Chemical/Temperature Effects on Containment Sump Head Loss

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NRC Meeting

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Chemical/Temperature Effects on Containment Sump Head Loss

- Background
  - NRC has completed testing that shows that chemical/temperature induced degradation mechanisms could contribute to debris generation and head loss
  - Information is still forthcoming
  - NRC plans to issue NUREG in the future.
    - Need information as soon as possible

ATTACHMENT 2

Plan of Action

- Industry is initiating scoping studies aimed at better understanding the effects of post-LOCA chemical effects on PWR ECCS Sump Screen head loss.
- Industry plans to aid in the resolution of this issue

Scoping Direction

- Get a better understanding on corrosion rates under LOCA conditions in Containment
  - Understand how Zinc and Aluminum corrosion products pacivate themselves
  - Compare PWR accident conditions to conditions reported in LASL presentation
  - Compare corrosion rates reported by LASL with:
    - WCAP-7316A and WCAP 8776
    - ORNL-TM-2368, ORNL-TM-2412 and ORNL-TM-2425
    - and other open literature
  - Compare corrosion rates
    - Submergence versus spray
    - Zinc coatings versus galvanized surfaces

Scoping Direction

- Determine how the corrosion by-products react with the "soup"in the containment after LOCA.
  - Better understand the solubility and insolubility of Zinc and Aluminum in the sump water

Scoping Direction

- What affect does the corrosion by-products have on ECCS pump head loss
  - What type of flock is the by-product?
  - Can NUREG/ CR 6224 be used?

OEM Protective Coating DBA Testing

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Chemical Precipitation Issue
on GSI-191, (PWR Sumps)
September 10, 2003

PSE EPRI

OEM Protective Coating Design Basis Accident Testing

Background

- The USNRC currently holds the position that 100% of DBA unqualified coating in PWR containment may fail during LOCA or MSLB (GL 98-04, Bulletin 2003-01)
  - Becomes potential ECCS sump debris
  - GSI-191, PWR sump performance
- Many OEM Components supplied with DBA unqualified coating material (usually a standard shop oil based alkyd)
  - electrical cabinets
  - small cranes
  - motors
  - pipe support components
  - other components

PSE EPRI

OEM Protective Coating Design Basis Accident Testing

Project Objectives

- Develop defensible basis for reduction in quantity of unqualified coatings assumed to fail during a PWR DBA to a value significantly less than 100%

Project Activities

- Review of existing original EQ DBA testing photographs of various plant equipment types to determine the "after DBA test" paint condition for those components
- Perform coatings testing, in accordance with ANSI N5.12 and ANSI N101.2, on 2"x 4" coupons from OEM painted components
  - Typical PWR radiation dose
  - Typical PWR temperature profile
  - Any coatings debris will be captured and characterized

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OEM Protective Coating Design Basis Accident Testing

Deliverable(s)

Technical Report – that determines the potential impact of OEM coatings on post accident debris source term

Schedule

6-9 months

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OEM Protective Coating Design Basis Accident Testing

PSE Status

- This 2004 Candidate Task was presented to the EPRI, Plant Support Engineering (PSE) Subcommittee during their August 19-20, 2003 meeting.
- Voting / approvals of 2004 Candidate Task has not yet been performed. However, this task was met with very favorable opinions by many utilities present, (i.e., project expected to be approved.)

PSE EPRI

ATTACHMENT 3

COMMENTS ON NEI DRAFT GUIDANCE

A review of the NEI draft guidance (made available July 1, 2003) resulted in the following comments. Because the draft guidance has been provided to the NRC in sections, these comments do not represent a thorough review regarding the overall acceptability of the integrated guidance document. Comments are offered on the following topics: General presentation, Fracture Mechanics, Debris Generation, Debris Transport, and Head Loss.

General

1. More attention should be given to the knowledge base report (NUREG/CR-6808) to ensure that important phenomena and processes are not neglected.

2. The NEI guidance contains many assumptions that need supporting justification.

3. If not experimentally determined, the values assumed for parameters of data missing from the parameter matrices should be conservatively based. Each parameter value should be individually referenced and justified.

4. More attention should be given to the NRC SER that was written on the BWROG URG, because significant discrepancies still exist between NRC and industry recommendations on issues such as debris generation. Where these discrepancies are noted, the NRC SER should be adopted in the guidance unless new analyses or experimental data are offered to support a differing opinion.

Fracture Mechanics

1. Because these concepts are new to the sump screen and strainer blockage issues, the NEI guidance should offer references that demonstrate previous NRC review and acceptance of fracture mechanics and leak-before-break theory and test data.

Debris Generation

1. The volume of the hemispherical ZOI associated with break flow from a circular hole should have a volume equivalent to the freely expanding jet volume within the appropriate damage-pressure isobar, not ½ of a 12-D sphere (Table 4-1, Option 4). When defining the size of non-spherical ZOI, the guidance should always fall back to the principal of equivalency to the appropriate jet volume. This issue is similar to the robust barriers point made in Section 4.2.2 where the radius of the truncated sphere is redefined so that it has the same volume as the equivalent sphere. Under the proposed guidance, reduction in ZOI volume comes from the assumed size of the orifice, not from geometric reduction of the damage volume. It should also be noted in the guidance that ZOI volume is a function of the insulation type. The cited value of 12 times the orifice diameter is recommended by the staff for high-pressure, two-phase jets impinging on unjacketed fiberglass. Other insulation types may be more robust, thus having higher damage pressures and smaller ZOI.

2. Depressurization flows can generate miscellaneous debris beyond the ZOI normally associated with common insulation types, e.g., tags, tape, plastic sheeting, burst light bulbs, etc. This type of debris generation should also be considered.

3. Guidance is specifically included for calcium silicate (Section 6.2) but not for the other microporous insulations. The guidance should treat all microporous insulations as a class with specific data or appropriate conservatisms recommended for each member of the class. Min-K, for example, is used in PWR containments and behaves in a manner similar if not worse than calcium silicate with respect to head loss. It should also be noted that these types of insulation have their own fiber built into the insulation matrix, but that the internal fiber constituent tends to be rather fine compared to a low-density fiberglass (LDFG) insulation like NUKON, for example.

4. Table 6-1 recommends using the NUKON debris-size distribution data for other types of fibrous insulation where test data is lacking. This may be reasonable for LDFG insulations similar to NUKON (e.g., Transco), but it may be an unjustified assumption for HDFG insulations like Temp Mat and for mineral wool. The debris generation data for these types of insulation are very limited (BWROG URG AJIT testing). Furthermore, some advice should be given regarding the effects of coverings for these types of insulation. Unless the required data is achieved through testing, the conservative approach would be to skew the NUKON size distribution significantly towards smaller debris fractions.

5. The guidance should recommend NRC endorsed damage pressures rather than the BWROG recommended damage pressures whenever the two values do not agree and no additional data are available to support the alternate recommendation. In Table 6-1, the recommendation for NUKON jacketed with modified "Sure-Hold" bands, Camloc strikers, and latches is 190 psi, but the NRC recommendation was 150 psi in Appendix B of the NRC SER to the BWROG URG. The reasons for this reduction are discussed in Appendix B of the SER.

6. Table 6-1 suggests that the destruction pressure for Fiberglass-Transco might be found in NUREG/CR-6369. These tests did not determine threshold destruction pressures, rather, targets were all placed for maximum destruction to provide maximum debris loadings for debris transport. However, the CEESI tests described in NUREG/CR-6369 did provide data on the debris size distribution. For example, these tests clearly showed that a significant fraction of the debris was in the form of very fine and highly transportable fibers. The debris size distribution for Transco fiberglass is likely to be better known than that for NUKON.

7. In Table 6-2, the parameter ' >24 ' should read ' <24 ' (see NUREG/CR-6762, Volume 3). Also, the suggestion that a generic destruction pressure for calcium silicate be set at 20 psi was made in NUREG/CR-6808 (Page 3-18. Footnote 17), not in the NRC SER to the BWR URG.

8. The debris size distribution could be determined using an appropriate volume integral rather than simply adapting a test result. This approach was described in NUREG/CR-6808, Section 3.3.3. This approach favors the industry, because for a given spherical ZOI, more volume exists at the fringes of the sphere where the jet pressures, and hence the damage fractions, are lower.

9. In Figure 1-1, the item "Determine Spherical ZOI Outer Boundary" also requires information from the item "Identify Destruction Characteristics", i.e., the type of insulation determines the damage pressure, which in turn, determines the radius of the ZOI. This figure should note that source term data is debris-type specific.

10. In Section 2.2, the identity of fire barrier materials should also be noted.

11. Section 2.3.1.4 needs clarification. What point is being made?

12. Section 3.1.1 needs clarification. How, for example, does the timing of the head loss account for the break size? The break size determines the debris generation, which in turn, determines the head loss, not the other way around.

13. In Section 3.5.4 (or some other suitable location), it should be noted that because debris accumulation is transient, a minimum uniform thin-bed layer could form early in the transport even if the total predicted debris accumulation was a great deal more than this minimum layer. In other words, even if the total debris generation predictions indicate relatively thick mixed beds, the thin-bed effect can still be a concern.

14. In Section 5.2.1.3.6, the assumption regarding the use of 4 times the gap width to determine debris volume should be justified.

15. In Section 5.2.3.3.3, it should be noted that these same water holdup volumes should be considered in the minimum sump-water-level analyses.

16. In Section 6.6.7.2, caution should be taken when assuming destruction pressures without appropriate test data, and the assumptions should include conservative safety factors. Further, these assumed destruction pressures should receive adequate peer review and NRC endorsement before their application to debris generation analyses.

Debris Transport

1. At present, it appears that the NEI guidance is focused on predicting bulk sump-pool flow velocities, which will presumably be used to determine whether or not debris will transport along the containment floor by tumbling and sliding motions. As such, the NEI debris transport guidance is incomplete and does not adequately reflect the base of knowledge on the subject (i.e., NUREG/CR-6808). In particular:

   a. NEI guidance does not address blowdown or washdown debris transport. If this implies that NEI is recommending the assumption of 100% transport to the containment floor, the guidance should explicitly state this assumption. While this approach is conservative, it limits licensee options for more refined analyses.
   b. NEI guidance does not specifically address suspended debris transport (or buoyant debris transport). The importance of accounting for the transport of fine fibrous and fine particulate debris has clearly been demonstrated by testing. Such debris can form very uniform beds of debris that can result in high head losses (thin-bed effect).
   c. NEI guidance does not address the effects of pool turbulence. The guidance should discuss the potential of turbulence to keep debris in suspension, particularly near spray-water cascades into the pool, and how turbulence may further degrade certain types of debris (fibrous and microporous) to form more of the very fine, highly transportable debris. Testing has demonstrated the formation of fine debris from larger pieces caused by pool turbulence and thrashing.

d. NEI guidance does not address sump-pool fill-up debris transport, as opposed to quasi-steady-state debris transport. Debris initially deposited onto the containment floor easily travels as water spreads across the floor in sheets. Even entire cassettes and insulation blankets will move under these conditions. This phase may be important to a licensee for justifying fractions of debris that are sequestered in dead pool regions sheltered from spray-water cascades and directed flow paths established during recirculation. Transport during fill up may also be the dominant vulnerability for RMI plants with horizontal sump screens or vertical screens that do not have much height above the floor.
e. NEI guidance does not address the entry of debris into the pool, which must be specified in order to determine ultimate transport. Determining the pattern of containment spray drainage is very important here, both because the debris would tend to enter the pool with the flow and because the spray drainage strongly affects pool flow patterns and flow turbulence.

2. The NEI guidance mentions entrapment of debris in isolated areas of the pool where flow velocities are not sufficient to transport the debris. Care must be taken with this assumption so that the eventual transport of suspended or buoyant debris is not underestimated. In particular, dead pool regions must be sheltered from spray-water drainage and from direct spray impingement. Total isolation for the duration of the accident scenario may be difficult to ensure.

3. The NEI guidance uses the term "transportable debris" (Sections 6.1 and 6.5.4 and perhaps others) insinuating that certain types or sizes of debris are not transportable and perhaps could be dismissed from consideration. The use of this term is not recommended because all debris is transportable under some conditions, such as, during the initial fill-up phase where cassettes and blankets have been shown to move readily.

4. Most of the data for such parameters as floor tumbling velocities and curb-lift velocities were obtained in laboratory conditions where a great effort was taken to ensure uniform and relatively non-turbulent flow. In realistic conditions, water flows may be substantially less stable than those established in the tests. Therefore, debris may still transport even though the predicted bulk flow velocities are less than the lab determined minimum velocity needed to move the debris. This is particularly true if approximate methods are used to estimate the bulk flow velocity. Some level of conservatism should be factored into the recommended debris transport velocities to ensure a conservative estimate of debris accumulation on the screen. Each recommended threshold velocity should be justified. Where test data is lacking, the recommended parameters should be adjusted to permit additional transport.

5. The provided calcium silicate data does not reflect the fact that a substantial portion of this debris will be in the form of dust suspended in the pool and that this type of debris tends to degrade (disassociate) in water when any significant pool turbulence exists.

6. The NEI guidance recommends the network flow method as an alternative to CFD calculations for predicting flow velocities in the sump pool. The network method is more appropriate for closed piping systems than for open-channel flow in a pool of water, and it has several potential deficiencies when applied to debris transport within a sump pool. The guidance should eventually comment on these issues and provide benchmark comparisons with data and 3-D calculations to adequately validate the method for debris transport. Potential deficiencies include the following:

a. The network method is much less detailed in terms of nodalization relative to a CFD calculation.
b. The network method will not predict pool turbulence. Therefore, the method cannot indicate the suspension of debris that will not settle even in calm pools. Nor can the method be used to indicate the potential for further degradation of debris due to thrashing.
c. The network solution will provide channel-averaged velocities rather than three-dimensional velocities patterns. Realistic flow patterns include such features as vortices and floor sheeting (near water inlet flows) that have been shown to substantially affect debris transport. The network-method average flow could predict that debris would not move along the floor when, in fact, a localized faster flow near the floor might actually move debris forward from that location.
d. The network method requires many more input parameters that must be estimated *a priori* than does a CFD model. These parameters must be estimated from correlations that are generally developed for non-pool flow conditions. Each of these parameter estimates will introduce uncertainties that will compound.
e. Spray drainage analysis for the volunteer plant illustrated that the drainage enters the sump pool at many location including floor drains from the level above the pool, stair wells, containment liner flow, refueling pool drains, elevator shaft, sump level containment spray trains, etc. The corresponding sump pool flow patterns have been shown to be very complex and three-dimensional. At each drainage entrance location, a floor-level sheeting effect can be established. Adequate treatment of these complex effects should be demonstrated by comparisons with CFD calculations and transport test data..

Head Loss

1. The present NEI guidance needs much more information regarding head-loss correlations, head-loss data bases, and the validation of the correlations using applicable test data.

2. In Section 6.5.4 it may be very inappropriate to assume that tape, sticker, and tag debris (and plastic sheeting materials) would be reduced to fine debris or small pieces. If flow conditions suggest potential transport of these items, the appropriate method would be to estimate the head loss assuming fine pieces, and then to recalculate the head loss assuming that each item remains intact and independently covers an area of the screen, thereby reducing the effective screen area. The assumption predicting the higher head loss would then be conservative.