physical processes. The program is based on the fundamental laws of mass, momentum, and energy conservation, and includes the ability to model free surface fluid. It was constructed for the treatment of time-dependent multi-dimensional problems, and is applicable to most flow processes. Flow-3D is configuration-controlled under Alion's QA program, which contains a varied collection of exacting test problems. Version 9.0 (with the modified subroutine) was validated and verified under the Alion QA program.

The CFD model was developed to simulate the flow patterns that would occur during recirculation.

1. The mesh in the CFD model was nodalized to sufficiently resolve the features of the CAD model, but still keep the cell count low enough for the simulation to run in a reasonable amount of time.

2. The boundary conditions for the CFD model were set based on the configuration of TMI Unit 1 during the recirculation phase.

3. The containment spray flow was included in the CFD calculation with the appropriate flow rate and kinetic energy to accurately model the effects on the containment pool.

4. At the postulated LOCA break location, a mass source was added to the model to introduce the appropriate flow rate and kinetic energy associated with the break flow.

5. A negative mass source was added at the sump location with a total flow rate equal to the sum of the break flow and spray flow with the exception of the refueling canal spray flow.

6. A representative turbulence model was selected for the CFD calculations.

7. After running the CFD calculations, the mean kinetic energy was checked to verify that the model had been run long enough to reach steady-state conditions.

8. Transport metrics were determined based on relevant tests and calculations for each significant debris type present in the TMI Unit 1 containment building. Results are detailed in Section 3.e.6 of this response.

AmerGen Response to Issue 3e.4:

No credit was taken in the transport analysis for debris interceptors.

AmerGen Response to Issue 3e.5:

The debris transport fraction for fine debris was assumed to be 100%. No credit was taken for settling of fine debris.

AmerGen Response to Issue 3e.6:

1) Debris Type: Insulation (RMI and NUKON)

Table 5. Insulation (RMI and NUKON) for the East D-ring Hot Leg Break

Debris Type	Debris Transport Fraction	Debris Quantity at Sump
RMI	39%	4,792 ft^2
NUKON®	84%	199 ft^3

Table 6. Insulation (RMI and NUKON) for the West D-ring Hot Leg Break

Debris Type	Debris Transport Fraction	Debris Quantity at Sump
RMI	39%	4,515 ft^2
NUKON®	49%	96.3 ft^3

Table 7. Insulation (RMI and NUKON) for the Nozzle Break in Reactor Cavity

Debris Type	Debris Transport Fraction	Debris Quantity at Sump
RMI	90%	23,028 ft^2
NUKON®	N/A	N/A

Table 8. Insulation (RMI and NUKON) for the Letdown Line Break

Debris Type	Debris Transport Fraction	Debris Quantity at Sump
RMI	100%	1,218 ft^2
NUKON®	N/A	N/A

2) Qualified Coatings

Table 9. Qualified Coatings for the East D-ring Hot Leg Break

Debris Type	Debris Transport Fraction	Debris Quantity at Sump
K&L E-I-7475 Epoxy	100%	1.7 lb
K&L 4000 Epoxy	100%	390.8 lb
K&L D-Series Epoxy	100%	39.1 lb
K&L 6548/7107 Epoxy	100%	104.2 lb
K&L E-1-1860 Epoxy	100%	46.5 lb

Table 10. Qualified Coatings for the West D-ring Hot Leg Break

Debris Type	Debris Transport Fraction	Debris Quantity at Sump
K&L E-I-7475 Epoxy	100%	0 lb
K&L 4000 Epoxy	100%	389.3 lb
K&L D-Series Epoxy	100%	39.0 lb
K&L 6548/7107 Epoxy	100%	45.7 lb
K&L E-1-1860 Epoxy	100%	21.1 lb

3) Unqualified Coatings and OTHER Debris

Table 11. Unqualified Coatings and OTHER debris for All Break Locations

Debris Type	Debris Transport Fraction	Debris Quantity at Sump
Unqualified High Heat Aluminum (East/West D-rings)	100%	14.2/7.2 lb
Unqualified Misc. Alkyd	100%	60 lb
Unqualified Misc. Enamel	100%	29 lb
Unqualified Misc. Epoxy	100%	244 lb
Dirt/Dust	100%	255 lb
Latent Fiber	100%	45 lb
Tape, Tags, Labels	100%	400 ft^2
Thermolag (West D-ring only)	100%	5 ft^3

<u>*USNRC Issue 3f:*</u>

Head Loss and Vortexing

The objectives of the head loss and vortexing evaluations are to calculate head loss across the sump strainer and to evaluate the susceptibility of the strainer to vortex formation.

1. *Provide a schematic diagram of the emergency core cooling system (ECCS) and containment spray systems (CSS).*
2. *Provide the minimum submergence of the strainer under small-break loss-of-coolant accident (SB LOCA) and large-break loss-of-coolant accident (LB LOCA) conditions.*
3. *Provide a summary of the methodology, assumptions and results of the vortexing evaluation. Provide bases for key assumptions.*
4. *Provide a summary of the methodology, assumptions, and results of prototypical head loss testing for the strainer, including chemical effects. Provide bases for key assumptions.*
5. *Address the ability of the design to accommodate the maximum volume of debris that is predicted to arrive at the screen.*
6. *Address the ability of the screen to resist the formation of a "thin bed" or to accommodate partial thin bed formation.*
7. *Provide the basis for the strainer design maximum head loss.*
8. *Describe significant margins and conservatisms used in the head loss and vortexing calculations.*
9. *Provide a summary of the methodology, assumptions, bases for the assumptions, and results for the clean strainer head loss calculation.*
10. *Provide a summary of the methodology, assumptions, bases for the assumptions, and results for the debris head loss analysis.*
11. *State whether the sump is partially submerged or vented (i.e., lacks a complete water seal over its entire surface) for any accident scenarios and describe what failure criteria in addition to loss of net positive suction head (NPSH) margin were applied to address potential inability to pass the required flow through the strainer.*
12. *State whether near-field settling was credited for the head-loss testing and, if so, provide a description of the scaling analysis used to justify near-field credit.*
13. *State whether temperature/viscosity was used to scale the results of the head loss tests to actual plant conditions. If scaling was used, provide the basis for concluding that boreholes or other differential-pressure induced effects did not affect the morphology of the test debris bed.*
14. *State whether containment accident pressure was credited in evaluating whether flashing would occur across the strainer surface, and if so, summarize the methodology used to determine the available containment pressure.*

AmerGen Response to Issue 3f.1:

Figure 1. TMI Unit 1 Schematic of the Emergency Core Cooling System and Containment Spray Systems

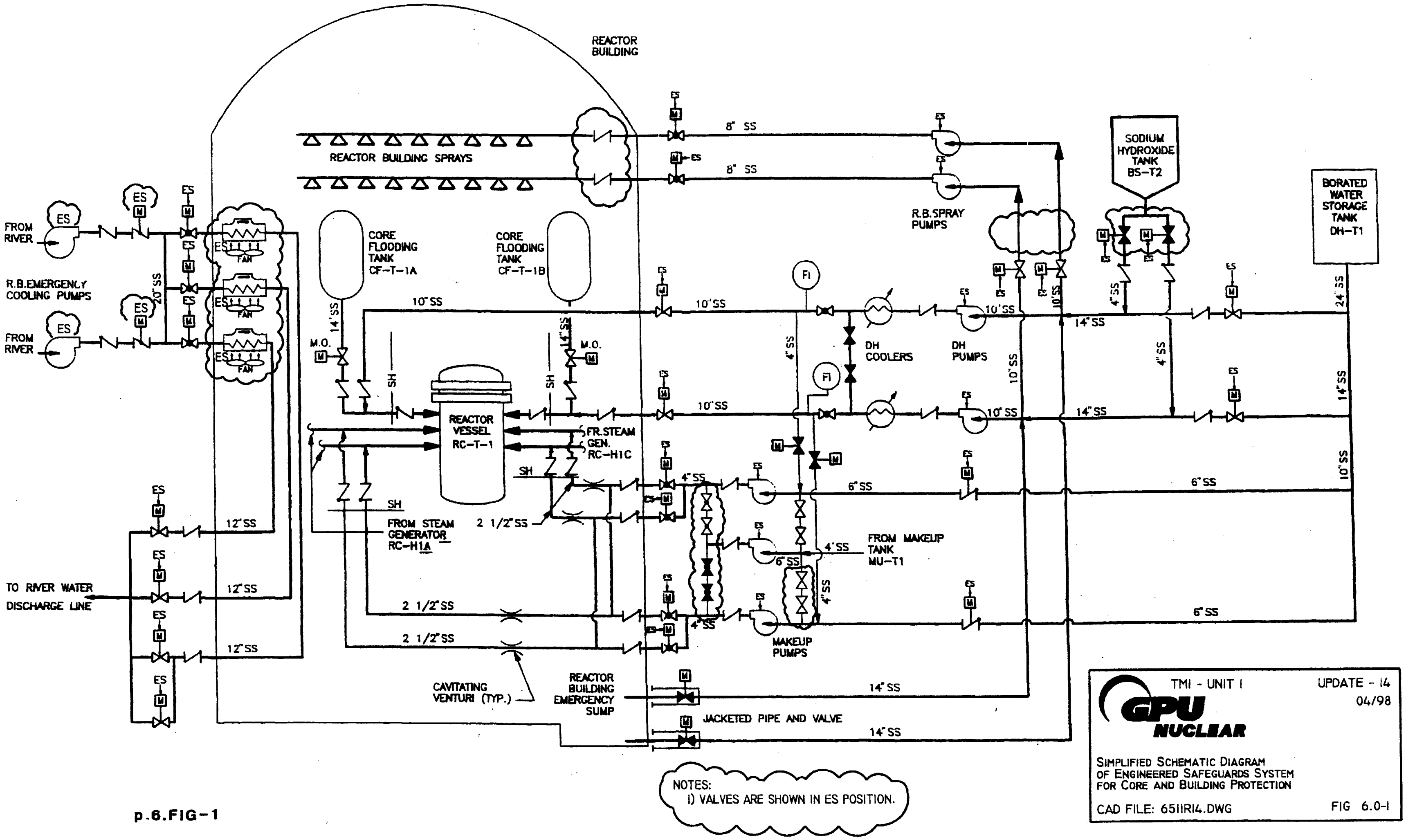


Figure taken from TMI Unit 1 UFSAR (Reference 18) Figure 6.0-1

<u>AmerGen Response to Issue 3f.2:</u>

The minimum submergence of the strainer under SB LOCA and LB LOCA conditions is at least 15 inches.

<u>AmerGen Response to Issue 3f.3:</u>

Enercon Services, Inc. has performed prototype testing of the top hat strainer modules utilized at TMI Unit 1. This testing has shown that the top hat strainer modules are not susceptible to drawing an air-core vortex from the water surface causing air to be drawn into the top hat strainer modules for flow rates scaled to plant design basis flow conditions and a submergence of approximately 6 inches above the top hat modules. This testing was performed for both a 3 x 3 vertical array and 2 x 2 vertical array of top hat modules. The testing demonstrated that for the TMI Unit 1 conventional (i.e. non-chemical) and chemical effects debris loads, no vortexing was observed for the operating conditions of the TMI sump strainer design. In addition, TMI Unit 1's 15 inch top hat module submergence is greater than that used in the testing. Therefore, TMI Unit 1 concludes that no air ingestion occurs for the top hat modules.

The testing did not include horizontal grating over the top of the top hat modules; therefore, the trash rack grating does not need to be credited for vortex suppression. However, the TMI Unit 1 trash rack design incorporates horizontal grating over the top hat modules, at an elevation of 283'-6". The minimum water level is 283.9'. Therefore, the trash rack provides an added measure of conservatism in the prevention of vortices at TMI Unit 1.

<u>AmerGen Response to Issue 3f.4:</u>

See the response for sections 3.o and 3.f.10.

<u>AmerGen Response to Issue 3f.5:</u>

RB sump screen head loss calculation compared the volume of debris (both RMI and fibrous) arriving at the screen to the interstitial volume of the RB strainer. Under the controlling break scenarios, the volume of fibrous plus RMI debris is significantly less than the interstitial volume of the screen. The screen remains fully effective and does not transition to a simple shape with a reduced effective screen area.

The configuration of the RB sump pit and location of the screen pose challenges for the RMI to physically transport to all interstitial volumes within the screen. The sump pit contains a "settling" area prior to entry into the screen area.

<u>AmerGen Response to Issue 3f.6:</u>

The Enercon Top Hat design was shown to resist the formation of a thin-bed through prototypical testing. The screen configuration, and incorporation of the DBE feature, was shown to load non-uniformly. Due to the internal losses of the top hat, flow tends to preferentially be drawn from the bottom of the top hat. As debris builds, the debris bed and internal losses equalize, forcing flow to the end of the top hat. This results in a non-uniform debris bed for typical thin bed debris loads. Prototypical head loss testing with scaled thin-bed debris loads did not show a thin bed to develop.

AmerGen Response to Issue 3f.7:

TMI Unit 1 developed a strainer design maximum head loss calculation. The design differential pressure was developed from the NPSH margin available at the time of the strainer design, which was 1.5 ft at 208 degrees F. An additional 0.5 ft was added to account for additional losses such as chemical effects. This total value was then scaled for viscosity effects from 208 degrees F to 60 degrees F to account for changes in debris head loss as a function of temperature, yielding a differential pressure of 3.5 psi at 60 degrees F. This value was then doubled to provide a robust design differential pressure of 7 psi.

AmerGen Response to Issue 3f.8:

TMI Unit 1 performed prototype testing of a section of the replacement sump screen with scaled plant specific debris loads. Therefore, the debris head loss for the RB sump screen is based on actual test data obtained on prototypical sump screen and extended to the full array analytically.

AmerGen Response to Issue 3f.9:

TMI Unit 1 developed a CSHL calculation. This is the total head loss due to the strainer assembly support structure and the “top hat” modules including the DBE up to but not including the entrance loss to the suction pipes. Standard hydraulic analysis methods are employed to determine the head losses through the support structure, while correlations drawn from testing are used to determine the head losses through the bypass eliminator and top hat. For the specified 8,800 gpm flow rate, the following results are obtained:

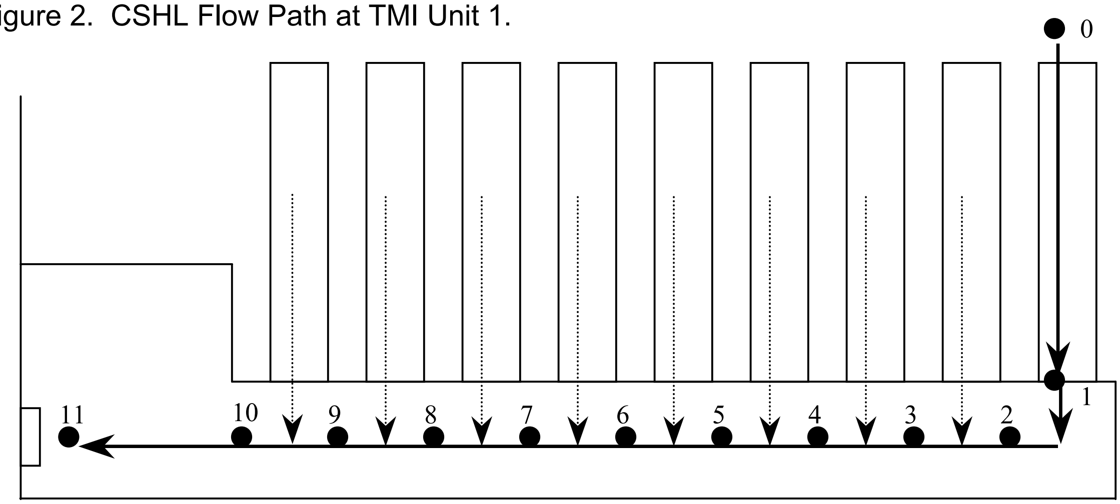
CSHL = 0.1508 ft-H_2O

The clean strainer head loss is determined as follows:

1. The strainer net surface area is calculated. The net surface area is the area of the perforated plate that can accept flow.
2. The flow distribution per net surface area is calculated. This is referred to as “normalized flow.” Under actual conditions, flow through the strainer would pressure balance, i.e., flow would follow the path of least resistance, and greater flow would be pulled through the top hats nearest the suction pipes. Using normalized flow effectively acts to push the flow farther out to the extremities of the strainer, resulting in a conservative head loss calculation. The path of greatest resistance is calculated, in this case, from the farthest row of top hats through the collector box (Nodes 0 through 10).
3. Nodes 0 to 1 are modeled as flow through the top hat.
4. Nodes 1 to 2 models the expansion and contraction through the I-beam structure and the 90 degrees mitre into the channel using the entire top hat row flow rate. Because of the shape of the I-beam, it forces the flow to expand into the depth of the beam and then contract at the flange. The 90 degrees mitre is used to model the corner of the sump pit where the wall meets the floor.
5. Nodes 2 through 10 are modeled as converging wye intersections with each row of top hats entering the channel from the branch.
6. Finally, Nodes 10 to 11 are modeled as a sudden expansion into the collector box.

7. The top hat, channel, and collector box head losses are summed to produce the total clean strainer head loss.

Figure 2. CSHL Flow Path at TMI Unit 1.



The major assumptions in this analysis are as follows:

1. In calculating the head loss, the flow through the strainer is assumed uniform and normalized over the total strainer area. This is conservative because, in practice, the flow balances with the path of least resistance, i.e., more flow is experienced by those top hats that are closer to the recirculation lines. In addition, intake flow through the perforated plate is assumed uniform. This assumption is reasonable because the entire strainer is submerged, and after a bed of debris forms on the strainer, the flow becomes uniform.

2. The lowest sump water temperature is assumed constant at 60 degrees F. For the dynamic head losses, this is slightly conservative. Since water at higher temperatures (characteristic of post-accident sump temperatures) would exhibit lower viscosity, a conservatively low water temperature would result in lower Reynolds numbers, and consequently, higher friction factors.

3. The flow rate used in the analysis is conservatively applied as 8800 gpm. The calculated maximum sump flow rate is 8,706 gpm. This number is based on the fact that there are two trains, each with an LPI pump and a BS pump.

4. A trash rack is installed over the top of the top hat modules to protect them from large debris. Given the large flow area of the trash rack, it is assumed that there is negligible head loss due to the trash rack.

5. The head loss across the strainer top hat modules, including the knitted wire mesh DBE, as a function of top hat annular velocity, was determined by Enercon prototype testing.

6. Any obstructions due to support beams (structure legs) underneath the top hats are assumed to have negligible affects on head loss. The flow area is so large (yielding a low overall velocity) compared to the area occupied by the supports that the effects on the overall flow and head loss are insignificant.

AmerGen Response to Issue 3f.10:

Methodology

The methodology to develop the head loss at the RB sump is that approved by the USNRC (Reference 2) from the Guidance Report (Reference 16). The problem is divided into the following areas:

1. Debris Identification (Reference 16)
2. Debris Generation (References 2 and 16)
3. Debris Transport (References 2 and 16)
4. Debris Head loss (References 2 and 16)

The debris types identified and considered in the TMI Unit 1 debris blockage analyses include:

- Reflective Metallic Insulation (RMI)
- Fibrous Debris
    - Fibrous Insulation Products (NUKON/Thermal Wrap)
    - Fibrous Latent Debris
    - Thermo-lag
- Particulate Debris
    - Thermo-lag
    - Failed Coatings
    - Particulate Latent Debris (Dirt/Dust)
- Miscellaneous Debris
    - Labels and Tags
- Chemical Corrosion Products

Head Loss for RMI

The head loss for a RMI debris bed on the sump screen surface depends mainly on the accumulation at the sump screen and the type and size distribution of RMI debris. The key parameter needed to evaluate RMI head loss is the surface area of the foils of RMI deposited on the screen. The TMI Unit 1 analysis uses Equation K.5a of the USNRC's SE (Reference 2) to determine the head loss from RMI that may collect at the strainer.

Head Loss for Fibrous Debris with Particulate

TMI Unit 1 performed prototype testing of a section of the replacement sump screen with scaled plant specific debris loads. Therefore, the debris head loss for the RB sump screen is based on actual test data obtained on prototypical sump screen and extended to the full array analytically.

Mixed Debris and Thin Bed Effects

Mixed debris beds are handled by superposition. RMI head loss is determined as above; then the particulate and fibrous debris bed head loss is determined as above. The results are added to estimate the total head loss from these debris types. TBE are evaluated for the debris as discussed in Item 3f.6.

Chemical Debris

The impact of chemical effects on debris head loss was quantified through plant specific chemical effects testing. This testing included both 30 day integrated testing, and WCAP-16530-NP / WCAP-16785-NP (References 12 /13) based prototype array testing.

Temperature Dependency and Laminar / Turbulent Effects

Temperature dependent viscosity and density effects are incorporated in the computations of head loss across the strainer and debris bed by using the fluid material properties at the various temperatures considered in the analyses. The flow through the debris bed captured at the strainer is a mixture of turbulent and laminar flows. Each flow type demonstrates different dependencies (linear with velocity and dependent on viscosity for laminar flow and quadratic with velocity and dependent on density for turbulent flow), a ratio of laminar to total flow and a ratio of turbulent to total flow were determined. Linear combination of the various flow speed effects was used to calculate head loss for conditions analyzed that were not explicitly tested.

Results

The total strainer head loss including the impact of calcium phosphate precipitants is 1.7 ft at 83 degrees F and a flow rate of 8800 gpm. This head loss value applies for sump temperatures above 140 degrees F. The total strainer head loss including the impact of calcium phosphate and aluminum precipitants is 21.3 ft at 85 degrees F and a flow rate of 8800 gpm. This head loss value applies for sump temperatures below 140 degrees F. These measured head loss results must be adjusted for temperature and flow rate for application in the NPSH analysis.

Credit for operator action to secure the BS pumps and reduce LPI flow ensures that the structural limit of 16.15 ft-H_2O (7 psi) is met for all cases. Hydraulic analysis of strainer DP has been completed which demonstrates DP will remain less than 7 psi for the duration of the event if all of the following are performed:

1. One train of BS is shutdown within one hour after initiating RB sump recirculation mode

2. The second train of BS is shutdown within 24 hours after initiating RB sump recirculation mode

3. If strainer DP exceeds 10 ft-H_2O, then throttle total LPI flow through the ECCS strainer to less than 3276 GPM within one hour of detection.

To ensure the integrity of the strainer in any design basis event, EOPs have been revised as follows:

1. A step was added to the EOP for RB sump recirculation to ensure that BS is shutdown within the limits assumed in the analysis.

2. EOP Guidance for LPI Throttling was revised. A new throttling requirement was added to throttle both LPI throttling valves to less than or equal to 1500 GPM in each line if ECCS sump level is less than RB Flood Level (after sump recirculation has been initiated). ECCS sump level instruments measure the water pressure below the ECCS strainer. A strainer differential pressure of greater than 7.5 ft-H_2O will cause ECCS sump level to indicate less than RB Flood Level indication. (See Section 3.j.2 for further description of RB sump instruments)

These actions are acceptable and can be reliably performed after a LOCA because:

- The reduction in LPI Flow to prevent excessive strainer DP is bounded by existing analysis for long term core cooling and reactor building conditions which support equipment environmental qualification.

- The action to throttle LPI flow is performed using the same flow indication and remote operated valves that are presently used to throttle LPI as required to ensure adequate NPSH. The equipment is qualified for this application.

- The instruments used to determine that throttling is required (ECCS sump level indication and RB Flood level indication) are Regulatory Guide 1.97 Category 1 qualified indicators.

- Operators were trained on the new actions prior to implementing these revisions (or prior to assuming licensed duty after the changes were made).

- The operator response times assumed in the analysis are conservative.

<u>AmerGen Response to Issue 3f.11:</u>

The sump is not partially submerged or vented. The RB sump screen is a vertical strainer design to assure full submergence at the minimum calculated recirculation pool water level.

Under “hot” (greater than 140 degrees F) conditions the loss of NPSH margin is the limiting condition. Under “cold” (140 degrees F and less) conditions excessive strainer differential pressure is the limiting condition. This is described further in sections 3g and 3k of this response.

<u>AmerGen Response to Issue 3f.12:</u>

Near-field settling was not credited in the head loss testing.

AmerGen Response to Issue 3f.13:

Temperature/viscosity was used to scale the results of the prototype head loss tests to the plant conditions. The basis of the scaling methodology was obtained from the NUREG/CR-6224 (Reference 3) correlation which attributes head loss to both turbulent and laminar flow regimes. The turbulent term is adjusted by density and the laminar term is adjusted by dynamic viscosity. At the end of the experiment, flow sweeps are performed to determine the relative proportionality of the laminar and turbulent flow contribution to head loss. This allowed scaling the test values at room temperature to various plant temperatures and flow rates.

Corrections to head loss due to changes in approach velocity can be made using the equation generated from the test data.

Equation 1. Head Loss Due to Changes in Approach Velocity

$$\Delta H_2 = \Delta H_1 \left[R_L \frac{V_2}{V_1} + R_T \frac{V_2^{\,2}}{V_1^{\,2}} \right]$$

(Correction for changes in velocity)

ΔH = Head Loss
R_L = ratio of laminar flow
V= approach velocity (ft/sec)
R_T = ratio of turbulent flow

The equation below is used to correct the measured head loss for changes in temperature.

Equation 2. Head Loss Due to Changes in Temperature

$$\Delta H_2 = \Delta H_1 \left[R_L \frac{\mu_2}{\mu_1} + R_T \frac{\rho_2}{\rho_1} \right]$$

ΔH = Head Loss
R_L = fraction of laminar flow
μ = Dynamic viscosity at temperature (lbm/ft/sec)
R_T = fraction of turbulent flow
ρ = Density at temperature (lbm/cu.ft)

The TMI Unit 1 debris load is fiber and particulate and is well represented by the NUREG/CR-6224 (Reference 3) correlation. Although it is not explicitly used to develop head loss, the application is appropriate and within the bounds of the correlation. The “boreholes” or “other differential pressure induced effects” are generally attributed to calcium silicate debris or other unstable debris beds that have a highly non-linear head loss response to flow. This is not the case for TMI Unit 1. Support is provided by the flow sweeps that are performed during the prototype testing that demonstrate the proportion of the head loss that can be explained by the contributions from laminar and turbulent flow.

AmerGen Response to Issue 3f.14:

Containment accident pressure was not credited in evaluating whether flashing would occur across the strainer surface.

USNRC Question 3g:

Net Positive Suction Head (NPSH)

The objective of the NPSH section is to calculate the NPSH margin for the ECCS and CSS pumps that would exist during a loss-of-coolant accident (LOCA) considering a spectrum of break sizes.

1. *Provide applicable pump flow rates, the total recirculation sump flow rate, sump temperature(s), and minimum containment water level.*
2. *Describe the assumptions used in the calculations for the above parameters and the sources/bases of the assumptions.*
3. *Provide the basis for the required NPSH values, e.g., three percent head drop or other criterion.*
4. *Describe how friction and other flow losses are accounted for.*
5. *Describe the system response scenarios for LB LOCA and SB LOCAs.*
6. *Describe the operational status for each ECCS and CSS pump before and after the initiation of recirculation.*
7. *Describe the single failure assumptions relevant to pump operation and sump performance.*
8. *Describe how the containment sump water level is determined.*
9. *Provide assumptions that are included in the analysis to ensure a minimum (conservative) water level is used in determining NPSH margin.*
10. *Describe whether and how the following volumes have been accounted for in pool level calculations: empty spray pipe, water droplets, condensation and holdup on horizontal and vertical surfaces. If any are not accounted for, explain why.*
11. *Provide assumptions (and their bases) as to what equipment will displace water resulting in higher pool level.*
12. *Provide assumptions (and their bases) as to what water sources provide pool volume and how much volume is from each source.*
13. *If credit is taken for containment accident pressure in determining available NPSH, provide description of the calculation of containment accident pressure used in determining the available NPSH.*
14. *Provide assumptions made which minimize the containment accident pressure and maximize the sump water temperature.*
15. *Specify whether the containment accident pressure is set at the vapor pressure corresponding to the sump liquid temperature.*
16. *Provide the NPSH margin results for pumps taking suction from the sump in recirculation mode.*

AmerGen Response to Issue 3g.1:

Pump Flow Rates and Total Recirculation Sump Flow Rate

Table 12. Bounding NPSH Case: Pump Flow and Total Recirculation Sump Flow Rates

Item	Actual Pump Flow (gpm)	Total Indicated Flow (gpm)	Total Instrument Error (gpm)	Pump Recirculation (gpm)
LPI Pump	3351	2800	276	131
BS Pump	1180	N/A	N/A	N/A
Recirculation Sump	4256	N/A	N/A	N/A

The total recirculation sump flow is 4256 gpm.

For testing and head loss analyses, the bounding flow rate value is 8800 gpm.

Sump Temperatures

The sump temperature ranges from approximately 268 degrees F to the temperature of the ultimate heat sink. TMI Unit 1 takes no credit for accident overpressure in excess of the previously approved application of vapor pressure in the analysis for NPSH.

Table 13. Sump Liquid Temperatures from the LB LOCA EQ Temperature Calculation

Maximum sump liquid temperature	268.6 degrees F
Sump temperature at minimum time to switch over to recirculation mode (1681 seconds).	259.6 degrees F
Sump temperature at time of switch over to recirculation mode with one train of ECCS operating (3433 seconds).	243 degrees F

Minimum Containment Water Level

The minimum containment water level is 2.9 ft. above the elevation of the RB floor (elevation of RB floor is 281').

AmerGen Response to Issue 3g.2:

To compute NPSH, the RB pressure is set equal to the sump water vapor pressure for times when the sump water temperature is elevated. This is consistent with prior analysis methodology provided in UFSAR (Reference 18) Chapter 6. TMI Unit 1 Pressure Drop Analysis during Recirculation calculation confirms the accident generated RB pressure exceeds the vapor pressure.

Once the RB sump water temperature decreases until the vapor pressure is equal to or less than (–1) psig (approximately 208 degrees F) then a containment pressure equal to (–1) psig is applied. A pressure of (–1) psig is chosen as the lower bound containment pressure as this is the lower bound pressure per TMI Unit 1 Technical Specification 3.6.4. This (–1) psig containment is not considered application of "overpressure" as the initial containment atmosphere must be at least (–1) psig prior to the event to support plant power operations, and is therefore not generated by the accident.

AmerGen Response to Issue 3g.3:

The LPI and BS pumps apply a three percent head drop criterion to determine the NPSH curves consistent with the original plant design. The NPSH data is provided in plant vendor manual drawings.

AmerGen Response to Issue 3g.4:

Pipe friction is included based on piping K-resistance factors using Crane Technical Paper 410 (Reference 19) methodologies. The strainer head loss is provided in the TMI Unit 1 Reactor Building Sump Screen Head Loss Calculation. The TMI Unit 1 Pressure Drop Analysis during Recirculation Calculation details the specific K-factors applied in the computation model.

AmerGen Response to Issue 3g.5:

In a LB LOCA, engineering safeguards automatically actuate both trains of the HPI system, LPI system, RBEC system, and BS system.

A single train of LPI (and Core Flood System operation) is capable of meeting the requirements for core cooling. No HPI is credited in LB LOCA analysis. A single train of BS is capable of satisfying the assumptions of the accident dose consequence analysis. The post LOCA initial containment cooling requirements can be satisfied by various combinations of BS and RBEC. Long term containment cooling is provided by the RBEC system.

Each train of HPI takes water from BWST and injects at 100 to 500 gpm into the RCS over the full range of RCS pressure. Each train of LPI takes water from BWST and injects over 4000 gpm into the reactor vessel once RCS pressure is approaching atmospheric pressure. Operators manually throttle LPI flow to 3300 gpm/train. If at any time, one train of LPI is not functional, operators cross-tie the LPI injection headers and inject into both trains from one pump, or ensure HPI remains in operation. Each train of BS takes water from BWST and sprays approximately 1000 gpm into the reactor building.

RCS leakage and RB spray accumulates in the RB ECCS sump and overflows onto the RB floor. When BWST level is approaching the low action level, operators ensure LPI flow is satisfactory and shutdown HPI. When BWST level is low, operators throttle LPI flow to 3000 gpm/train, open the RB sump isolation valves and close the BWST isolation valves to switch the suction of the LPI & BS pumps from the BWST to the RB sump. Each train of LPI takes water from the RB sump, transfers energy to the DCCS through a closed cycle heat exchanger, and returns flow to the reactor vessel. If one LPI train is not available and the LPI trains have been cross-connected, then LPI is throttled to a total indicated flow of 2800 gpm. Each train of BS takes water from RB sump and sprays approximately 1000 GPM into the reactor building. If both trains of BS are operating, then operators shutdown one train and begin evaluating the need for any building spray flow. If ECCS suction strainer DP is high and both trains of LPI are in service, operators throttle total LPI flow to 3000 gpm.

In a SB LOCA, engineering safeguards automatically actuate HPI system, LPI system, and RBEC system. EFW is automatically actuated to each OTSG. Each train of HPI takes water from BWST and injects at 100 to 500 gpm into the RCS over the full range of RCS pressure. Each train of LPI is operating in recirculation mode. There is no LPI injection into the reactor vessel until RCS pressure is less than 200 psig. Operators raise OTSG levels to maintain boiler condenser cooling capability. Operators throttle HPI if the RCS returns to a subcooled condition. The combination of HPI and RCS leakage, and OTSG heat removal with EFW, is used to cool the core and the RCS. RCS leakage accumulates in the ECCS sump and overflows onto the RB floor. When BWST level is approaching the low action level, operators transfer HPI suction to the LPI pump discharge header. When BWST level is low, operators throttle LPI flow to 3000 gpm/train, open the RB sump isolation valves and close the BWST isolation valves to switch the suction of the LPI & BS pumps from the BWST to the RB sump. If RCS pressure is above LPI pump shutoff head, then each train of LPI takes water from the RB sump, transfers energy to the DCCS through a closed cycle heat exchanger, and supplies cool water to HPI suction. When RCS pressure is reduced, LPI injection to the reactor vessel begins in parallel with HPI. When LPI flow is sufficient and stable, then HPI and EFW are shutdown.

AmerGen Response to Issue 3g.6:

See response for 3.g.5 above.

AmerGen Response to Issue 3g.7:

See response for 3.g.5 above.

AmerGen Response to Issue 3g.8:

The following steps outline the method used to determine minimum containment water level:

1) Determine the mass of water held up in various locations.

2) Determine the volume of structures, systems, and components that may displace volume on the RB floor.

3) Determine the net mass of water that reaches the RB floor: equal to the total minimum injected water plus the water released from the RCS minus the water held up in the RCS.

4) Determine the elevation of the final water level by converting the net mass of water deposited on the floor to a volume and determining what flood elevation results from that volume.

AmerGen Response to Issue 3g.9:

The following assumptions are made to ensure a minimum water level is determined:

1) The LOCA occurs at the highest elevation in the RCS. This results in the maximum amount of coolant being retained in the RCS.

2) The RB sump is assumed to be empty at the beginning of the LOCA event.

3) The Fuel Transfer Canal is assumed to be empty at the beginning of the LOCA event.

4) Both BS loops are assumed to be in operation at the time of recirculation. This results in the maximum amount of water being held up in the Fuel Transfer Canal and RB floors.

5) The CFT and the Borated Water Storage Tank are each assumed to be at their maximum operating temperatures. This represents the smallest mass of water to be injected to the RB.

6) Minimum water volumes are assumed to be injected from the CFTs and BWST.

7) The humidity of the containment atmosphere remains at 100% following the LOCA to maximize the amount of water vapor being held up in the RB atmosphere.

AmerGen Response to Issue 3g.10:

Empty spray pipe: The portion of the RB spray system from the containment isolation valves (BS-V-1A/B) to the spray headers is assumed to be empty at the start of the event. The volume of water required to fill this piping is subtracted from the volume of water available on the containment floor.

Water droplets: Water droplets in transit from the RB spray headers to the RB floor and water in transit from the break location to the floor are subtracted from the volume of water available on the containment floor.

Condensation and holdup on horizontal and vertical surfaces: Condensation that is held up on various surfaces inside the containment building is subtracted from the volume of water available on the containment floor. These surfaces include the RB walls and dome, and steel and concrete surfaces.

The water that collects on the floors at the 308' and 346' elevations in the RB is subtracted from the volume of water available on the containment floor.

AmerGen Response to Issue 3g.11:

The following structures and components are accounted for in the water level calculation:

1) Miscellaneous walls

2) RB Secondary shield

3) RB Primary shield

4) Column and equipment piers/foundations

5) RCP Lube Oil Drain Tanks (However, the volume of water required to fill these tanks is subtracted from the volume of water available on the containment floor.)

6) The inwardly sloped portion of the RB wall (RB skirt) near the floor at elevation 281'.

These structures and components displace water and result in a higher pool level.

AmerGen Response to Issue 3g.12:

The water sources and volumes that contribute to the containment water level for a LOCA are:

1) The Borated Water Storage Tank: 40,684 ft^3

2) The Core Flood Tanks: 1900 ft^3

AmerGen Response to Issue 3g.13:

Credit is not taken for containment accident pressure in determining available NPSH for TMI Unit 1.

AmerGen Response to Issue 3g.14:

Based on the response to section 3g.13, above, this item is not applicable to TMI Unit 1.

AmerGen Response to Issue 3g.15:

The containment pressure is set to the vapor pressure corresponding to the sump liquid temperature when the sump water vapor pressure exceeds (–1) psig in the NPSH computations.

When the sump water temperature vapor pressure no longer exceeds (–1) psig, a lower bound containment pressure of (–1) psig is applied.

AmerGen Response to Issue 3g.16:

Table 14 – LPI Pump NPSH Results

Case	Reactor Building Cooling	Initial Indicated Train Flow (gpm)	Initial Pump Flow (gpm)	Initial Strainer Flow (gpm)	Minimum Excess NPSH (ft- H_2O) [7]
Case I	EQ	3000	3247	8582	0.5
Case II	EQ	3000	3247	6222	1.9
Case III	EQ	2800	3351	3076	2.4
Case IV	EQ	2800	3351	4256	0.1 [8]
Case I	Maximum	3000	3247	8582	11.9
Case II	Maximum	3000	3247	6222	18.5
Case III	Maximum	2800	3351	3076	23.3
Case IV	Maximum	2800	3351	4256	19.5

Table 15 – Building Spray Pump NPSH Results

Case	Reactor Building Cooling	Pump Flow (gpm)	Initial Strainer Flow (gpm)	Minimum Excess NPSH (ft- H_2O)
Case I	EQ	1180	8582	2.0
Case IV	EQ	1180	4256	2.5
Case I	Maximum	1180	8582	13.6
Case IV	Maximum	1180	4256	22.0

The EQ profile results in higher sump temperatures when recirculation is established. The Maximum cool-down profile is evaluated for maximum strainer differential pressure concerns.

- Case I represents two trains of LPI operating at 3000 gpm indicated flow and two trains of BS operating at 1180 gpm.

- Case II represents the same LPI configuration as described in Case I with both BS pumps secured.

- Case III represents a single LPI pump in operation feeding both trains of injection. No BS pumps are operating for this case.

- Case IV represents the same LPI pump configuration as described in Case III with the corresponding BS pump in operation at 1180 gpm.

[7] It was originally reported to the USNRC in 2005 by Reference 8 that the NPSH margin for the LPI and BS pumps in recirculation mode at ECCS and BS switchover was 1.3 and 2.94 (ft- H_2O), respectively. This was provided in response to USNRC required question 2(d)(i) and has not been recalculated for this response.

[8] It was originally reported to the NRC in 2005 by Reference 8 that the "NPSH margin upon installation of the new screen will be 0.6 ft[-H_2O]." The minimum NPSH margin for the LPI pumps is 0.1 ft-H_2O, which includes debris and chemical effects, not included in the basis for the 2005 statement.

USNRC Issue 3h:

Coatings Evaluation

The objective of the coatings evaluation section is to determine the plant-specific ZOI and debris characteristics for coatings for use in determining the eventual contribution of coatings to overall head loss at the sump screen.

1. *Provide a summary of type(s) of coating systems used in containment, e.g., Carboline CZ 11 Inorganic Zinc primer, Ameron 90 epoxy finish coat.*
2. *Describe and provide bases for assumptions made in post-LOCA paint debris transport analysis.*
3. *Discuss suction strainer head loss testing performed as it relates to both qualified and unqualified coatings and what surrogate material was used to simulate coatings debris.*
4. *Provide bases for the choice of surrogates.*
5. *Describe and provide bases for coatings debris generation assumptions. For example, describe how the quantity of paint debris was determined based on ZOI size for qualified and unqualified coatings.*
6. *Describe what debris characteristics were assumed, i.e., chips, particulate, size distribution and provide bases for the assumptions.*
7. *Describe any ongoing containment coating condition assessment program.*

AmerGen Response to Issue 3h.1:

The following types of coating systems are present, or approved to be used, inside Containment, per TMI Unit 1 Engineering Procedures and Specifications.

- Carboline Phenoline 368 over Carboline Phenoline primer
- Carboline Plasite 9009 over Carboline Plasite 7155 primer
- Carboline Phenoline 368 over Carboline Phenoline 368 primer
- Carboline Phenoline 368 over Carboline Carbo Zinc 11 primer
- Carboline Phenoline 368WG over Carboline Carbo Zinc 11 primer
- Carboline Phenoline 368WG over Carboline primer
- Carboline 801 finish
- K&L 6548/7107 and K&L E-Series over Carboline Phenoline 368 primer
- K&L 7107 primer, K&L 7107 surfacer, K&L E-Series epoxy finish coat
- K&L 4129 sealer, K&L 4000 surfacer, K&L D-Series epoxy enamel topcoat
- Unqualified coatings (aluminum hi-temperature coatings, alkyds, enamels, and epoxys) from various manufacturers.

AmerGen Response to Issue 3h.2:

The following assumptions and justifications apply to post-LOCA coating debris transport analysis:

1. It was assumed that the settling velocity of coating particulate can be calculated using Stokes' Law. This is a reasonable assumption since particulate debris is generally spherical and would settle slowly (within the applicability of Stokes' Law).

2. It was conservatively assumed that all debris blown upward would be subsequently washed back down by the containment spray flow. The fraction of debris washed down to various locations was determined based on the spray flow split determined based on the geometry of TMI Unit 1 RB and the BS system.

3. With the exception of debris washed directly to the sump screen or to inactive areas, it was assumed that the fine coating debris that is not blown to upper containment would be uniformly distributed in the recirculation pool at the beginning of recirculation. This is a reasonable assumption, since the initial shallow flow at the beginning of pool fill-up would carry the fine debris to all regions of the pool.

4. During pool fill-up, it was assumed that a fraction of the coating debris would be transported to inactive areas, as well as some debris directly to the sump screen as the sump cavity fills with water. These fractions were determined based on the ratio of the cavity volumes to the pool volume at the point when the cavities are filled.

5. It was assumed that the unqualified coatings in lower containment would enter the recirculation pool in the vicinity of the locations where they are applied. This is a reasonable assumption since unqualified coatings outside the ZOI would break down gradually, and would fail after recirculation was initiated.

6. All unqualified coatings, and qualified coatings within the postulated ZOI, were assumed to fail as particulate in the debris generation analysis for TMI Unit 1. The recirculation transport fraction for particulate debris was assumed to be 100%.

AmerGen Response to Issue 3h.3:

Prototype strainer testing was conducted on a scaled array of strainer top hat sections identical to the materials used in construction of the TMI Unit 1 strainer. The testing considered only coating materials calculated to reach the strainer and did not include coating materials calculated to not transport. Surrogates were used to represent qualified and unqualified coatings. Scaling was by area ratio (test strainer area to plant strainer area). Amounts of surrogate used were scaled from the plant quantities by the area ratio and adjusted by the ratio of the density of the various coating types to the density of the surrogate to ensure an appropriate particle volume (and not an equal mass). NEI 04-07 (Reference 16) specifies the particle size of the qualified coatings at 10 microns with an approximate density of 100 lbs/ft^3 for epoxy and 457 lbs/ft^3 for zinc based coatings.

SIL-CO-SIL™ 53 Ground Silica manufactured by U.S. Silica Company was used as a surrogate for both the approved and non-approved coatings, as well as the particulate portion of Thermolag for debris only testing (without chemical effects).

AmerGen Response to Issue 3h.4:

The ground silica used for debris only testing, SIL-CO-SIL 53, is a spherical particulate ranging in size from just under 1 micron to approximately 100 micron with 98% passing a 53 micron screen. The ground silica material specific gravity is 2.65 which corresponds to a density of 165 lbm/ft^3. Unqualified coatings density is typically on the order of 95 lb/ft^3. An adjustment is made to compensate for the difference in the volume of the material such that an equivalent volume of the surrogate material used. Similarly, qualified coatings identified at TMI Unit 1 have an average density of about 104 lbm/ft^3. The quantity of surrogate material is likewise adjusted to occupy an equivalent volume in the debris bed. Lastly, ground silica is also used as the surrogate material for Thermolag "fire resistant" insulation. As data were not available regarding the microscopic density, the known values for bulk density of Thermolag were assumed to be equivalent. This approach is conservative, as it increases the volume of material in the test. Since a significant portion of the ground silica material is less than 10 micron, the ground silica would tend to produce a debris bed with a lower porosity and higher surface-to-volume ratio than a debris bed comprised of coating materials and Thermolag. Thus, the use of ground silica as a surrogate for coating material is conservative.

The surrogate used in combined debris and chemical effects testing, silicon carbide (SiC), is considered an excellent candidate as a surrogate material due to its resistance to chemical attack by most aqueous acids (including Hydrofluoric Acid (HF), but not concentrated Phosphoric Acid (H_3P0_4)). Furthermore, the material only oxidizes when exposed in air above 1000 degrees C. SiC is utilized in many abrasive applications due to its intrinsic hardness (mechanical stability) and thus is able to retain its general shape and volume. The fine particle size of this material selected is observed to result in appropriate suspension characteristics for modeling particulate debris. In addition, a higher purity SiC is employed to minimize sources of impurities inherent in the manufacturing of any starting materials for SiC.

AmerGen Response to Issue 3h.5:

The following assumptions were applied to coating debris generation calculations.

1. It is assumed that all coatings within the 5D ZOI fail as a result of impingement.

2. Qualified coatings outside the ZOI are assumed to not fail during a design basis accident.

3. The impingement-destroyed coatings fail as 10 micron particles.

4. It is assumed that unqualified coatings not covered by intact insulation fail as a result of post accident environmental conditions. This maximizes the amount of available coating debris and is conservative.

5. It is assumed that the applied thickness of the uncovered unqualified coatings is 6 mils. This is consistent with the average thickness of typical vendor coatings and is double the thickness recommended in NEI 04-07 (Reference 16).

6. It is assumed that 600 ft^2 of failed DBA qualified coatings exists in the RB. It is also assumed that this quantity of failed qualified coatings is on the floor. This, conservatively, results in the largest amount of debris.

7. Q-Deck epoxy coating area is assumed to be 1,520 sq.ft of unqualified epoxy coatings, which is added to the unqualified coating inventory assumed to fail.

8. The density for the Hi Heat Aluminum coatings is derived from similar coating materials on the market today.

AmerGen Response to Issue 3h.6:

Coatings are assumed to be destroyed to 10 micron particulates in accordance with the USNRC SE (Reference 2).

AmerGen Response to Issue 3h.7:

The acceptability of visual inspection as the first step in monitoring of Containment Building coatings is validated by an EPRI Report (Reference 20). Monitoring of Containment Building coatings is conducted at a minimum, once each fuel cycle (Response to GL 98-04) in accordance with TMI Unit 1 and Exelon Fleet program procedures. Monitoring involves conducting a general visual examination of all assessable coated surfaces within the Containment Building, followed by additional nondestructive and destructive examinations of degraded coating areas as directed by the plant Protective Coatings Specialist. Examinations and degraded coating inspections are conducted by qualified personnel as defined in TMI Unit 1 and Exelon Fleet program procedures. Detailed instructions on conducting coating examinations, including deficiency reporting criteria and documentation requirements, are delineated in TMI Unit 1 and Exelon / AmerGen Fleet program procedures.

USNRC Issue 3i:

i. Debris Source Term
The objective of the debris source term section is to identify any significant design and operational measures taken to control or reduce the plant debris source term to prevent potential adverse effects on the ECCS and CSS recirculation functions.

Provide the information requested in GL 04-02 Requested Information Item 2.(f) regarding programmatic controls taken to limit debris sources in containment.

GL 2004-02 Requested Information Item 2(f)

A description of the existing or planned programmatic controls that will ensure that potential sources of debris introduced into containment (e.g., insulations, signs, coatings, and foreign materials) will be assessed for potential adverse effects on the ECCS and CSS recirculation functions. Addressees may reference their responses to GL 98-04, A *Potential for Degradation of the Emergency Core Cooling System and the Containment Spray System after a Loss-of-Coolant Accident Because of Construction and Protective Coating Deficiencies and Foreign Material in Containment," to the extent that their responses address these specific foreign material control issues.*

In responding to GL 2004 Requested Information Item 2(f), provide the following:

1. *A summary of the containment housekeeping programmatic controls in place to control or reduce the latent debris burden. Specifically for RMI/low-fiber plants, provide a description of programmatic controls to maintain the latent debris fiber source term into the future to ensure assumptions and conclusions regarding inability to form a thin bed of fibrous debris remain valid.*
2. *A summary of the foreign material exclusion programmatic controls in place to control the introduction of foreign material into the containment.*
3. *A description of how permanent plant changes inside containment are programmatically controlled so as to not change the analytical assumptions and numerical inputs of the licensee analyses supporting the conclusion that the reactor plant remains in compliance with 10 CFR 50.46 and related regulatory requirements.*
4. *A description of how maintenance activities including associated temporary changes are assessed and managed in accordance with the Maintenance Rule, 10 CFR 50.65.*

If any of the following suggested design and operational refinements given in the guidance report (guidance report, Section 5) and SE (SE, Section 5.1) were used, summarize the application of the refinements.

5. *Recent or planned insulation change-outs in the containment which will reduce the debris burden at the sump strainers*
6. *Any actions taken to modify existing insulation (e.g., jacketing or banding) to reduce the debris burden at the sump strainers*
7. *Modifications to equipment or systems conducted to reduce the debris burden at the sump strainers*
8. *Actions taken to modify or improve the containment coatings program*

<u>AmerGen Response to Issue 3i.1:</u>

Planned activity materials control inside the TMI Unit 1 Reactor Building when containment entry is required, including pre-outage loading of material into containment, is governed by a TMI Unit 1 specific planned containment entry procedure and checklist. The procedure includes requirements to establish controls in accordance with the FME Program procedure for a containment entry.

Exelon / AmerGen Nuclear's fleet wide FME program procedure provides the requirements and guidance to prevent and control introduction of foreign materials into structures, systems, and components. Also included within this procedure are attachments which govern the specific steps necessary to establish and maintain FME areas to prevent foreign material intrusion and to recover/monitor when a loss of FME integrity occurred.

Housekeeping and foreign material assessments after a plant outage and prior to heat-up are performed at the direction of TMI Unit 1 operating procedure which provides the requirements and guidance to perform walkdowns of the Reactor Building to assess debris that may represent a risk of blocking the ECCS recirculation sump screen.

<u>AmerGen Response to Issue 3i.2:</u>

See Response to Issue 3.i.1.
<u>AmerGen Response to Issue 3i.3:</u>

The Exelon / AmerGen Fleet configuration control procedure controls permanent plant changes inside containment so as to not change the analytical assumptions and numerical inputs. A design input consideration was added to the Exelon / AmerGen Fleet's design input and configuration change impact screening procedure to specifically address the PWR Sump GL 2004-02 Program. Engineers are required to review the impact of a proposed change on the documentation that forms the design basis for the response to Generic Letter 2004-02. The specific areas that are addressed, as a minimum, are:

- Insulation inside containment
- Coatings inside containment
- Structural changes (i.e., Choke points) in containment
- Inactive volumes in containment
- Downstream Effects (piping components downstream of the ECCS sump screens)
- Labels inside containment
- Addition of materials inside containment that may produce chemical effects in the post-LOCA flood pool/environment

AmerGen Response to Issue 3i.4:

Maintenance activities including temporary changes are subject to the provisions of 10 CFR 50.65(a)(4) as well as TMI Unit 1's Technical Specifications. Exelon / AmerGen fleet procedures also provide guidance such as the 50.59 Review Process procedure, which provides details and guidance on maintenance activities and temporary alterations; the On-Line Work Control Process procedure, which establishes the administrative controls for performing on-line maintenance of SSCs in order to enhance overall plant safety and reliability; and the Temporary Configuration Changes procedure, which establishes the overall requirements for TCC.

AmerGen Response to Issue 3i.5:

There are no recent or planned insulation change-outs in the TMI Unit 1 containment which will reduce the debris burden at the sump strainers.

AmerGen Response to Issue 3i.6:

No modification to existing insulation was performed to reduce the debris burden at the sump strainers.

AmerGen Response to Issue 3i.7:

The Reactor Building Moisture Barrier was replaced during T1R17 (Fall 2007) with a qualified sealant. The new barrier material was confirmed by testing to not fail and become debris.

AmerGen Response to Issue 3i.8:

TMI Unit 1 created an Unqualified / Degraded Qualified Coating Inventory calculation to programmatically track these coating systems.

<u>USNRC Issue 3j:</u>

Screen Modification Package

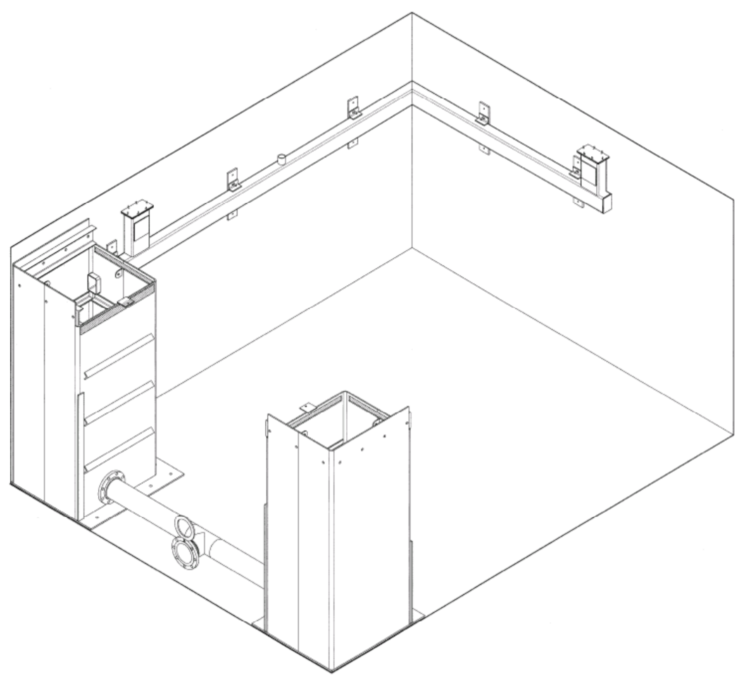
The objective of the screen modification package section is to provide a basic description of the sump screen modification.

1. *Provide a description of the major features of the sump screen design modification.*
2. *Provide a list of any modifications, such as reroute of piping and other components, relocation of supports, addition of whip restraints and missile shields, etc., necessitated by the sump strainer modifications.*

<u>AmerGen Response to 3j.1:</u>

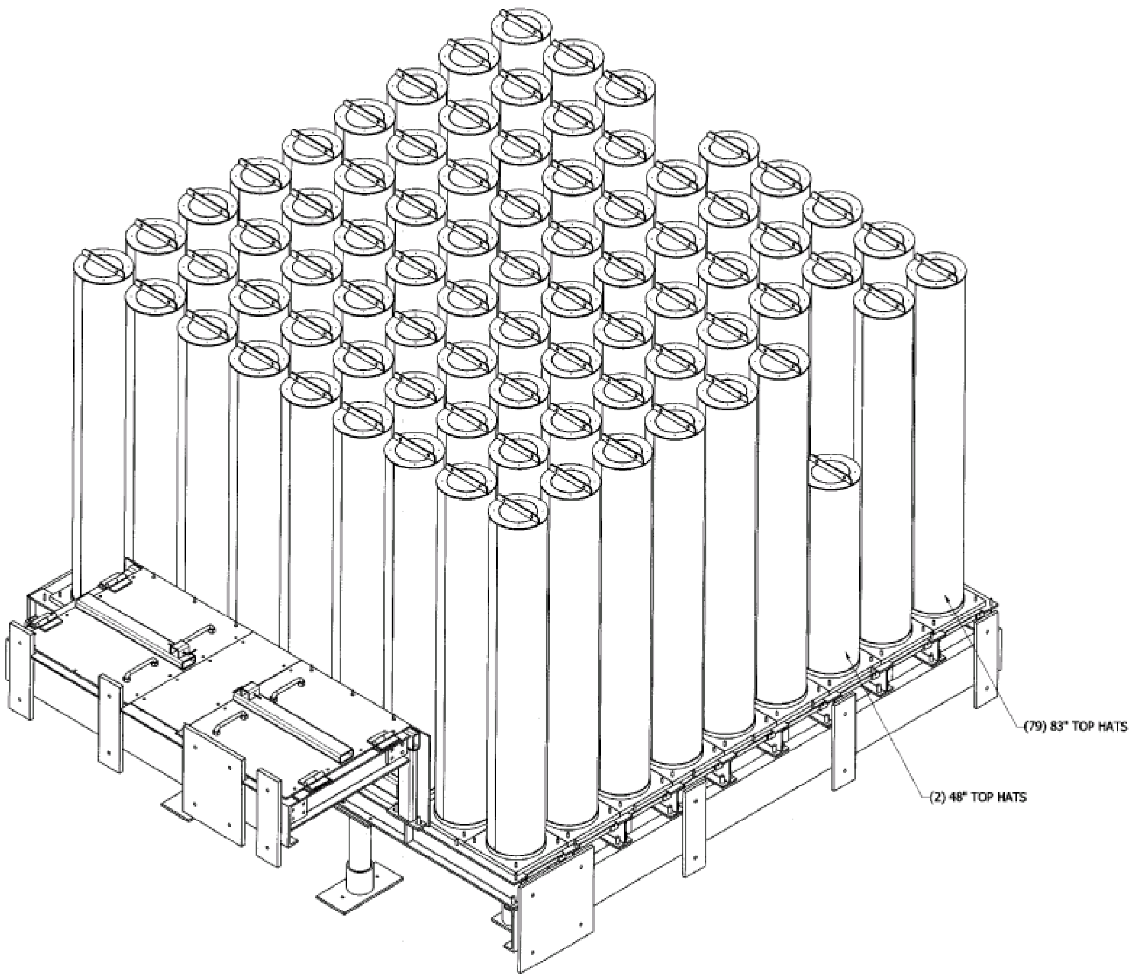
The sump was divided into a normal "wet" sump and an ECCS "dry" sump. The new normal sump design is two (2) boxes that are approximately 3 ft x 2.5 ft in plan and 6 ft in height located in the corners at the west end of the existing sump pit on either side of the ECCS suction pipes.

Figure 3. Schematic of the TMI Unit 1 Reactor Building Sump



The ECCS sump is the remaining volume of the pit. The "box" strainer assembly was replaced with an array of "top hat" strainer modules. The top hat module is comprised of two perforated plate tubes (8" and 12" diameter) forming an annular flow area between. The perforated plate has 3/32" holes and the annular region contains a DBE (wire mesh filter element) to minimize debris bypass that can negatively affect downstream components[9]. There are a total of 81 top hat modules; 79 modules are 83" in long, and two are 48" long[10]. The surface area of the strainer has increased from 224 ft^2 to 2580 ft^2.

Figure 4. Schematic of the TMI Unit 1 Top Hat Array

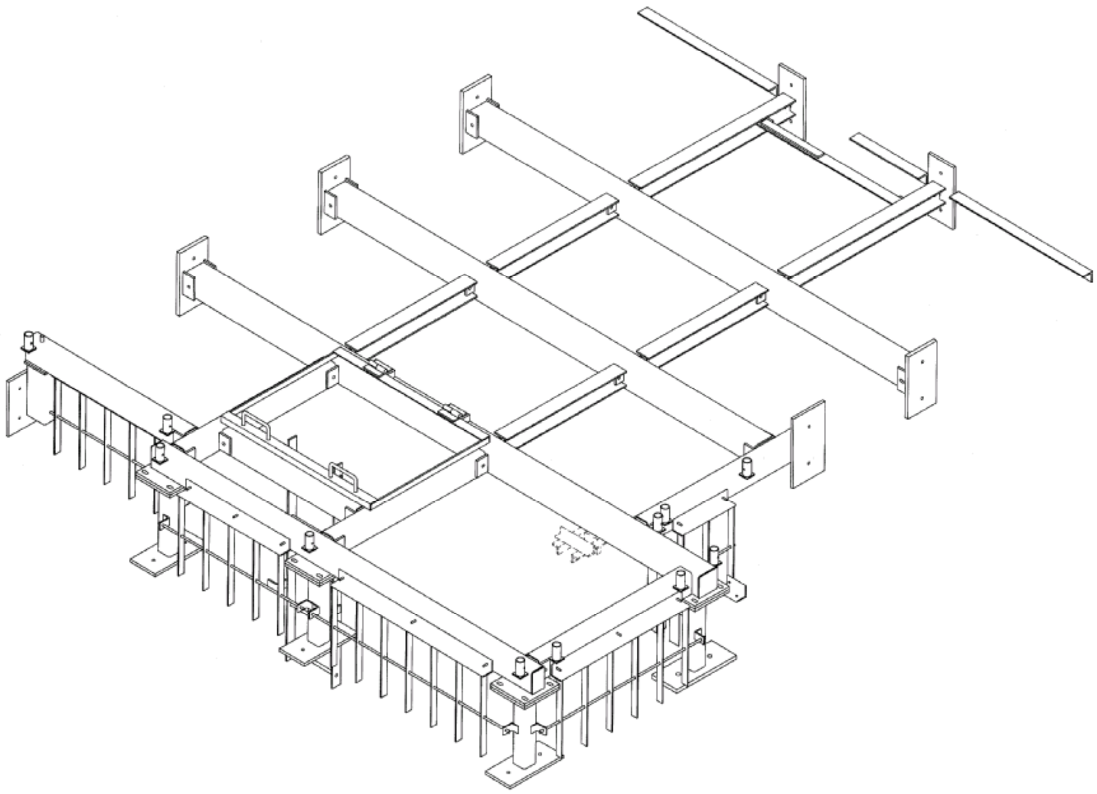


[9] It was originally reported to the NRC by AmerGen in the GL 2004-02 Supplemental Response (Reference 8) dated September 1, 2005, that the "new strainer will be designed to prevent particles greater than 1/8 inch from passing." The straining surface has 3/32-inch diameter holes.

[10] Two modules limited to 48" tall were installed to clear existing interferences.

The trash rack covers the strainer assembly. The new trash rack has horizontal grating and vertical bars to ensure that the trash rack does not become the primary screen surface. Thus the trash rack protects the strainer from large debris.

Figure 5. Schematic of the TMI Unit 1 Trash Rack. *Note: the grating was removed for clarity.*



<u>AmerGen Response to 3j.2:</u>

The following piping interferences with the new sump trash rack have been modified:

- ¾" Tubing check valve test vent line containing VT-V-24B
- ¾" FTC leak detection lines from behind the canal liner in the deep end of the canal.
- Extended valve stem for WDL-V-520

The following normal drain lines emptied into the sump below the grating, outside of the old strainer cage and were redirected to the new normal sumps:

- 4" FTC drain downstream of valve SF-V 31
- 2" Reactor cavity drain line discharging through WDL-V-520
- Two other 4" embedded RB floor drain lines
- ½" Leak off drain line from SF-V-24

Configuration changes were made to address upstream flow concerns.

- Replacement of the door to the entrance of the D-rings
- Installation of fuel transfer canal drain strainer.

The internals of the DH throttle valves have been replaced with a new design that has larger passageways. The overall capacity of the valve was not changed. The changes were based on the downstream effects evaluations, discussed in this response, which identified additional corrective actions were needed for the DH manual throttle valves.

An access ladder located at the southeast corner of the sump, which allows access to the 291'-0" elevation, was modified to make room for the trash rack.

Radiation monitor RM-G-21 was elevated above RB flood level to make room for the strainer and trash rack.

The RB sump level instruments were modified. Water level in and above the RB sump is now monitored by three sets of redundant safety grade level instruments: (1) RB Flood Level (WDL-LT-806 & 807) provides indication of water level above the RB sump. The instrument range is 0" to 90" where 0" is equal to 281'0" elevation. (2) ECCS Sump Level (DH-LT-810 & 811) provides indication of water level in the "dry" ECCS sump. The instrument range is 0" to 144" where 0" is equal to 273'6" elevation. (3) Normal RB Sump Level (WDL-LT-804 & 805) provides indication of water level in the "wet" normal sump tanks. The instrument range is 0" to 144" where 0" is equal to 273'6" elevation.

<u>*USNRC Issue 3k:*</u>

Sump Structural Analysis
The objective of the sump structural analysis section is to verify the structural adequacy of the sump strainer including seismic loads and loads due to differential pressure, missiles, and jet forces. Provide the information requested in GL 2004-02 Requested Information Item 2(d)(vii). GL 2004-02 Requested Information Item 2(d)(vii) Verification that the strength of the trash racks is adequate to protect the debris screens from missiles and other large debris. The submittal should also provide verification that the trash racks and sump screens are capable of withstanding the loads imposed by expanding jets, missiles, the accumulation of debris, and pressure differentials caused by post-LOCA blockage under flow conditions.

1. *Summarize the design inputs, design codes, loads, and load combinations utilized for the sump strainer structural analysis.*
2. *Summarize the structural qualification results and design margins for the various components of the sump strainer structural assembly.*
3. *Summarize the evaluations performed for dynamic effects such as pipe whip, jet impingement, and missile impacts associated with high-energy line breaks (as applicable).*
4. *If a backflushing strategy is credited, provide a summary statement regarding the sump strainer structural analysis considering reverse flow.*

<u>AmerGen Response to Issue 3k.1:</u>

The replacement strainer top hats were modeled utilizing standard static analysis methods in GTSTRUDL and hand calculations. The strainer supporting structure, normal sump structure, and trash rack were modeled in GTSTRUDL using dynamic analysis methods. Deadweight, thermal, seismic (including hydrodynamic mass) and differential pressure loads were considered.

Design Inputs/Loads
The following are the design inputs and loads used in the qualification of the structures:

Material Properties
The strainer is constructed of type 304 SS and 316 SS. Appropriate allowables are assumed for individual parts in the analyses. Stainless steel fasteners (bolts, studs, anchors) are incorporated into the design and analyses are performed with appropriate allowables.

Concrete Strength
A concrete strength of 5000 psi is used in the evaluation of concrete anchors.

Deadweight:Weight, densities, etc.
Stainless steel weights are based on a density of 0.29 lbs/cu-in.

Design Temperature and Thermal Expansion
Thermal expansion of the structure at 300 degrees F is considered. Generally, thermal releases in the form of bolted/slotted connections are employed in the design to minimize the impact of thermal stresses.

Differential Pressure Loading
A differential pressure loading of 7 psi was placed on all strainer external surfaces.

Seismic

- Damping values: 2.5 % for bolted steel structure is given for OBE & SSE.
- 2% damping value is conservatively used for OBE & SSE.
- The strainer structure is installed above EL. 273'-6", thus TMI Unit 1 used the chart for Reactor-Inside Concrete Response Spectra at elevation 304'- 6".
- The Vertical response spectra are 2/3 of horizontal response spectra
- SSE response spectra = OBE response spectra x 2.

Hydrodynamic Mass
Hydrodynamic mass is considered due to submergence of structure during post LOCA condition.

Seismic Inertia Loading
For Dynamic Modal Analyses (Trash Rack, Normal Sump, Strainer Structure), the following Seismic Combination Methods were applied:

- Modal responses: Modal response is combined using the GRP method for closely spaced modes.
- Directional responses: The responses due to each of the three directional components of the earthquake are combined by using the SRSS method

Design Codes
The following are the representative design codes and references used in the qualification of these structures:

- Annual Book of ASTM Standards, 1993
- AISC Manual of Steel Construction, 9th Edition
- ASME Section III, 1989 Edition
- ANSI/AWS D1.6 "Structural Welding Code-Stainless Steel"

Loads, Load Combinations, and Allowables
The following load combinations are analyzed for the Top Hats, Normal Sump Structure, and Strainer Structure:

- Dead Weight + Thermal + Seismic (SSE) including Hydrodynamic Mass + Differential Pressure

The following load combination requirements are applicable to the *Trash Rack:*

- Normal:
  - Dead Weight + Thermal

  OR
  - Dead Weight + 100 psf, Live Load

The following load combination was conservatively applied to the trash rack:

- Dead Weight + Thermal + Seismic (SSE) including Hydrodynamic Mass + HELB (pipe whip & jet impingement, etc) + Live Load, 50 psf

Dead load, differential pressure, and seismic load are combined algebraically to obtain worst-case results. Hydrodynamic mass is added in the frequency analysis since the structure is submerged under LOCA conditions.

In GTSTRUDL analysis all members are evaluated based on normal allowables unless noted otherwise. Member stresses and weld stresses shall be less than the allowable specified in AISC Manual of Steel Construction, 9th Edition. Anchor bolt loads shall be kept below the allowable limits specified in TMI Unit 1 bolting specifications. Also, high strength bolt loads shall be below the allowable specified in ASME Section III, 1989 Edition.

<u>AmerGen Response to Issue 3k.2:</u>

The structural qualifications were performed in four separate analyses:

1) Analysis of the Reactor Building Sump Strainer Top Hat

2) Analysis of the Reactor Building Sump Strainer Structure

3) Analysis of the Reactor Building Sump Strainer Trash Rack

4) Analysis of the Reactor Building Normal Sump

Given the loading combinations and inputs described above, qualifications for all of these structures were found to have applied loads within allowable limits. These structures are capable of withstanding the required design differential pressure loads (where applicable), deadweight loads, seismic loads (including hydrodynamic loads), and thermal loads at design temperatures of 300 degrees F.

<u>AmerGen Response to Issue 3k.3:</u>

An evaluation has been performed which concluded the strainer is not subject to pipe whip, jet impingement, or missile impact associated with a HELB.

<u>AmerGen Response to Issue 3k.4:</u>

A backflushing strategy is not credited in the TMI Unit 1 analyses.

USNRC Issue 3l.

Upstream Effects
The objective of the upstream effects assessment is to evaluate the flowpaths upstream of the containment sump for holdup of inventory, which could reduce flow to and possibly starve the sump. Therefore, provide a summary of the upstream effects evaluation including the information requested in GL 2004-02, "Requested Information," Item 2(d)(iv) including the basis for concluding that the water inventory required to ensure adequate ECCS or CSS recirculation would not be held up or diverted by debris blockage at choke-points in containment recirculation sump return flowpaths.

1. *Summarize the evaluation of the flow paths from the postulated break locations and containment spray washdown to identify potential choke points in the flow field upstream of the sump.*
2. *Summarize measures taken to mitigate potential choke points.*
3. *Summarize the evaluation of water holdup at installed curbs and/or debris interceptors.*
4. *Describe how potential blockage of reactor cavity and refueling cavity drains was evaluated, including likelihood of blockage and amount of expected holdup.*

AmerGen Response to Issue 3l.1:

Evaluations of the flow paths from the postulated break locations and containment spray washdown have been reviewed and no choke points exist. Previous choke points identified in the 2005 GL 2004-02 Response for TMI Unit 1 (Reference 8) have been resolved by plant modifications (See section 2j.2) or further evaluation that determined the location not to be a choke point.

AmerGen Response to Issue 3l.2:

No measures are necessary to mitigate potential choke points.

AmerGen Response to Issue 3l.3:

No new curbs and/or debris interceptors were installed. See response below for refueling cavity drains.

AmerGen Response to Issue 3l.4:

The FTC drain line provides a flow path for water from the FTC to the RB Sump during accident conditions. The volume of water captured in the FTC is 4,644 gallons (620.8 cu ft).

USNRC Issue 3m:

Downstream effects - Components and Systems
The objective of the downstream effects, components and systems section is to evaluate the effects of debris carried downstream of the containment sump screen on the function of the ECCS and CSS in terms of potential wear of components and blockage of flow streams. Provide the information requested in GL 04-02, "Requested Information," Item 2.(d)(v) and 2.(d)(vi) regarding blockage, plugging, and wear at restrictions and close tolerance locations in

the ECCS and CSS downstream of the sump by explaining the basis for concluding that inadequate core or containment cooling would not result due to debris blockage at flow restrictions in the ECCS and CSS flowpaths downstream of the sump screen, (e.g., a HPSI throttle valve, pump bearings and seals, fuel assembly inlet debris screen, or containment spray nozzles). The discussion should consider the adequacy of the sump screen's mesh spacing and state the basis for concluding that adverse gaps or breaches are not present on the screen surface. For GL 2004-02, Item 2(d)(vi) provide verification that the close-tolerance subcomponents in pumps, valves and other ECCS and CSS components are not susceptible to plugging or excessive wear due to extended post-accident operation with debris-laden fluids.

GL 2004-02 Requested Information Item 2(d)(v)
The basis for concluding that inadequate core or containment cooling would not result due to debris blockage at flow restrictions in the ECCS and CSS flowpaths downstream of the sump screen, (e.g., a HPSI throttle valve, pump bearings and seals, fuel assembly inlet debris screen, or containment spray nozzles). The discussion should consider the adequacy of the sump screen's mesh spacing and state the basis for concluding that adverse gaps or breaches are not present on the screen surface.

GL 2004-02 Requested Information Item 2(d)(vi)
Verification that the close-tolerance subcomponents in pumps, valves and other ECCS and CSS components are not susceptible to plugging or excessive wear due to extended post-accident operation with debris-laden fluids.

1. *If USNRC-approved methods were used (e.g., WCAP-16406-P with accompanying USNRC SE) briefly summarize the application of the methods.*
2. *Provide a summary and conclusions of downstream evaluations.*
3. *Provide a summary of design or operational changes made as a result of downstream evaluations.*

AmerGen Response to Issue 3m.2(d)(v):

Analysis was performed using the guidance from WCAP-16406-P (Reference 10). One modification to DH manual throttle valves was performed during T1R17 (Fall 2007) to address a downstream effect concern. Each is discussed in more detail below. Collectively, the analyses conclude that no additional actions or modifications are necessary.

Test data were obtained for an ECCS cyclone separator design installed at Byron and Braidwood Nuclear Power Stations. The tests measured the differential pressure across a cyclone separator with debris-laden water over a 24-hour period. The results demonstrated that the design was debris tolerant and would continue to function with debris laden water. The debris loading evaluation considered both the size distribution and types of debris that could pass through the containment sump strainers and the flow rate through the cyclone separators. The analysis concluded that the test data were applicable to the TMI Unit 1 cyclone separators. Therefore, TMI Unit 1 cyclone separators are not expected to become blocked with debris following a LOCA.

In the event of a CF injection line break coincident with a failure of the opposite LPI train, the DH Pumps are unable to provide core cooling. In this situation, post-accident core cooling is provided by the MU, or HPI Pumps. This CF LOCA scenario is the limiting event for evaluation of the MU Pumps. For this postulated event, as discussed below, the pumps are shown to operate reliably for at least 30 days, as required by the USNRC SE (Reference 2), following the LOCA.

The TMI Unit 1 MU Pumps have been evaluated for operation with debris entrained in the water from the containment sump. The analyses were performed consistent with the guidance provided in Westinghouse report WCAP-16406-P (Reference 10). However, there were several instances where the analyses were performed using approaches slightly different from the WCAP methodology. The changes and the basis for each are summarized in the response to 3m.2(d)(vi).1 below.

The MU Pump downstream effects analysis included the following.

- Wear analyses to predict the increase in make-up pump close clearances during debris operation.

- Thermal-hydraulic calculations to determine the required injection flow following a CF line LOCA.

- Analyses to evaluate hydraulic capability of the make-up pump with increased clearances compared to the required injection flow.

- Rotordynamic analyses to predict pump vibration levels and rotordynamic performance with the increased clearances.

The hydraulic and rotordynamic analyses demonstrated that make-up pump performance would be satisfactory in the worn condition and the make-up pumps would perform their required safety function.

AmerGen Response to Issue 3m.2(d)(vi).1:

The following documents were created to detail the evaluations performed on the impact of debris passed by the sump strainer on select ECCS and BS flow path components:

Evaluation of Containment Recirculation Sump Downstream Effects
This calculation evaluated the flow paths and components of the ECCS and BS (with the exception of the cyclone separators, MU pumps, and the fuel) that are required to operate following a DBA using the guidance and methodology set forth in the WCAP-16406-P (Reference 10). These components, with their respective evaluation results, are summarized in Table 16.

Table 16. TMI Unit 1 Components Requiring Evaluation per WCAP-16406-P

Component Number	Description	Evaluation Results	Component Number	Description	Evaluation Results
BS-FE-1	Orifice	Acceptable	DH-P-1B	Pump	Acceptable*
BS-FE-2	Orifice	Acceptable	DH-C-1A	Cooler	Acceptable
BS-FE-1299	Orifice	Acceptable	DH-C-1B	Cooler	Acceptable
BS-FE-1300	Orifice	Acceptable	MU-V-16A	Globe	Acceptable
	Spray Nozzle	Acceptable	MU-V-16B	Globe	Acceptable
BS-P-1A	Pump	Acceptable *	MU-V-16C	Globe	Acceptable
BS-P-1B	Pump	Acceptable *	MU-V-16D	Globe	Acceptable
DH-V-147	Globe	Acceptable	MU-23-FE1	Flow Nozzle	Acceptable
DH-V-148	Globe	Acceptable	MU-23-FE2	Flow Nozzle	Acceptable
DH-V-149	Globe	Acceptable	MU-23-FE3	Flow Nozzle	Acceptable
DH-V-150	Globe	Acceptable	MU-23-FE4	Flow Nozzle	Acceptable
DH-V-151	Globe	Acceptable	MU-FE-384	Cavitating Venturi	Acceptable *
DH-V-152	Globe	Acceptable	MU-FE-385	Cavitating Venturi	Acceptable *
DH-V-56A	Globe	Acceptable	MU-FE-386	Cavitating Venturi	Acceptable *
DH-V-56B	Globe	Acceptable	MU-FE-387	Cavitating Venturi	Acceptable *
DH-V-19A	Angle	Acceptable	Cold Leg RC-P-1A	M/U Nozzle Thermal Sleeve	Acceptable
DH-V-19B	Angle	Acceptable	Cold Leg RC-P-1B	M/U Nozzle Thermal Sleeve	Acceptable
DH-V-4A	Gate	Acceptable	Cold Leg RC-P-1C	M/U Nozzle Thermal Sleeve	Acceptable
DH-V-4B	Gate	Acceptable	Cold Leg RC-P-1D	M/U Nozzle Thermal Sleeve	Acceptable
	CF Nozzle Flow Restrictor	Acceptable	DH-V69	Check	Acceptable
	CF Nozzle Flow Restrictor	Acceptable	RC-V-4	Globe	Acceptable
DH-FE-1	Orifice	Acceptable	RC-V-23	Check	Acceptable
DH-FE-2	Orifice	Acceptable	Pressurizer Spray	Nozzle	Acceptable
DH-P-1A	Pump	Acceptable *	MU cyclone separator inlet piping	Orifice	Acceptable

* Evaluations were performed using the debris depletion methodology

GSI-191 Downstream Effects Analysis for Make-Up Pumps
This calculation evaluated the MU Pumps using the guidance and methodology set forth in the WCAP-16406-P (Reference 10). This includes a wear analysis, hydraulic analysis, and rotordynamic analysis of the MU Pumps. It was concluded that the pumps are capable of providing the necessary long term cooling and no configuration changes to the MU pumps are required.
The MU Pump wear analysis approach was modified slightly from the approach presented in WCAP-16406-P (Reference 10). The modifications to the approach and the basis for each change are summarized below.

- An erosive wear model was not included in the analysis because this mode of degradation does not apply to pumps. If included, the maximum erosive wear rate for the pumps would be negligible (on the order of 1×10^{-7} in/hr).
- Wear of the central volute bushing was calculated.
- The suction wear ring wear factor was not applied for conservatism.
- The Archard model friction coefficient was calculated to provide more conservative results relative to the approach recommended in the WCAP-16406-P (Reference 10) report.

GSI-191 Downstream Effects Analysis for Cyclone Separators
This calculation evaluated the BS, DH, and MU pump cyclone separators using the guidance and methodology set forth in the Westinghouse WCAP-16406-P (Reference 10). Debris laden testing was performed on the Byron and Braidwood Plant's cyclone separators, which showed that the cyclone separators are not expected to become blocked with debris following a LOCA. This report demonstrates that the test results are applicable to TMI Unit 1 cyclone separators since they are very similar in design and function. Most importantly, the limiting flow passages are the same size. Therefore, it was concluded that no configuration changes are required in regards to the BS, DH, and MU pump cyclone separators.

<u>AmerGen Response to Issue 3m.2(d)(vi).2:</u>

The above discussion provides the results of each of the analyses for downstream evaluations. In conclusion, no additional actions or modifications were necessary.

<u>AmerGen Response to Issue 3m.2(d)(vi).3:</u>

Using the configuration change process, an Engineering Change Package was completed to replace the internals of the DH system throttling valves, DH-V-19A/B. The existing valves were 10" drag valves. The stacked disk cage design used in the valves contained small openings in the disk stack that had the potential to become blocked with the small debris that could pass through the Reactor Building Sump Strainer. These valve disk stacks were therefore replaced in T1R17 (Fall 2007) with a new design with larger flow passages less susceptible to blockage by fibrous debris.

USNRC Issues 3.n

Downstream Effects - Fuel and Vessel
The objective of the downstream effects, fuel and vessel section is to evaluate the effects that debris carried downstream of the containment sump screen and into the reactor vessel has on core cooling.

1. *Show that the in-vessel effects evaluation is consistent with, or bounded by, the industry generic guidance (WCAP-16793), as modified by USNRC comments on that document. Provide a basis for any exceptions.*

AmerGen Response to Issue 3n.1**:**

AREVA, TMI Unit 1's fuel supplier, performed an evaluation to estimate the effect on core cooling from debris that may enter the RCS from containment when the ECCS suction is switched to the containment sump. In particular, an assessment of potential core blockage was performed that considered all RCS break locations, the potential for particulates to be transported to the core inlet, and the effect of fibrous debris. The guidance provided to the industry in WCAP-16406-P (Reference 10) was used to provide the framework of this analysis. It was demonstrated that the cladding temperature remains well below 2200 degrees F (less than 904 degrees F).

The TMI Unit 1 Downstream Analysis (Fuels) calculation using WCAP-16793-NP (Reference 11) evaluates the core chemical effects associated with LTCC capability of TMI Unit 1 considering the presence of fibrous, particulate and chemical debris in the recirculating fluid following a postulated design basis LOCA. This evaluation was performed based upon bounding plant-specific design parameters and the guidance published within WCAP-16793-NP and the associated LOCADM Spreadsheet to evaluate the expected final scale thicknesses and peak cladding temperatures expected for a single postulated condition. The results of the evaluation state that the acceptance criteria outlined in the evaluation [Cladding temperature upper limit of 800 degrees F; Deposition limit of 50 mil (1270 microns) for debris (on top of existing oxide and crud layers)] were met throughout the accident. The LOCADM simulation of plant-specific conditions resulted in peak cladding temperatures of approximately 439 degrees F, and final maximum scale thickness of approximately 205.6 microns. The final scale thicknesses and peak cladding temperatures were determined to be well below the limiting values, and hence the acceptance criteria and requirements within 10 CFR 50.46 have been satisfied. Therefore, the results of this LOCADM simulation have shown that TMI Unit 1 specific chemical plate-out in bounding conditions does not prevent adequate removal of core decay heat.

USNRC Issues 3.o

Chemical Effects
The objective of the chemical effects section is to evaluate the effect that chemical precipitates have on head loss and core cooling.

1. *Provide a summary of evaluation results that show that chemical precipitates formed in the post-LOCA containment environment, either by themselves or combined with debris, do not deposit at the sump screen to the extent that an unacceptable head loss results, or deposit downstream of the sump screen to the extent that long-term core cooling is unacceptably impeded.*
2. *Content guidance for chemical effects is provided in Enclosure 3 to a letter from the NRC to NEI dated September 27, 2007 (ADAMS Accession No. ML0726007425).*
   2.1 Sufficient 'Clean' Strainer Area
      i. *Those licensees performing a simplified chemical effects analysis should justify the use of this simplified approach by providing the amount of debris determined to reach the strainer, the amount of bare strainer area*

and how it was determined, and any additional information that is needed to show why a more detailed chemical effects analysis is not needed.

2.2 *Debris Bed Formation*

i. *Licensees should discuss why the debris from the break location selected for plant-specific head loss testing with chemical precipitate yields the maximum head loss. For example, plant X has break location 1 that would produce maximum head loss without consideration of chemical effects. However, break location 2, with chemical effects considered, produces greater head loss than break location 1. Therefore, the debris for head loss testing with chemical effects was based on break location 2.*

2.3 *Plant Specific Materials and Buffers*

i. *Licensees should provide their assumptions (and basis for the assumptions) used to determine chemical effects loading: pH range, temperature profile, duration of containment spray, and materials expected to contribute to chemical effects.*

2.4 *Approach to Determine Chemical Source Term (Decision Point)*

i. *Licensees should identify the vendor who performed plant-specific chemical effects testing.*

2.5 *Separate Effects Decision (Decision Point)*

i. *State which method of addressing plant-specific chemical effects is used.*

2.6 *AECL Model*

i. *Since the NRC USNRC is not currently aware of the testing approach, the NRC USNRC expects licensees using it to provide a detailed discussion of the chemical effects evaluation process along with head loss test results.*

ii. *Licensees should provide the chemical identities and amounts of predicted plant-specific precipitates.*

2.7 *WCAP Base Model*

i. *For licensees proceeding from block 7 to diamond 10 in the Figure 1 flow chart [in Enclosure 3 to a letter from the NRC to NEI dated September 27, 2007 (ADAMS Accession No. ML0726007425)], justify any deviations from the WCAP base model spreadsheet (i.e., any plant specific refinements) and describe how any exceptions to the base model spreadsheet affected the amount of chemical precipitate predicted.*

ii. *List the type (e.g., AlOOH) and amount of predicted plant-specific precipitates.*

2.8 *WCAP Refinements: State whether refinements to WCAP-16530-NP were utilized in the chemical effects analysis.*

2.9 *Solubility of Phosphates, Silicates and Al Alloys*

i. *Licensees should clearly identify any refinements (plant-specific inputs) to the base WCAP-16530 model and justify why the plant-specific refinement is valid.*

ii. *For crediting inhibition of aluminum that is not submerged, licensees should provide the substantiation for the following: (1) the threshold concentration of silica or phosphate needed to passivate aluminum, (2) the time needed to reach a phosphate or silicate level in the pool that would result in aluminum passivation, and (3) the amount of containment spray time (following the achieved threshold of chemicals) before aluminum that is sprayed is assumed to be passivated.*

iii. *For any attempts to credit solubility (including performing integrated testing), licensees should provide the technical basis that supports extrapolating solubility test data to plant-specific conditions. In addition, licensees should indicate why the overall chemical effects evaluation remains conservative when crediting solubility given that small amount of chemical precipitate can produce significant increases in head loss.*

iv. *Licensees should list the type (e.g., AlOOH) and amount of predicted plant specific precipitates.*

2.10 Precipitate Generation (Decision Point)

i. *State whether precipitates are formed by chemical injection into a flowing test loop or whether the precipitates are formed in a separate mixing tank.*

2.11 Chemical Injection into the Loop

i. *Licensees should provide the one-hour settled volume (e.g., 80 ml of 100 ml solution remained cloudy) for precipitate prepared with the same sequence as with the plant-specific, in-situ chemical injection.*

ii. *For plant-specific testing, the licensee should provide the amount of injected chemicals (e.g., aluminum), the percentage that precipitates, and the percentage that remains dissolved during testing.*

iii. *Licensees should indicate the amount of precipitate that was added to the test for the head loss of record (i.e., 100 percent 140 percent).*

2.12 Pre-Mix in Tank

i. *Licensees should discuss any exceptions taken to the procedure recommended for surrogate precipitate formation in WCAP-16530.*

2.13 Technical Approach to Debris Transport (Decision Point)

i. *State whether near-field settlement is credited or not.*

2.14 Integrated Head Loss Test with Near-Field Settlement Credit

i. *Licensees should provide the one-hour or two-hour precipitate settlement values measured within 24 hours of head loss testing.*

ii. *Licensees should provide a best estimate of the amount of surrogate chemical debris that settles away from the strainer during the test.*

2.15 Head Loss Testing Without Near Field Settlement Credit

i. *Licensees should provide an estimate of the amount of debris and precipitate that remains on the tank/flume floor at the conclusion of the test and justify why the settlement is acceptable.*

ii. *Licensees should provide the one-hour or two-hour precipitate settlement values measured and the timing of the measurement relative to the start of head loss testing (e.g., within 24 hours).*

2.16 Test Termination Criteria

i. *Provide the test termination criteria.*

2.17 Data Analysis:

i. *Licensees should provide a copy of the pressure drop curve(s) as a function of time for the testing of record.*

ii. *Licensees should explain any extrapolation methods used for data analysis.*

2.18 Integral Generation (Alion)

2.19 Tank Scaling / Bed Formation

i. *Explain how scaling factors for the test facilities are representative or conservative relative to plant-specific values.*

ii. *Explain how bed formation is representative of that expected for the size of materials and debris that is formed in the plant specific evaluation.*

2.20 *Tank Transport*

i. *Explain how the transport of chemicals and debris in the testing facility is representative or conservative with regard to the expected flow and transport in the plant-specific conditions.*

2.21 *30-Day Integrated Head Loss Test*

i. *Licensees should provide the plant-specific test conditions and the basis for why these test conditions and test results provide for a conservative chemical effects evaluation.*

ii. *Licensees should provide a copy of the pressure drop curve(s) as a function of time for the testing of record.*

2.22 *Data Analysis Bump Up Factor*

i. *Licensees should provide the details and the technical basis that show why the bump-up factor from the particular debris bed in the test is appropriate for application to other debris beds.*

AmerGen Response to Issue 3o.1:

Chemical precipitates that form in the post-LOCA containment environment combined with debris do not result in an unacceptable head loss. Head loss due to chemical precipitates and debris is demonstrated by test using WCAP-16530-NP (Reference 12) methods with relatively minor modifications. See sections 3.o.2.9 and 3.o.2.10 for additional detail.

AmerGen Response to Issue 3o.2.1.i

TMI Unit 1 is not performing a simplified chemical effects analysis. The plant has significant fibrous insulation postulated to be destroyed in a design basis accident. No bare screen is expected and no credit is taken for bare screen.

AmerGen Response to Issue 3o.2.2.i

A break in the East D-ring hot leg has the largest potential for fibrous debris generation and transport. A break in the West D-ring has the largest potential for particulate debris. Chemical effects testing used a conservative combination of the highest quantity of each type of debris from each break location.

AmerGen Response to Issue 3o.2.3.i

The following assumptions were applied to the modified WCAP-16530-NP (Reference 12) chemical effects testing for head loss.

1. It is assumed that the pH of the pool is approximately 4.5[11] for break flows and building spray flows prior to recirculation. The borated water in the reactor coolant and in the borated water storage tank contains 2750 ppm by weight boron (added as boric acid).

2. It is assumed that the pH after the buffer is fully dissolved is approximately 8.0. The buffer is TSP in granular form stored in baskets located in the reactor building at elevations lower than the minimum pool level. Sufficient buffer is stored to raise the pH

[11] It was originally reported in Reference 9 the "spray pH during the injection phase may be as low as 4.6." For testing purposes the spray pH was bound using 4.5 pH.

of the borated water a maximum of 8.0 with minimum water level and to greater than or equal to 7.3 with maximum water available. It is assumed (and was calculated) that the buffer fully dissolves within four (4) hours post-LOCA for a DBA.

3. The temperature profile used to calculate the possible chemical effects is the equipment EQ temperature profile. This maximizes the duration at elevated temperature, which maximizes the potential for corrosion of materials within the RB.

4. Containment sprays are assumed to be in operation for no more than 24 hours post-LOCA.

5. The main corrosion products that participate in chemical effects head loss are:

    - Calcium dissolved from concrete and glass fibers
    - Aluminum dissolved from metallic aluminum and hi-temperature aluminum coatings
    - Silica dissolved (primarily) from glass fibers and concrete
    - Phosphate and sodium from the TSP buffer.

6. It is assumed that the sump pool is never fully mixed, which ensures that dissolution rates from the various materials are not inhibited by one another.

7. For each applicable break case, all insulation destroyed within the ZOI is assumed to be present in the pool and therefore subject to reaction with pool chemistry.

8. The plant specific data for sump temperature versus time and containment temperature versus time was provided in the TMI Unit 1 LB LOCA EQ Temperature Profile calculation. The profile provided in the calculation extends out to 1,000,000 seconds (11.6 days). The profile was extrapolated until it reaches 95 degrees F at 30 days.

9. The mission time was assumed to be 30 days in accordance with the USNRC SE (Reference 2)

10. The aluminum components which are not exposed to direct spray were not included in the chemical effects testing analysis.

<u>AmerGen Response to Issue 3o.2.4.i</u>

Alion Science and Technology performed plant-specific chemical effects testing for TMI Unit 1.

<u>AmerGen Response to Issue 3o.2.5.i</u>

TMI Unit 1 plant specific chemical effects head loss was determined by two (2) sets of chemical effects testing:

1. 30-day integrated chemical effects testing – to understand the development of precipitates within the plant specific environment with respect to temperature and time under realistic conditions and their impact on head loss.

2. WCAP based prototype testing – utilizing the results of the 30-day testing, WCAP precipitates are added to the prototype test to determine the impact of chemical effects on head loss.

Testing used methods presented in WCAP-16530-NP (Reference 12) and WCAP-16785-NP (Reference 13) to determine the quantity of precipitates to be used.

<u>AmerGen Response to Issue 3o.2.6.i</u>

TMI Unit 1 does not use the AECL model.

<u>AmerGen Response to Issue 3o.2.6.ii</u>

TMI Unit 1 does not use the AECL model.

<u>AmerGen Response to Issue 3o.2.7.i</u>

TMI Unit 1 does not proceed from block 6 to diamond 10 in the Figure 1 flow chart detailed in Enclosure 3 of Reference 4, shown below as Figure 6, as WCAP refinements (block 8) are utilized on aluminum oxy-hydroxide components, as noted in the response to question 2.o.2.8.i.

Figure 6. NRC Chemical Effects Evaluation Process Flow Diagram

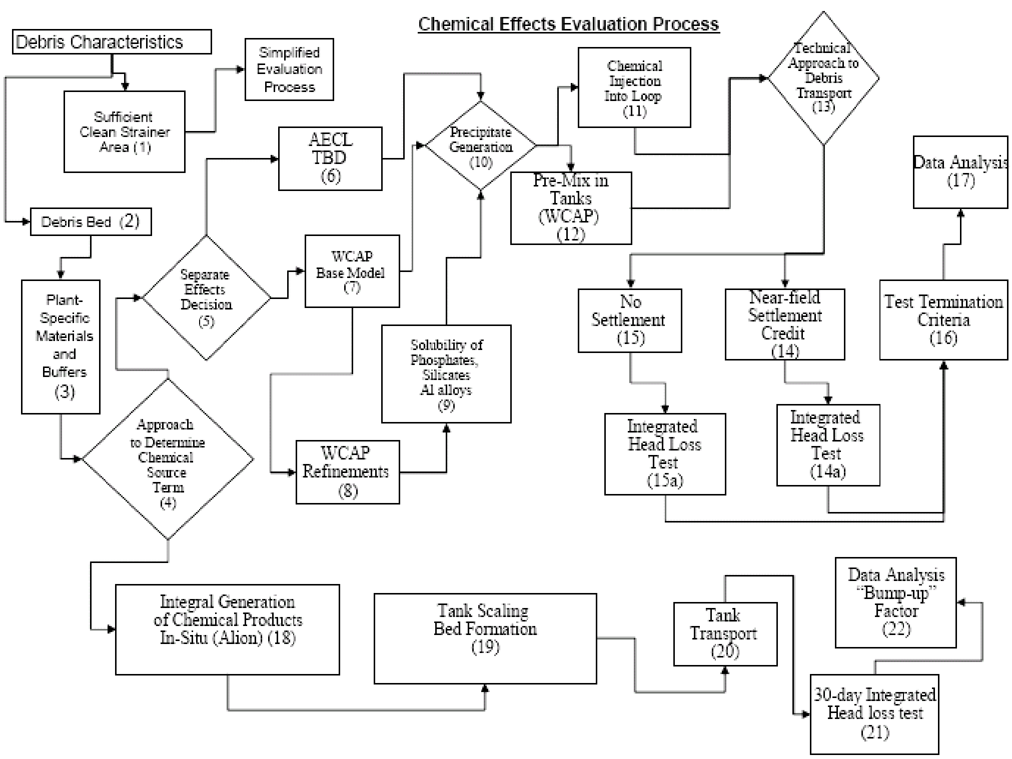


Figure 6 above, was taken from Enclosure 3, Figure 1 of Reference 4.

AmerGen Response to Issue 3o.2.7.ii

Table 17. Quantities of WCAP precipitate at TMI Unit 1

Precipitate	WCAP-16530	WCAP-16785	Qualified Loads
Sodium Aluminum Silicate	327.7 lbs	327.7 lbs	327.7 lbs
Aluminum Oxy-Hydroxide	112.0 lbs	95.7 lbs	95.7 lbs
Calcium Phosphate	34.3 lbs	34.3 lbs	34.3 lbs

AmerGen Response to Issue 3o.2.8.i

For TMI Unit 1, as shown in Table 17, the use of WCAP-16785-NP (Reference 13) resulted only in a slight reduction in aluminum oxy-hydroxide.

AmerGen Response to Issue 3o.2.9.i

The Alion Science and Technology 30-day integrated chemical effects testing identified that calcium phosphate precipitates can form very early post-LOCA due to the very low and retrograde solubility of calcium phosphate (lower solubility at high temperature). The 30-day integrated testing also identified that aluminum based precipitants do not form until the post-LOCA environment has cooled to below 140 degrees F. The prototype testing used these results to sequence the WCAP-16530-NP / 16785-NP (References 12 and 13) based precipitates. Head loss calculations used the head loss attributed to calcium phosphate to determine the head loss across the strainer at temperatures greater than 140 degrees F when the NPSH margin is limiting. Head loss calculations used the head loss attributed to aluminum and calcium precipitates at temperatures at or less than 140 degrees F when structural integrity of the screen is limiting.

The 30 day integrated testing and analyses concluded that no aluminum based precipitates would form in the TMI Unit 1 environmental conditions with a pH less than 8.0, therefore any reduction in the aluminum oxy-hydroxide precipitate is reasonable. The amount of aluminum oxy-hydroxide postulated to precipitate by WCAP-16785-NP (Reference 13) methods is less than that postulated by WCAP-16530-NP (Reference 12) by about 15% and the quantity of precipitate considered in the testing and final NPSH value remains conservative.

AmerGen Response to Issue 3o.2.9.ii

No Credit is taken at TMI Unit 1 for the inhibition of aluminum that is not submerged.

AmerGen Response to Issue 3o.2.9.iii

See response to 3o2.9i above.

AmerGen Response to Issue 3o.2.9.iv

See response to 3o.2.7ii above.

AmerGen Response to Issue 3o.2.10.i

Precipitates used in testing are formed in a separate mixing tank and subsequently introduced into the test loop.

AmerGen Response to Issue 3o.2.11.i

Chemical injection into the test loop was not used by TMI Unit 1 testing.

AmerGen Response to Issue 3o.2.11.ii

Chemical injection into the test loop was not used by TMI Unit 1 testing.

AmerGen Response to Issue 3o.2.11.iii

Chemical injection into the test loop was not used by TMI Unit 1 testing.

AmerGen Response to Issue 3o.2.12.i

No exceptions were taken to the recommended procedure in WCAP-16530-NP (Reference 12) at TMI Unit 1.

AmerGen Response to Issue 3o.2.13.i

No near field settlement was credited. (Refer to response 3.f.12)

AmerGen Response to Issue 3o.2.14.i

No near field settlement was credited. (Refer to response 3.f.12)

AmerGen Response to Issue 3o.2.14.ii

No near field settlement was credited. (Refer to response 3.f.12)

AmerGen Response to Issue 3o.2.15.i

The quantity of precipitate is added to the test tank as an additional debris source. The prototype testing performed by Alion Science and Technology does not credit near-field settling. A certain amount of material (both debris and precipitate) does accumulate in corners and other pockets in the tank. The quantities are negligible and reasonable and are consistent with testing best practices and occurred despite full turbulence within the test tank. Their impact on the results is insignificant.

<u>AmerGen Response to Issue 3o.2.15.ii</u>

The one-hour precipitate settlement values are provided in Tables 18 to 20.

Table 18: Calcium Phosphate Precipitate Settlement Values

Batch	Settled Volume (mL)	Time from date tested to date used (days)
Ca 11	5.1	15
Ca 12	5.2	8
Ca 13	6.6	8
Ca 14	6.2	8
Ca 15	5.6	8
Ca 16	4.4	8

Table 19. Sodium Aluminum Silicate Precipitate Settlement Values

Batch	Settled Volume (mL)	Time from date tested to date used (days)
Na 246	7.0	11
Na 247	8.0	11
Na 248	7.2	11
Na 249	9.2	11
Na 250	8.5	11
Na 251	9.5	11
Na 252	8.0	11
Na 253	8.5	11
Na 254	5.5	11
Na 255	6.0	11
Na 256	5.5	11
Na 257	5.5	11
Na 258	7.0	11
Na 259	7.1	11
Na 260	6.0	11
Na 261	5.5	11
Na 262	5.0	11
Na 263	6.1	11

Table 20. Aluminum Oxy-Hydroxide Precipitate Settlement Values

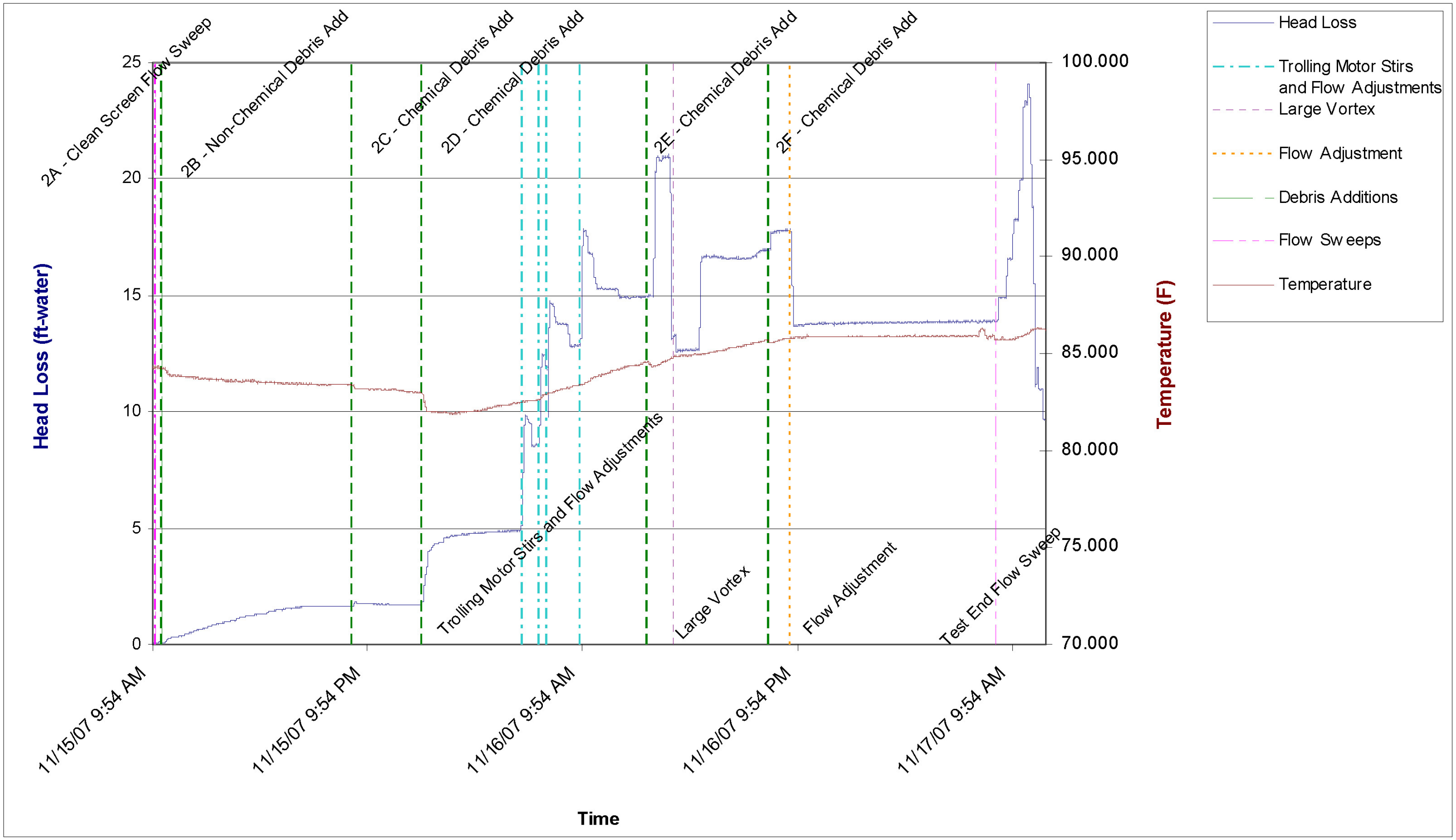
Batch	Settled Volume (mL)	Time from date tested to date used (days)
AIO 21	8.6	9
AIO 22	6.6	9
AIO 23	8.1	9
AIO 24	6.3	7
AIO 25	6.0	7
AIO 26	8.2	7
AIO 27	8.8	7
AIO 28	8.3	7
AIO 29	7.8	7
AIO 30	7.9	1
AIO 31	7.9	1
AIO 32	7.5	1
AIO 33	7.8	1
AIO 34	6.8	1
AIO 35	8.0	1

AmerGen Response to Issue 3o.2.16.i

Testing was continued until all precipitates were added.

<u>AmerGen Response to Issue 3o.2.17.i</u>

Figure 7. TMI Unit 1 Pressure Drop Curve as a Function of Time for TMI Unit 1



AmerGen Response to Issue 3o.2.17.ii

No extrapolation methods were used for test data analysis.

AmerGen Response to Issue 3o.2.18.i

Alion Science and Technology performed integrated chemical effects tests for TMI Unit 1. These tests are used to modify WCAP methods as noted above. The head loss results of these integrated tests are not used to determine the head loss of the plant strainer and debris.

AmerGen Response to Issue 3o.2.19.i

Based on the response to section 3o.2.18i, this item is not applicable to TMI Unit 1.

AmerGen Response to Issue 3o.2.19.ii

Based on the response to section 3o.2.18i, this item is not applicable to TMI Unit 1.

AmerGen Response to Issue 3o.2.20.i

Based on the response to section 3o.2.18i, this item is not applicable to TMI Unit 1.

AmerGen Response to Issue 3o.2.21.i

Based on the response to section 3o.2.18i, this item is not applicable to TMI Unit 1.

AmerGen Response to Issue 3o.2.21.ii

Based on the response to section 3o.2.18i, this item is not applicable to TMI Unit 1.

AmerGen Response to Issue 3o.2.22.i

No bump up factor is used in the TMI Unit 1 analyses.

USNRC Issue 3p:

Licensing Basis
The objective of the licensing basis section is to provide information regarding any changes to the plant licensing basis due to the sump evaluation or plant modifications. Provide the information requested in GL 04-02, "Requested Information," Item 2.(e) regarding changes to the plant licensing basis. That is, provide a general description of and planned schedule for any changes to the plant licensing bases resulting from any analysis or plant modifications made to ensure compliance with the regulatory requirements listed in the Applicable Regulatory Requirements section of this generic letter. Any licensing actions or exemption requests needed to support changes to the plant licensing basis should be included. The effective date for changes to the licensing basis should be specified. This date should correspond to that specified in the 10 CFR 50.59 evaluation for the change to the licensing basis.

AmerGen Response to Issue 3p:

AmerGen submitted TSCR 337, "Reactor Building Emergency Sump pH Control System Buffer Change" on June 29, 2007 (Reference 9) for NRC approval. The changes updated Technical Specification section 3.3.1.3, "Reactor Building Spray System and Reactor Building Emergency Core Cooling System." Related changes to Technical Specifications 3.3.2.1 and 4.1, and the Bases were also made. Approval for Technical Specification Amendment no. 263 was granted by the USNRC on December 21, 2007 (Reference 7).

There are no additional TSCRs required for GL 2004-02 issues.

The effective date for the changes to the licensing basis is December 27, 2007.

References

NRC References

1. Generic Letter 2004-02, “Potential Impact of Debris Blockage on Emergency Recirculation During Design Basis Accidents at Pressurized-Water Reactors,” dated September 13, 2004

2. Safety Evaluation by the Office of Nuclear Reactor Regulation Related to NRC Generic Letter 2004-02, Nuclear Energy Institute Guidance Report (Proposed Document Number NEI 04-07), “Pressurized Water Reactor Sump Performance Evaluation Methodology,” Issued December 6, 2004.

3. NUREG/CR-6224, “Parametric Study of the Potential for BWR ECCS Strainer Blockage Due to LOCA-Generated Debris”, dated October 1995

4. NRC Evaluation Guidance for the Review of GSI-191 Plant-Specific Chemical Effect Evaluations, Revision 0, September 2007

5. Letter from W. H. Ruland (NRC) to A. Pietrangelo (Nuclear Energy Institute), “Revised Content Guide for Generic Letter 2004-02 Supplemental Responses,” dated November 21, 2007

6. Deleted

7. Letter from P. J. Bamford (NRC) to C. G. Pardee (AmerGen Energy Company, LLC), “Three Mile Island Nuclear Power Station, Unit 1 -Issuance of Amendment Regarding Reactor Building Sump pH Buffer Change (Amendment 263),” dated December 21, 2007

AmerGen / NRC Correspondence

8. Letter from P. B. Cowan (AmerGen Energy Company, LLC) to U. S. Nuclear Regulatory Commission “Exelon/AmerGen Response to NRC Generic Letter 2004-02, ‘Potential Impact of Debris Blockage on Emergency Recirculation During Design Basis Accidents at Pressurized-Water Reactors,’” dated September 1, 2005

9. Letter from P. B. Cowan (AmerGen Energy Company, LLC) to U. S. Nuclear Regulatory Commission. “Technical Specification Change Request (TSCR) 337, “Reactor Building Emergency Sump pH Control System Buffer Change” dated June 29, 2007

Westinghouse Reports

10. WCAP-16406-P, “Evaluation of Downstream Sump Debris Effects in Support of GSI-191,” Revision 1

11. WCAP-16793-NP, Evaluation of Long Term Core Cooling Associated With Sump Debris Effects”, Revision 0

12. WCAP-16530-NP, “Evaluation of Post-Accident Chemical Effects in Containment Sump Fluids to Support GSI-191,” Revision 0

13. WCAP-16785-NP, “Evaluation of Additional Inputs to the WCAP-16530-NP Chemical Model,” Revision 0

14. WCAP-16568-P, “Jet Impingement Testing to Determine the Zone of Influence (ZOI) for DBA Qualified/ Acceptable Coatings,” Revision 0

15. WCAP-16710-P, “Jet Impingement Testing to Determine the Zone of Influence (ZOI) of Min-K and NUKON® Insulation for Wolf Creek and Callaway Nuclear Operating Plants, “ Revision 0

NEI Reports

16. NEI 04-07, “Pressurized Water Reactor Sump Performance Evaluation Methodology”, Revision 0

17. NEI 02-01 “Condition Assessment Guidelines: Debris Sources Inside PWR Containment” Revision 0

Other

18. Three Mile Island Unit 1 Updated Final Safety Analysis Report, Revision 18

19. Crane Valve Company, “Flow of Fluids Through Valves, Fittings, and Pipes - Technical Paper #410, “ Crane Valve Company, Long Beach, CA, 1988

20. EPRI Report No. 1014883, "Plant Support Engineering: Adhesion Testing of Nuclear Coating Service Level 1 Coatings," August 2007