May 12, 2003

MEMORANDUM TO: ACRS Members

FROM: Michael Snodderly, Cognizant ACRS Staff Engineer

Michael Snodderly

SUBJECT: CERTIFICATION OF THE MINUTES OF THE MEETING OF THE ACRS SUBCOMMITTEE ON THERMAL-HYDRAULIC PHENOMENA, FEBRUARY 4, 2003 - ROCKVILLE, MARYLAND

The minutes of the subject meeting, issued May 8, 2003, have been certified as the official record of the proceedings of that meeting. A copy of the certified minutes is attached.

Attachment: As stated

cc: J. Larkins
S. Bahadur
H. Larson
S. Duraiswamy
ACRS Staff Engineers

Issued:05/08/2003
Certified:05/10/2003

ADVISORY COMMITTEE ON REACTOR SAFEGUARDS
MEETING OF THE ACRS SUBCOMMITTEE ON
THERMAL-HYDRAULIC PHENOMENA
MEETING MINUTES - FEBRUARY 4, 2003
ROCKVILLE, MARYLAND

INTRODUCTION

The ACRS Subcommittee on Thermal-Hydraulic Phenomena met on February 4, 2003, at 11545 Rockville Pike, Rockville, MD, in Room T-2B3. The purpose of this meeting was to review two proposed NRC documents for resolution of Generic Safety Issue (GSI) 191: "Assessment of Debris Accumulation on PWR Sump Pump Performance". These documents are: proposed NRC Generic Letter (GL) 2003-XX, "Potential Impact of Debris Blockage on Emergency Recirculation During Design-Basis Accidents at Pressurized Water Reactors", and associated draft Regulatory Guide DG-1107, "Water Sources for Long-Term Recirculation Cooling Following a Loss-of-Coolant Accident".

The Nuclear Energy Institute requested an opportunity to discuss their efforts associated with the resolution of GSI 191. The Subcommittee received no other written comments or requests for time to make oral statements from members of the public regarding the meeting. The entire meeting was open to public attendance. Michael Snodderly was the cognizant ACRS staff engineer for this meeting. Med El-Zeftawy was the designated federal official. The meeting was convened at 1:02 p.m. on February 4, 2003 and adjourned at 6:12 p.m on February 4, 2003.

ATTENDEES

ACRS Members

G. Wallis, Subcommittee Chairman
P. Ford, Member
T. Kress, Member
G. Leitch, Member
V. Ransom, Member
S. Rosen, Member
S. Banerjee, Consultant
M. El-Zeftawy, Staff (Designated Federal Official)
M. Snodderly, Staff

Principal NRC Speakers

R. Architzel, NRR
D. Dorman, RES
G. Holahan, NRR
B. Jain, RES
J. Lehning, NRR
J. Letellier, Los Alamos National Laboratory
S. Weerakkody, NRR

Principal Industry Speakers:

J. Butler, NEI

There were approximately five members of the public in attendance at this meeting. A complete list of attendees is in the ACRS Office File and will be made available upon request. The presentation slides and handouts used during the meeting are attached to the office copy of these minutes.

OPENING REMARKS BY THE SUBCOMMITTEE CHAIRMAN

Graham Wallis, Chairman of the ACRS Subcommittee on Thermal-Hydraulic Phenomena convened the meeting at 1:02 p.m. Chairman Wallis stated that the purpose of this meeting was to review two proposed NRC documents for resolution of Generic Safety Issue (GSI) 191: "Assessment of Debris Accumulation on PWR Sump Pump Performance," prior to release for public comment. The first document was proposed NRC Generic Letter (GL) 2003-XX, "Potential Impact of Debris Blockage on Emergency Recirculation During Design-Basis Accidents at Pressurized Water Reactors", and the second document was draft Regulatory Guide DG-1107, "Water Sources for Long-Term Recirculation Cooling Following a Loss-of-Coolant Accident." Chairman Wallis reminded the Subcommittee that the Full Committee had last been briefed on this issue in September 2001. At that time, the Office of Nuclear Reactor Research (RES) presented their recommendations for resolving the issue. Based on a generic study, RES found that an increase of sump screen surface area to reduce the vulnerability caused by debris accumulation on the sumps was net beneficial and recommended that plant-specific analyses be conducted to determine the vulnerability of individual plants to loss of net positive suction head margin. In a September 14, 2001 letter to the Executive Director for Operations, the Committee stated that, if plant-specific analyses are required as part of the resolution, guidance for performing these analyses should be developed. The staff was before the Subcommittee to present the above referenced documents which contain guidance for performing plant-specific analyses. Chairman Wallis had no specific comments relative to the meeting agenda.

DISCUSSION OF AGENDA ITEMS

NRC Staff Presentations

Ralph Architzel, B. P. Jain, and John Lehning were the main presenters for the NRC staff. Their contractor, John Letellier, from Los Alamos National Laboratory also presented material on research being conducted on behalf of RES. Dan Dorman, Gary Holahan, and Sunil Weerakkody were in the audience to provide support to the main presenters.

Mr. Gary Holahan, Director, Division of Systems Safety and Analysis, NRR, provided an introduction by stating that the staff was beginning the regulatory and implementation stages of resolving the issue of PWR sump screen blockage. Mr. Holahan reminded the Subcommittee that they were there because resolution of a GSI and issuance of a GL call for ACRS involvement. Mr. Holahan pointed out the staff is considering several factors in determining whether continued operation is appropriate during this period of resolution. The factors include: probability of needing the sump, possible compensatory actions, leak-before-break, and additional margin, such as containment overpressure. He said that industry has been rather proactive in responding to this issue by performing walkdowns and improving cleanliness. In

addition, two utilities have decided to make improvements to their sump. Based on plant-specific information, the staff may accelerate activities at more susceptible plants and be more tolerant of plants with only minor issues. Mr. Holahan ended by saying that if technical issues are identified sample audits or independent calculations may be performed and that a temporary instruction will be issued for resident inspectors to see that appropriate closeout actions are taken.

Ralph Architzel, NRR, provided historical background on GSI-191 and described how GSIs, in general, are resolved. John Lehning, NRR, discussed the proposed GL which requests that PWR licensees perform a mechanistic evaluation of the susceptibility of the ECCS and CSS recirculation functions to debris blockage. In the interim, while the evaluation is being performed, PWR licensees will assess the necessity for and implement, if appropriate, interim compensatory measures to mitigate the potential for sump clogging. Examples of potential interim compensatory measures include operator training, modified operational procedures that would delay the switchover to recirculation, more extensive containment cleaning, increased foreign material controls, and plant modifications. Dr. B. P. Jain, RES, than discussed DG-1107 which contains guidance for performing the requested evaluations. DG-1107 is intended to become Revision 3 to Regulatory Guide 1.82 and the revision would enhance guidance on debris sources and generation, debris transport, and debris accumulation and head loss to be consistent with that for BWRs. Significant points raised during the presentations include:

- Mr. Architzel gave the history of emergency sump performance examinations, including USI A-43 which was closed in 1985. GSI-191 was opened in 1996 due to events at BWRs and new information identified since USI A-43 was closed, including resolution of the issue for BWRs.

- Mr. Architzel explained that GSI-191 was presently in the Regulation and Guidance Development Stage of Management Directive 6.4. He reminded the Subcommittee that they were last briefed on the previous stage, Technical Assessment. It was concluded from the Technical Assessment Stage that plant-specific analyses should be conducted to determine whether debris accumulation in PWR containments will impede or prevent ECCS operation during recirculation.

- Mr. Architzel provided a chronology of staff and industry meetings concerning GSI-191. He then gave current plans and schedules for resolving GSI-191. Major milestones include: issuing DG-1107 for public comment by February 2003, issuing Revision 3 to RG 1.82 by September 2003, issuing a draft GL for public comment in the first quarter of 2003, issuing the GL in the Summer of 2003, and NEI issuing guidance for plant specific evaluations by the Fall of 2003.

- Mr. Lehning than gave a summary of the proposed GL. Mr. Lehning stated that the purpose of the GL was to request that PWR licensees evaluate the recirculation functions, and, if appropriate, take additional actions to ensure their reliability. The proposed GL would require that PWR licensees inform the NRC of the extent to which they will take the requested actions.

- Dr. Jain gave a summary of DG-1107. Dr. Jain explained that the amount of debris generated is a function of the type of insulation material, the proximity and orientation of

the insulation relative to the postulated pipe break, and whether the insulation is jacketed or reinforced.

- Dr. Jain provided an overview of insights from research conducted in support of the resolution of GSI-191. Fine fibers remain suspended and are eventually transported to the sump screen. Debris transport is more for shallower sump pools. Narrow channels accelerate flow and enhance debris transport. Debris curbs impede forward motion of debris along the floor. Fibrous in combination with particulate debris results in higher head losses. These research insights have been incorporated into DG-1107. Dr. Jain said that the current knowledge base of research on BWR strainer and PWR sump screen clogging issue will be issued as a NUREG/CR concurrently with Revision 3 of the RG to assist in the resolution of GSI-191.

- Dr. Jain provided the current schedule for issuing Revision 3 to RG 1.82. The staff plans to issue DG-1107 for public comment by February 2003 and then issue Revision 3 to RG 1.82 in September 2003 after incorporation of public comments. This schedule is contingent upon NEI issuing their guidance for plant specific evaluation in the Fall of 2003.

- Dr. Letellier described the Containment Accident Sequence Insulation Outcome Verification Analysis (CASINOVA) model debris generation analysis. The CASINOVA model performs CAD-like simulations and compiles statistics on break size, reactor system, debris volume, and debris composition. The CASINOVA model maps spherical damage pressure zones on spatial insulation data.

- Dr. Letellier explained that guidance for estimating debris generation is based on a spherical zone of influence which is determined by the destruction pressure of each insulation type. Examples are provided in NUREG/CR-6224, BWROG URG, and staff evaluation of the BWROG response to NRC Bulletin 96-03. Dr. Letellier provided selected insulation destruction pressures recommended by the BWROG and NRC.

- Dr. Letellier presented the associated scaling analysis. Dr. Letellier explained that the PWR blowdown begins at 2300 psig. Initially water flashes ($x \sim 0$) at stagnation. After 10 seconds the quality rises ($x=0.2$) and the jet is modeled as a steam continuum with a suspended droplet field.

- Dr. Letellier described the debris transport model. The debris is initially dispersed throughout containment by depressurization flow. Debris is than transported by containment spray drainage. Dr. Letellier presented logic charts for debris transport fractions.

- Dr. Letellier discussed the approach to pool transport models as given in NUREG-6772 and 6773. Dr. Letellier explained that the approach was to consider contiguous areas with velocities higher than incipient velocity as regions susceptible to transport. The model considers settling time from surface as an opportunity to drift into another contour or into a stagnant zone. Any debris reaching the contiguous contour surrounding the sump is assumed to eventually collect on the screen. Dr. Letellier said that containment spray return paths should be added.

- Dr. Letellier felt that quantitative flow paths provide access to an approximate, yet tractable, estimate of the fraction transported. He went on to say that logic maps and engineering judgement will be needed to consider fractions and characteristics of debris returned to the pool via various paths.

- Dr. Letellier claimed that the University of New Mexico testing confirmed that the BWR head-loss correlation is robust, and obtained additional data for Cal-Si, Aluminum RMI, and fibrous insulation. He said that the testing showed that appropriate material properties must be used for head-loss estimates.

- Dr. Letellier presented a curve entitled, "Conditions for Sump Failure." The curve showed that less than 0.2 cubic feet of particulate volume is needed to fail the sump given one cubic foot of fiber. Dr. Letellier said that depending on the area and the approach velocity, there may be plant configurations that could be blocked with one cubic foot of fiber and some amount of particulate. He clarified that this was not a generic statement but very plant-specific.

NEI Presentations

John Butler was the main presenter for NEI. Mr. Butler explained that his presentation would address the who, what, and when of industry activities to address PWR ECCS sump performance. Mr. Butler stated that NEI has been an active observer of the NRC's activities in this area. This presentation took place from 5:00 to 6:00 p.m. Significant points raised during the presentation include:

- Mr. Butler stated that the NEI PWR Sump Performance Task Force includes representatives from PWR owners groups, PWR utilities, EPRI, EDF, and consultants. Mr. Butler explained that the Task Force's activities fall into three general categories: collection of data applicable to ECCS Sump performance, development of ECCS evaluation methodology, and communication of industry and regulatory activities to PWR plant operators.

- Mr. Butler summarized NEI-02-01, "Condition Assessment Guidelines: Debris Sources Inside PWR Containments." The purpose of NEI-02-01 is to document information to support plant-specific sump performance assessments, identify potential debris sources inside containment resulting from affected design basis events, support walk-downs to verify location and amount of insulation materials, unqualified coatings, and foreign materials.

- Member Wallis asked if NEI saw the methodology as a computer program where plant specific information is provided to determine if the sump design is adequate or not. Mr. Butler answered that would be a possibility if there were more similarity among PWRs. Mr. Butler anticipates that the NEI guidance will provide a framework to address debris generation, transportation and accumulation.

- Member Kress asked Mr. Butler what he thought of the zone of influence approach and whether or not NEI would use that approach. Mr. Butler said that he agreed with Member Kress that there were pros and cons to the approach but that he imagined that NEI would use the approach. Mr. Butler went on to say that in a lot of cases it will not impact the final

result because it takes very little fibrous and particulate material to make a difference. So whether or not you assume a large value or half that value, you still have a substantial test of the sump strainers.

- Member Rosen asked if the industry was thinking about replacing particulate and fibrous insulation with reflective metallic insulation. Mr. Butler said that NEI was not advocating that but he thought some plants were making corrective changes in their insulation.

- Member Wallis questioned what types of analysis could be accomplished by September 2003 as discussed in the proposed GL. Mr. Butler responded the guidance methodology is not going to include the CFD analysis that someone would need to calculate transport fractions. That would be part of the plant-specific resolution after gathering the plant-specific data. The NEI methodology identifies what you need to look at as part of a CFD analysis.

- Member Rosen asked how long before the plants make either appropriate fixes or are able to show that they're okay. Dr. Weerakkody recalled that an exact date is not specified but certain timelines for initial assessments and then evaluations have been specified and that the furthest a plant could go without resolving the issue was 2007.

SUBCOMMITTEE COMMENTS, CONCERNS, AND RECOMMENDATIONS

Subcommittee members raised the following significant points during its discussion with the representatives from the NRC staff and NEI.

- Member Rosen estimated that the minimum time to respond to the proposed GL was two years. 90 days to provide a schedule for performing the requested evaluation, 90 days to provide a description of the actions taken to address the issue, and a likely 18 month refueling outage in between. He was concerned that there did not appear to be a maximum time and questioned whether there was a need for a date certain to have addressed the issue. Dr. Kress shared this concern.

- Member Wallis noted that the schedule appears to be contingent on NEI publishing its guidance document, which will recommend methodologies for evaluating a PWR's susceptibility to sump clogging based upon the information collected in accordance with NEI 02-01. Member Wallis expressed his concern about NEI's ability to publish the guidance document by September 2003 given they did not have a draft to present to the Subcommittee.

- Member Leitch had no problem with issuing the proposed GL and associated RG for public comment. Member Leitch felt that we have over analyzed this issue while trying to determine the affected population of plants. In doing so, the staff has determined that some plants are more susceptible than others. Therefore, we should get on with it and get those plants fixed.

- Member Kress agreed with issuing the proposed GL and associated RG for public comment but he believed that the GL should reflect that some plants are more vulnerable than others. He questioned, "How urgent does the issue become if the plant is found to be vulnerable?" and,"Can plants that aren't vulnerable be given more time?"

- Member Ford agreed with issuing the proposed GL and associated RG for public comment. He too was frustrated by the time table for resolving this issue.

- Member Rosen asked if any PWR plants had already modified their sumps to address the issue. Mr. Holahan responded that Davis-Besse and Diablo Canyon had modified their sumps.

- Member Wallis asked if sump screen blockage was assessed as part of the Davis-Besse reactor vessel head corrosion investigation. Mr. Holahan said that the Significance Determination Process conducted as part of the investigation concluded that it was not an important contributor because of its location, the lack of fibrous insulation, and the path to the sump. RES is now going through a second stage, as part of the Accident Sequence Precursor program. Mr. Holahan said that he believes they are considering potential sump screen blockage because the sequences they are looking at involve recirculation.

- Member Wallis commented that the tone of the generic communication is very conciliatory for a perceived safety issue. Mr. Architzel explained that the reason for a GL, as opposed to a bulletin or order, was that an event had not occurred as was the case for BWRs. Mr. Lehning added that the information requested by the GL is needed to determine whether or not a safety issue exists and its significance.

- Member Wallis asked if the scenario of concern involved core damage. Mr. Architzel responded that the scenario of concern involved core damage due to lack of core cooling but that containment integrity could be maintained with the containment sprays. Member Wallis clarified that using the sprays in this matter is outside their normal design. Mr. Architzel agreed.

- Dr. Banerjee questioned whether it was credible to assume both trains of ECCS fail because both trains are physically separated at the sump. Dr. Letellier said no, not always. In some cases they are co-located. In most plants they are physically separated by a baffle or a separation, but in many instances they are in the same location of the plant and subjected to the same transport fractions.

- Member Rosen asked what is meant by destruction pressure threshold. Dr. Letellier responded that the destruction pressure threshold is that distance beyond which the pressure from the jet is not be great enough to cause erosion.

- Member Wallis questioned why pressure contours within a jet were used to identify erosion mechanisms instead of momentum fluxes. Dr. Letellier said that most of the information is based on test data, where pressures were the easiest thing to measure. Member Ransom commented that the stagnation pressure on the face of the insulation blanket would have some momentum effects.

- Member Rosen envisioned a debris pool where finer debris is suspended due to the violent stirring caused by the loss-of-coolant accident. Dr. Letellier responded that there are quiet areas where there is an opportunity for settling but fine debris is suspended indefinitely and will eventually transport.

- Member Wallis asked how this issue was being addressed internationally. Dr. Jain said that France was the most active in this area but that they have been reluctant to share information at this time. Mr. Architzel commented that the Belgians were closely following the staff's approach and the Swedes had addressed the problem by increasing screen size.

- Dr. Banerjee asked if the acceptable analytical methods had been or were going to be peer reviewed. Dr. Jain responded that they had not. Member Wallis commented that independent peer review increases public confidence.

- Member Wallis questioned why the break was not modeled as a directional jet. Dr. Letellier agreed that was a more realistic model but they do not have a predictive model for jet deflections near concrete or a predictive model for pipe separation. For example, the two ends of a guillotine break may be opposed, generating opposing cones. Dr. Letellier went on to explain that the standard practice is to look at the free-field jet expansion and investigate the damage threshold of different insulation types. The interior volume of that pressure contour is mapped into an equivalent sphere for the purpose of plant assessment. Mr. Architzel reminded the Committee that this was the approach used to resolve this issue for BWRs.

- Member Kress asked if all the debris is assumed to be uniformly distributed in the containment volume, so that when it falls out, it distributes itself uniformly over that whole surface of the pool. Dr. Letellier said they assumed the debris is preferentially returned at stairwells and drainage holes that have been designed for that purpose.

- Dr. Banerjee asked which assumptions affect the results the most. Dr. Letellier responded that, from a plant-specific perspective, the most important assumptions were the flow conditions of the sump screen is the most important consideration followed by the insulation types. Dr. Wallis pointed out that those are known variables not physical assumptions. Dr. Letellier clarified that it would be the minimum amount of debris to cause head loss.

- Member Rosen noted that based on Figure 43 it would only take one cubic foot of fiber and a tenth of a cubic foot of particulate insulation to clog a sump strainer. Dr. Letellier said that this would apply to a plant with very small screens and very high approach velocities. Dr. Letellier than said that the point of this slide was to demonstrate that licensees need to assess their own vulnerabilities in much the same way. They need to have an understanding of transport and head loss in order to respond to the GL.

STAFF AND INDUSTRY COMMITMENTS

The staff did not plan to bring the GL back to the ACRS unless there were significant public comments or the ACRS requested to see it prior to the GL being issued. The staff expects to come back in July 2003 to discuss resolution of public comments on the RG in order to support issuance in September 2003.

SUBCOMMITTEE DECISIONS AND ACTIONS

Subcommittee planned to recommend a staff presentation to the Full Committee on the staff's proposed resolution of GSI-191. The Subcommittee also recommended that the GL and associated RG be published for public comment.

BACKGROUND MATERIALS PROVIDED TO THE SUBCOMMITTEE PRIOR TO THIS MEETING

1. Subcommittee status report, including agenda.
2. U. S. Nuclear Regulatory Commission, Office of Nuclear Reactor Regulation, Generic Letter 2003-XX, "Potential Impact of Debris Blockage on Emergency Recirculation During Design-Basis Accidents at Pressurized-Water Reactors," transmitted January 15, 2003.
3. U. S. Nuclear Regulatory Commission, Office of Nuclear Regulatory Research, Draft Regulatory Guide DG-1107, "Water Sources for Long-Term Recirculation Cooling Following a Loss-of-Coolant Accident," transmitted December 2002.
4. Letter dated September 14, 2001, from George E. Apostolakis, ACRS, to William D. Travers, EDO, Subject: Generic Safety Issue-191, "Assessment of Debris Accumulation on PWR Sump Performance."

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Note: Additional details of this meeting can be obtained from a transcript of this meeting available for downloading or viewing on the Internet at "http://www.nrc.gov/ACRSACNW' or can be purchased from Neal R. Gross and Co., Inc., (Court Reporters and Transcribers) 1323 Rhode Island Avenue, NW., Washington, DC 20005 (202) 234-4433.

SUMMARY: Notice is hereby given, pursuant to 25 CFR 514.1(a)(3), that the National Indian Gaming Commission has adopted preliminarily annual fee rates of 0.00% for tier 1 and 0.059% (.00059) for tier 2 for calendar year 2003. These rates shall apply to all assessable gross revenues from each gaming operation under the jurisdiction of the Commission. If a tribe has a certificate of self-regulation under 25 CFR part 518, the preliminary fee rate on class II revenues for calendar year 2003 shall be one-half of the annual fee rate, which is 0.0295% (.000295).

FOR FURTHER INFORMATION CONTACT: Bobby Gordon, National Indian Gaming Commission, 1441 L Street, NW., Suite 9100, Washington, DC 20005; telephone 202/632–7003; fax 202/632–7066 (these are not toll-free numbers).

SUPPLEMENTARY INFORMATION: The Indian Gaming Regulatory Act established the National Indian Gaming Commission which is charged with, among other things, regulating gaming on Indian lands.

The regulations of the Commission (25 CFR part 514), as amended, provide for a system of fee assessment and payment that is self-administered by gaming operations. Pursuant to those regulations, the Commission is required to adopt and communicate assessment rates; the gaming operations are required to apply those rates to their revenues, compute the fees to be paid, report the revenues, and remit the fees to the Commission on a quarterly basis.

The regulations of the Commission and the preliminary annual rate being adopted today are effective for calendar year 2003. Therefore, all gaming operations within the jurisdiction of the Commission are required to self-administer the provisions of these regulations and report and pay any fees that are due to the Commission by March 31, 2003.

Richard B. Schiff,

Acting Chief of Staff, National Indian Gaming Commission.

[FR Doc. 03–1377 Filed 1–21–03; 8:45 am]

BILLING CODE 7565–01–M

NUCLEAR REGULATORY COMMISSION

Advisory Committee on Reactor Safeguards Subcommittee Meeting on Thermal-Hydraulic Phenomena; Notice of Meeting

The ACRS Subcommittee on Thermal-Hydraulic Phenomena will hold a meeting on February 4, 2003, Room T–2B3, 11545 Rockville Pike, Rockville, Maryland.

The entire meeting will be open to public attendance.

The agenda for the subject meeting shall be as follows:

Tuesday, February 4, 2003—1:00 p.m. Until the Conclusion of Business

The Subcommittee will review two proposed NRC documents for resolution of Generic Safety Issue–191, "Assessment of Debris Accumulation on PWR Sump Performance". These documents are: proposed NRC Generic Letter 2003–XX, "Potential Impact of Debris Blockage on Emergency Recirculation During Design-Basis Accidents at Pressurized Water Reactors", and associated draft Regulatory Guide DG–1107, "Water Sources for Long-Term Recirculation Cooling Following a Loss-of-Coolant Accident". The purpose of this meeting is to gather information, analyze relevant issues and facts, and formulate proposed positions and actions, as appropriate, for deliberation by the full Committee.

Oral statements may be presented by members of the public with the concurrence of the Subcommittee Chairman. Written statements will be accepted and made available to the Committee. Persons desiring to make oral statements should notify the Designated Federal Official or the Cognizant Staff Engineer named below five days prior to the meeting, if possible, so that appropriate arrangements can be made. Electronic recordings will be permitted only during those portions of the meeting that are open to the public.

During the initial portion of the meeting, the Subcommittee, along with any of its consultants who may be present, may exchange preliminary views regarding matters to be considered during the balance of the meeting.

The Subcommittee will then hear presentations by and hold discussions with representatives of the NRC staff, Nuclear Energy Institute, and other interested persons regarding this review.

Further information regarding topics to be discussed, whether the meeting has been canceled or rescheduled, and the Chairman's ruling on requests for the opportunity to present oral statements and the time allotted therefor can be obtained by contacting the Designated Federal Official, Mr. Sam Duraiswamy (telephone: 301–415–7364) or Mr. Michael R. Snodderly, Cognizant Staff Engineer (telephone: 301–415–6927) between 7:30 a.m. and 4:15 p.m. (EST). Persons planning to attend this meeting are urged to contact one of the above named individuals at least two working days prior to the meeting to be advised of any potential changes to the agenda.

Dated: January 15, 2003.

Sher Bahadur,

Associate Director for Technical Support, ACRS/ACNW.

[FR Doc. 03–1329 Filed 1–21–03; 8:45 am]

BILLING CODE 7590–01–P

NUCLEAR REGULATORY COMMISSION

Advisory Committee on Reactor Safeguards; Meeting Notice

In accordance with the purposes of sections 29 and 182b. of the Atomic Energy Act (42 U.S.C. 2039, 2232b), the Advisory Committee on Reactor Safeguards (ACRS) will hold a meeting on February 6–8, 2003, in Conference Room T–2B3, 11545 Rockville Pike, Rockville, Maryland. The date of this meeting was previously published in the **Federal Register** on Monday, November 20, 2002 (67 FR 70094).

Thursday, February 6, 2003

8:30 a.m.–8:35 a.m.: Opening Statement by the ACRS Chairman (Open)—The ACRS Chairman will make opening remarks regarding the conduct of the meeting.

8:35 a.m.–10:15 a.m.: Catawba and McGuire License Renewal Application (Open)—The Committee will hear presentations by and hold discussions with representatives of the NRC staff and the Duke Energy Corporation regarding the license renewal application for the Catawba and McGuire Nuclear Plants and the associated NRC staff's final Safety Evaluation Report.

10:30 a.m.–12 Noon: Draft Regulatory Guide DG–1107, "Water Sources for Long-Term Recirculation Cooling Following a Loss-of-Coolant Accident" and Draft Generic Letter 2003–xx, related to the Resolution of GSI–191, "Assessment of Debris Accumulation on PWR Sump Performance" (Open)—The Committee will hear presentations by and hold discussions with representatives of the NRC staff regarding Draft Regulatory Guide DG–1107 and Draft Generic Letter 2003–xx associated with the resolution of Generic Safety Issue (GSI)–191.

1 p.m.–3 p.m.: PTS Reevaluation Project: Technical Bases for Potential Revision to PTS Screening Criterion (Open)—The Committee will hear presentations by and hold discussions with representatives of the NRC staff

regarding the technical bases for potential revision to the pressurized thermal shock (PTS) screening criterion.

3:15 p.m.–4:45 p.m.: Draft Final Version of Regulatory Guide DG–1077, "Guidelines for Environmental Qualification of Microprocessor-Based Equipment Important to Safety in Nuclear Power Plants" (Open)—The Committee will hear presentations by and hold discussions with representatives of the NRC staff on the draft final version of DG–1077.

5 p.m.–7:15 p.m.: Proposed ACRS Reports (Open)—The Committee will discuss proposed ACRS reports on matters considered during this meeting, as well as a proposed ACRS report on Safety Culture.

Friday, February 7, 2003

8:30 a.m.–8:35 a.m.: Opening Remarks by the ACRS Chairman (Open)—The ACRS Chairman will make opening remarks regarding the conduct of the meeting.

8:35 a.m.–8:50 a.m.: Subcommittee Report (Open)—Report by the Chairman of the ACRS Subcommittee on Reliability and Probabilistic Risk Assessment regarding the coherence plan for risk-informed regulatory activities that was discussed at the January 22, 2003 Subcommittee meeting.

8:50 a.m.–9:15 a.m.: Subcommittee Report (Open)—Report by the Chairman of the ACRS Subcommittee on Reliability and Probabilistic Risk Assessment regarding the Westinghouse AP1000 passive plant design PRA that was discussed at the January 23–24, 2003 Subcommittee meeting.

9:15 a.m.–10:15 a.m.: Future ACRS Activities/Report of the Planning and Procedures Subcommittee (Open)—The Committee will discuss the recommendations of the Planning and Procedures Subcommittee regarding items proposed for consideration by the full Committee during future meetings. Also, it will hear a report of the Planning and Procedures Subcommittee on matters related to the conduct of ACRS business, including anticipated workload and member assignments.

10:15 a.m.–10:30 a.m.: Reconciliation of ACRS Comments and Recommendations (Open)—The Committee will discuss the responses from the NRC Executive Director for Operations (EDO) to comments and recommendations included in recent ACRS reports and letters. The EDO responses are expected to be made available to the Committee prior to the meeting.

10:45 a.m.–12:15 p.m.: Annual ACRS Report on the NRC Safety Research Program (Open)—The Committee will discuss the draft ACRS Report on the NRC Safety Research Program.

1:15 p.m.–7 p.m.: Proposed ACRS Reports (Open)—The Committee will discuss proposed ACRS reports.

Saturday, February 8, 2003

8:30 a.m.–1 p.m.: Proposed ACRS Reports (Open)—The Committee will continue to discuss proposed ACRS reports. In addition, the Committee will discuss a draft report prepared by an ACRS consultant on the role and use of PRA in the regulatory decisionmaking process.

1 p.m.–1:30 p.m.: Miscellaneous (Open)—The Committee will discuss matters related to the conduct of Committee activities and matters and specific issues that were not completed during previous meetings, as time and availability of information permit.

Procedures for the conduct of and participation in ACRS meetings were published in the **Federal Register** on October 11, 2002 (67 FR 63460). In accordance with those procedures, oral or written views may be presented by members of the public, including representatives of the nuclear industry. Electronic recordings will be permitted only during the open portions of the meeting. Persons desiring to make oral statements should notify the Associate Director for Technical Support named below five days before the meeting, if possible, so that appropriate arrangements can be made to allow necessary time during the meeting for such statements. Use of still, motion picture, and television cameras during the meeting may be limited to selected portions of the meeting as determined by the Chairman. Information regarding the time to be set aside for this purpose may be obtained by contacting the Associate Director prior to the meeting. In view of the possibility that the schedule for ACRS meetings may be adjusted by the Chairman as necessary to facilitate the conduct of the meeting, persons planning to attend should check with the Associate Director if such rescheduling would result in major inconvenience.

Further information regarding topics to be discussed, whether the meeting has been canceled or rescheduled, as well as the Chairman's ruling on requests for the opportunity to present oral statements and the time allotted therefor can be obtained by contacting Dr. Sher Bahadur, Associate Director for Technical Support (301–415–0138), between 7:30 a.m. and 4:15 p.m., EST.

ACRS meeting agenda, meeting transcripts, and letter reports are available through the NRC Public Document Room at *pdr@nrc.gov*, or by calling the PDR at 1–800–397–4209, or from the Publicly Available Records System (PARS) component of NRC's document system (ADAMS) which is accessible from the NRC Web site at *http://www.nrc.gov/reading-rm/adams.html or http://www.nrc.gov/reading-rm/doc-collections/* (ACRS & ACNW Mtg schedules/agendas).

Videoteleconferencing service is available for observing open sessions of ACRS meetings. Those wishing to use this service for observing ACRS meetings should contact Mr. Theron Brown, ACRS Audio Visual Technician (301–415–8066), between 7:30 a.m. and 3:45 p.m., EST, at least 10 days before the meeting to ensure the availability of this service. Individuals or organizations requesting this service will be responsible for telephone line charges and for providing the equipment and facilities that they use to establish the videoteleconferencing link. The availability of videoteleconferencing services is not guaranteed.

Dated: January 16, 2003.

Andrew L. Bates,

Advisory Committee Management Officer.

[FR Doc. 03–1330 Filed 1–21–03; 8:45 am]

BILLING CODE 7590–01–P

NUCLEAR REGULATORY COMMISSION

Sunshine Meeting Notice

DATES: Weeks of January 20, 27, February 3, 10, 17, 24, 2003.

PLACE: Commissioners' Conference Room, 11555 Rockville Pike, Rockville, Maryland.

STATUS: Public and Closed.

MATTERS TO BE CONSIDERED:

Week of January 20, 2003

Tuesday, January 21, 2003

10 a.m.—Discussion of Security Issues (Closed—Ex. 1)

Thursday, January 23, 2003

1:55 p.m.—Affirmation Session (Public Meeting) (If needed)

2 p.m.—Briefing on Status of Office of Nuclear Material Safety and Safeguards (NMSS) Programs, Performance, and Plans—Materials Safety (Public Meeting) (Contact: Claudia Seelig, 301–415–7243)

This Meeting Will Be Webcast Live at the Web Address—*http://www.nrc.gov.*

Week of January 27, 2003—Tentative

There are no meetings scheduled for the Week of January 27, 2003.

ADVISORY COMMITTEE ON REACTOR SAFEGUARDS
THERMAL-HYDRAULIC PHENOMENA SUBCOMMITTEE MEETING:
RESOLUTION OF GSI-191:
"ASSESSMENT OF DEBRIS ACCUMULATION ON PWR SUMP PERFORMANCE"
FEBRUARY 4, 2003
ROCKVILLE, MARYLAND

PRESENTATION SCHEDULE

Contact: M. Snodderly (301/415-6927) ("mrs1@nrc.gov")

TOPIC	PRESENTER	TIME
I. Introduction	**G. Wallis, Chairman** **D. Dorman, RES** **G. Holahan, NRR**	1:00 p.m.
II. Status and Proposed Resolution Of GSI-191: "Assessment of Debris" Accumulation on PWR Sump Performance"	**R. Architzel, NRR**	
III. NRC Documents for Resolution Of GSI-191		
A. Draft Generic Letter 2003-XX: Potential Impact of Debris Blockage On Emergency Recirculation During Design-Basis Accidents at PWRs • Introduction • Requested Action/Information • NRC/Industry Interactions/Issues • Follow-up Actions	**R. Architzel, NRR** **J. Lehning, NRR**	1:15 p.m.
B. Draft Regulatory Guide, DG-1107: "Water Sources for Long-Term Recirculation Cooling Following A Loss-Of- Coolant Accident" • Background • Regulatory Position • Acceptable Analytical Approaches	**B. P. Jain, RES** **D. V. Rao, LANL**	2:15 p.m.

TOPIC	PRESENTER	TIME
B. Draft Regulatory Guide, DG-1107: "Water Sources for Long-Term Recirculation Cooling Following A Loss-Of- Coolant Accident"	**B. P. Jain, RES** **D. V. Rao, LANL**	
• Conclusions		
	BREAK	3:30 p.m.
IV. NEI Comments on Resolution of GSI-191	**J. Butler, NEI**	3:45 p.m.
A. Introduction B. NEI Evaluation Methodology (Ground Rules) C. NEI Guidance - Coordination With NRC Resolution Approach D. Resolution Schedule		
VI. Subcommittee Caucus A. Comments on Meeting Presentations B. Follow-on Actions C. Decision Regarding Future Action on This Matter by ACRS		4:45 p.m.
VII. Adjourn		5:00 p.m.

ADVISORY COMMITTEE ON REACTOR SAFEGUARDS SUBCOMMITTEE MEETING ON THERMAL-HYDRAULIC PHENOMENA

FEBRUARY 4, 2003
Today's Date

ATTENDEES PLEASE SIGN IN BELOW

PLEASE PRINT

NAME	AFFILIATION
Gordon Hart	Performance Contracting Inc.
John BUTLER	NEI
Chris Hutchins	Westinghouse
TIM ANDREYCHEK	WESTINGHOUSE
JOHN G. LAMB	NRC
~~John Lehning~~	~~NRC~~
Tim Maher	PWRO-POWER Corp
Bruce Letellier	Los Alamos National Laboratory

ADVISORY COMMITTEE ON REACTOR SAFEGUARDS SUBCOMMITTEE MEETING ON THERMAL-HYDRAULIC PHENOMENA

FEBRUARY 4, 2003
Today's Date

NRC STAFF PLEASE SIGN IN BELOW

PLEASE PRINT

NAME	NRC ORGANIZATION
Sunil Weerakkody	NRC/NRR/DSSA/SPLB.
John Lehning	NRR/DSSA/SPLB
Ralph Architzel	NRR/DSSA/SPLB.
Dan Dorman	RES/DET/ERAB
T. Y. Chang	RES/DET/ERAB
Tony Hsia	RES/DET/ERAB
B. P. Jain	RES/DET/ERAB
J. A. Davis	RES/DET/MEB
Yong Li	RES/DET/ERAB
SID FELD	RES-DSARE/RRAHKB
ART BUSLIK	RES/DRAA/PRAB

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GSI-191
"ASSESSMENT OF DEBRIS ACCUMULATION ON PWR SUMP PERFORMANCE"

Gary M. Holahan
gmh@nrc.gov (301) 415-2884
Office of Nuclear Reactor Regulation
Director Division of Systems Safety and Analysis
February 4, 2003

United States Nuclear Regulatory Commission

GSI-191 Presentation

- RES Study Concluded that PWR Sump Concerns were Credible but Need to be Addressed on Plant Specific Basis
  - More and finer debris could be generated by a HELB
  - Sump clogging due to more and finer debris
- ACRS Involvement requested
  - MD 6.4 role to Advise the Staff on the processes and methodologies for addressing Generic Safety Issues
  - OL 701 Role to Review selected CRGR Generic Communication packages before Public Comment Stage

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GSI-191 Presentation

- Justification for Interim Operation
  - Low probability of LOCA requiring recirculation
  - Higher frequency LOCAs more time to or no recirculation, less debris, operator recovery potential
  - Likelihood qualified piping will leak before break
  - Margins in NPSH available, uncredited containment overpressure, cavitation operation potential
  - PWR containment/sump compartmentalized configuration
  - Ongoing industry actions to improve sumps and increase containment cleanliness
  - Ongoing configuration assessment walkdowns

United States Nuclear Regulatory Commission

Resolution Process for GSI-191

- Activities include
  - Revise Regulatory Guide 1.82
  - PWR Industry Initiative to Develop Guidance for Plant Specific Evaluation
  - Generic Letter
- Plant specific assessment needed to assure the reliability of ECCS in recirculation
- PWR industry to develop guidance acceptable to NRC to evaluate configurations
- Oversee evaluations of recirculation adequacy
  - Review generic letter responses
  - Sample audits of evaluations
  - Temporary instruction to allow inspection oversight of activities

United States Nuclear Regulatory Commission

STATUS AND PROPOSED RESOLUTION OF GSI-191 "ASSESSMENT OF DEBRIS ACCUMULATION ON PWR SUMP PERFORMANCE"

Ralph E. Architzel
rea@nrc.gov (301) 415-2804
Office of Nuclear Reactor Regulation
Division of Systems Safety and Analysis
Plant Systems Branch
February 4, 2003

United States Nuclear Regulatory Commission

OVERVIEW

- Generic Safety Issue (GSI) - 191
- Generic Issue Program Stages
- Technical Assessment
- Regulations and Guidance Development
  - Generic Letter –John Lehning
  - RG 1.82 Rev 3 – B. P. Jain
  - Industry Evaluation Guidelines John Butler
- LANL Support Activities
- Industry Meetings/Initiatives
- Current Plans and Schedules
- GSI-191 Resolution/Closure

United States Nuclear Regulatory Commission

Generic Safety Issue GSI -191

- 10 CFR 50.46 (b)(5) and Appendix A to 10 CFR 50, Criterion 35 Require Long Term Emergency Core Cooling
- Debris Blockage of Sump Screens may Prevent the Injection of Water into the Reactor Core or Containment Spray
- USI A-43 Examined Emergency Sump Performance
  - closed in 1985 (Generic Letter 85-22; Reg Guide 1.82 Rev. 1)
- GSI -191 Re-Assesses Effect of Debris Accumulation on PWR Sump Performance due to
  - Events at BWRs
  - New information identified since USI A-43 closure, including BWR resolution

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Generic Issue Program Stages

(Management Directive 6.4)

1. Issue Identification
2. Initial Screening
3. Technical Assessment
4. Regulation and Guidance Development (Development of GL and RG DG -1107)
5. Regulation and Guidance Issuance
6. Implementation
7. Verification

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Technical Assessment (Stage 3)

- Parametric evaluation to determine if loss of ECCS NPSH margin due to sump clogging was a credible concern.
  - Modeled plant specific parameters based on NEI survey information (e.g., ECCS flow, debris types, etc.)
  - Did not have sufficient information to model plant piping layout and insulation debris locations.
  - Calculated a range of likely amounts of debris that could accumulate on sump screen and the associated head loss. This head loss was compared to the NPSH margin to determine the likelihood of clogging.

United States Nuclear Regulatory Commission

Technical Assessment (Cont.)

- Confirmed Recirculation Performance is a Credible Concern for PWRs
  - More and finer debris could be generated by a HELB
  - Sump clogging due to thin bed effect
  - Upstream (inventory loss) and downstream blockage (HPSI throttle valves) concerns
  - Other effects such as loads on screens from debris beds at design conditions

United States Nuclear Regulatory Commission

Technical Assessment Conclusions

- Plant Specific Analyses should be conducted to determine whether debris accumulation in PWR containments will impede or prevent ECCS operation during Recirculation
- Appropriate Corrective Action, as necessary, should be implemented on the basis of these plant-specific analyses
- The Industry and the ACRS were briefed on the study findings in July and September, 2001,respectively.
  - ACRS agreed with potential issue; developing guidance for plant-specific analyses if needed, and requested review of proposed final disposition

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Regulations and Guidance Development (Stage 4)

- NRR Action Plan Developed to Address GSI Resolution
- Revise Regulatory Guide 1.82
- PWR Industry (NEI) to Issue Guidance for Plant Specific Evaluation (Fall 2003)
- Generic Letter

United States Nuclear Regulatory Commission

LANL Support Activities

- NRR Contracted LANL for technical support
- Provides continuity of GSI issue and related technical support
- Completing a set of calculations for volunteer plant
- Commenting on Industry Evaluation Guidelines
- Addressed testing or knowledge base uncertainties
- Evaluated potential operator recovery actions to complement parametric study results

United States Nuclear Regulatory Commission

Industry Meetings/Initiatives

- NEI PWR Sump Performance Task Force 1997
- Regular Meetings and Conference calls
- Since completion of Technical Assessment:
- March 28, 2002
  - NRC Action Plan addressed
  - Industry Initiative 6 Step program
    - No submittal but will coordinate with NRC
    - Regulatory Implementation for NRC action

United States Nuclear Regulatory Commission

NRC/PWR Industry Meetings (cont.)

- May 30, 2002
  - Presentation/discussion of Condition Assessment Guidelines (NEI-02-01)
- July 2, 2002
  - Review of potential interim actions and regulatory assessment
- July 30-31, 2002
  - NRC attended/presented at NEI PWR Sump Performance Workshop

United States Nuclear Regulatory Commission

NRC/PWR Industry Meetings (Cont.)

- August 29, 2002
  - Revision of Condition Assessment Guidelines (NEI-02-01) for NRC comments and Industry experience
  - Addition of HPSI throttle valve blockage to scope
- October 24, 2002
  - Status of action plan/GL
  - Discuss draft NEI Evaluation methodology ground rules
  - Discuss PCI letter concerning head loss due to fiber/particulate combinations
- November 18, 2002 - ANS Winter meeting session

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NRC/PWR Industry Meetings (cont.)

- December 12, 2002
  - Additional ground rules sections presented
    - General Technical
    - Debris Generation
  - Discussed NRC perspectives on Design and Testing for GSI-191 Resolution
- Planned March 4, 2003
  - Status of action plan/GL/Operator Recovery TLR
  - Discuss NRC comments on NEI Evaluation methodology ground rules received
  - NEI present additional ground rules sections
  - Visit UNM Thermal Hydraulics laboratory

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Current Plans and Schedules

- Issue Draft Regulatory Guide (DG-1107) for Public Comment (February, 2003)
- Issue Regulatory Guide 1.82, Rev. 3 (September 2003)
- Issue Draft Generic Letter for Public Comment (First Quarter, 2003)
  - Following CRGR review
  - Draft GL is predecisional pending CRGR approval
- Issue Generic Letter (Summer 2003)
- Industry (NEI) to Issue Guidance for Plant Specific Evaluation (Fall 2003)

United States Nuclear Regulatory Commission

GSI-191 Resolution/Closure

- Implementation (Stage 6) begins following Guidance development Fall 2003
  - Completes action plan and focus shift to plant specific MPA activity
- Verification (Stage 7) planned though a combination of Audits, inspection activities and GL response reviews
- Leads to effective closure of GSI-191

United States Nuclear Regulatory Commission

PROPOSED GENERIC LETTER 2003-XX "POTENTIAL IMPACT OF DEBRIS BLOCKAGE ON EMERGENCY RECIRCULATION AT PRESSURIZED-WATER REACTORS"

John Lehning, General Engineer
Jxl4@nrc.gov (301) 415-3285
Office of Nuclear Reactor Regulation
Division of Systems Safety and Analysis
Plant Systems Branch

February 4, 2003

United States Nuclear Regulatory Commission

Package for CRGR Review

- Memorandum to CRGR Chairman
- Attachment 1, Proposed Generic Letter
- Attachment 2, Required Information for CRGR Review
- Attachment 3, Risk Considerations and Benefits Associated with GSI-191
- Attachment 4, Cost Analysis for GSI-191

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Purposes of Generic Letter

- Apprise PWR licensees of NRC research identifying the potential susceptibility of PWRs to containment recirculation sump screen blockage
- Apprise PWR licensees of additional adverse effects due to post-accident debris blockage
- Request that PWR licensees evaluate the ECCS and CSS recirculation functions, and, if appropriate, take additional actions to ensure their reliability
- Require that PWR licensees inform the NRC of the extent to which they will take the requested actions

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Background

- During initial plant licensing, a 50%-blockage assumption was made in assessing the adequacy of sump screens
- USI A-43 research demonstrated the non-conservatism of this assumption in the mid-1980s, but backfitting operating plants was not justified
- BWR ECCS strainer clogging events and research in the mid-1990s justified backfitting for BWRs
- Research and analysis for Generic Safety Issue 191 indicates that generic action is also justified for PWRs

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Phenomenology

- Debris Generation
  - Primarily jet impingement
  - Secondarily temperature/humidity, flooding
- Pre-existing Debris Sources
- Debris Transport
  - Washdown from spray and break flows
  - Transport within pool if turbulence is sufficient
- Debris Accumulation
  - Suspended debris
  - Sliding debris

United States Nuclear Regulatory Commission

Concerns Addressed in Generic Letter

- Sump screen debris blockage
  - Potential loss of NPSH margin to ECCS and CSS pumps
  - Potential deformation of sump screens
- Upstream debris blockage at flow restrictions in containment drainage paths
- Downstream debris blockage at flow restrictions in ECCS and CSS

United States Nuclear Regulatory Commission

Requested Actions

- Perform a mechanistic evaluation of the susceptibility of the ECCS and CSS recirculation functions to debris blockage
- Assess necessity of, and, if appropriate, implement interim compensatory measures to mitigate the potential for sump clogging prior to performing evaluation
- Implement any plant modifications necessary to restore compliance with NRC regulations

United States Nuclear Regulatory Commission

Basis for Action Request

- GL invokes compliance exception to the Backfit Rule to ensure that PWR licensees are in compliance with:
  - 10 CFR 50.46, which requires long-term core cooling
  - licensing-basis requirements for the CSS
- Simplified cost-benefit analysis justifies compliance backfitting

United States Nuclear Regulatory Commission

Information Request

- GL cites 10 CFR 50.54(f) to require response
- Response is requested in two parts
- Purposes of information request:
  - To ensure PWR licensees have timely plans to perform requested actions
  - To ensure potential risks associated with sump clogging are being adequately managed
  - To elicit information concerning the results of the requested evaluation in support of resolving Generic Safety Issue 191

United States Nuclear Regulatory Commission

Coordination with Industry

- NEI is developing guidance for licensees to evaluate sump screen adequacy
- NEI addressed staff comments concerning guidance for containment surveillances
- NEI evaluation methodology guidance may be more challenging for reaching agreement
- GL tentatively endorses NEI guidance, but provides for potential disagreements

United States Nuclear Regulatory Commission

Draft Regulatory Guide, DG-1107 "Water Sources for Long-Term Recirculation Cooling Following A LOCA"

Dr. B. P. Jain
bpj@nrc.gov (301.415.6778)
Office of Nuclear Regulatory Research
Division of Engineering Technology
February 4, 2003

United States Nuclear Regulatory Commission

OVERVIEW

- Reg. Guide Issuance Process
- Historical Background – Reg. Guide 1.82
- Regulatory Position
- Acceptable Analytical Approaches
- Contributions of GSI-191 Research
- Current Plans and Schedules
- Conclusions

United States Nuclear Regulatory Commission

Reg. Guide 1.82, Rev. 3 Issuance Process

- Brief ACRS
- Issue DG -1107 For Public Comment
- Resolve Public Comments
- Brief CRGR/ACRS
- Resolve Comments
- Issue Reg. Guide 1.82, Rev. 3

United States Nuclear Regulatory Commission

DG -1107(Reg. Guide 1.82, Rev. 3)

Background

- Revision 0 – Issued June 1974
  - NPSH Calculations Based on 50% Blockage of Sump Screen
- Revision 1 – Issued November 1985
  - Guidance Based on USI A-43 Resolution
- GL 85-22 Concluded that RG. 1.82 (Rev.1)
  - Would Not Apply to Any Plant Then Licensed to Operate or Under Construction
  - Would be Limited to Conduct 10 CFR 50.59 Reviews Dealing with Change/Mod of Thermal Insulation
- Revision 2 – Issued May 1996
  - Revised Guidance for BWRs
  - Requested Licensee to Implement Measures to Ensure ECCS Functions Following LOCA (NRC Bulletin 96-03)
- Revision 3 – Issue September 2003 (Planned)
  - Revised Guidance for PWRs

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Regulatory Position

Key Revisions In DG -1107(Regulatory Guide 1.82 Rev.3)

- Primarily, PWR Sections Revised to Enhance Debris Blockage Evaluation Guidance
  - Consistent with BWRs Guidance in Rev.2, and,
  - Insights gained from Research Performed Under GSI -191
- Minor Editorial Changes to BWR Sections

  (Consistent with Staff's Position in Safety Evaluation on BWROG's Response to NRC Bulletin 96-03)
- Includes Guidance Previously Provided in Regulatory Guide 1.1, "Net Positive Suction Head for Emergency Core Cooling and Containment Heat Removal System Pumps"

United States Nuclear Regulatory Commission

Insights From GSI-191 Research Debris Sources and Generation

- Industry Insulation Survey (1999)
  - Fibrous
  - Reflective Metal Insulation
  - Calcium-Silicate
- Amount of Debris Generation Depends Upon
  - Type of Insulation Material (Different Destruction Threshhold Pressure for Different Materials)
  - Proximity and Orientation of the Insulation Relative to Postulated Pipe Break Location
  - Insulation Installation (Jacketing, reinforcement)

United States Nuclear Regulatory Commission

Insights From GSI-191 Research Debris Transport

- Substantially More Debris is Transported to Sump Screen Relatively Soon After Switchover to Recirculation
- Fine Fibers are Transported Easily and Remain Suspended for Long Time and Eventually Transported to the Sump Screen
- Fraction of Debris Transport is More for Shallower Sump Pools Than the Deeper ones
- Position (Location & Orientation) of Sump Relative to Break Location Affects the Fraction of Debris Transport
- Narrow Flowpaths (Channels) Accelerate Flow and Enhance Debris Transport
- Debris Curbs Affect Local Flow and Impede Forward Motion of Debris Sliding and Tumbling Along the Floor

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Insights From GSI–191 Research Debris Accumulation and Head Loss

- Fine Debris Accumulates Uniformly
- Debris Transported Along the Floor
  - ❑ Accumulates Uniformly on Horizontal Screen
  - ❑ Accumulates Near the Bottom of a Vertical Screen Initially
- PWR Head Loss Data is Consistent with the Correlation in NUREG/CR-6224 (BWR Parametric Study, 1995) with Adjustment to Material Property Parameters
- Fibrous Bed in Combination with the Particulate Debris (corrosion Products, Paint Chips, Concrete Dust, Calcium - Silicate) Results in Higher Head Losses

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Acceptable Analytical Approaches

- DG – 1107 describes Analytical Approaches Acceptable to the staff
- LANL Presentation of Analytical Approaches
- Licensee can Propose Alternate Approaches
- Current Knowledgebase of Research on BWR Strainer and PWR Sump Screen Clogging Issue (NUREG/CR)

United States Nuclear Regulatory Commission

Contributions of GSI-191 Research Program

- Confirmed the Credibility of the Generic Safety Issue
- Supported Agency's Performance Goal of Maintaining Safety by Gaining Knowledge Regarding the Effect of Debris Accumulation on PWR Sump Performance
- Periodic Meetings with the Public, Industry, ACRS, and Other Stakeholders
- Developed Tools (Computer Programs, e.g., CASINOVA, BLOCKAGE) for Staff and Industry Use

United States Nuclear Regulatory Commission

Contributions of GSI-191 Research Program (cont.)

- Developed NUREG/CRs and Regulatory Guide to Provide Valuable Insights for Resolution of GSI-191
- Developed a Knowledge Base Report Summarizing US and International Research on BWR strainer and PWR Sump Screen Clogging Issues
- Plan to Interact and Share Knowledge on Sump Clogging Issue with the International Community and Other Stakeholders in an International Conference (November 2003 - Tentative)

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Current plans and Schedules

- Issue Draft Regulatory Guide (DG-1107) for Public Comment (February, 2003)
- Issue Regulatory Guide 1.82, Rev. 3 (September 2003)
- Industry (NEI) to Issue Guidance for Plant Specific Evaluation (Fall 2003)

United States Nuclear Regulatory Commission

CONCLUSIONS

- GSI-191 Resolution Process at Regulation and Guidance Development Stage
- Draft Reg. Guide is Scheduled for Public Comment
- Final Reg. Guide Issuance is Planned and Scheduled
- Implementation of Regulations and Verification will Follow
- Lead to Effective Closure of GSI-191

Acceptable Analytical Approaches for ECCS Sump Vulnerability Assessment

Dr. Bruce Letellier
Probabilistic Risk Analysis Group
Los Alamos National Laboratory

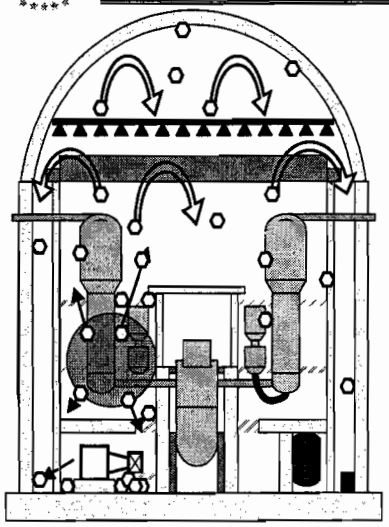
Advisory Committee on Reactor Safeguards
Rockville, Maryland
February 4, 2003

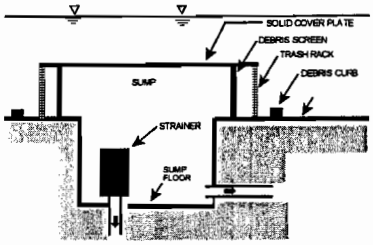
Overview

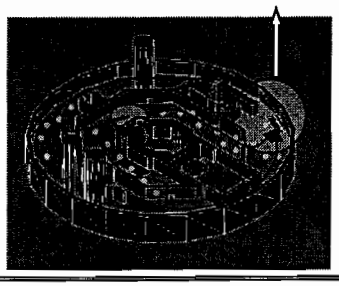
- **Introduction**
- **Debris Generation**
  - Break Location
  - Zone of Destruction
- **Debris Transport**
  - Blow Down/Wash Down
  - Pool Transport
- **Debris Accumulation/Head Loss**
- **Integrated Vulnerability Assessment**

Introduction

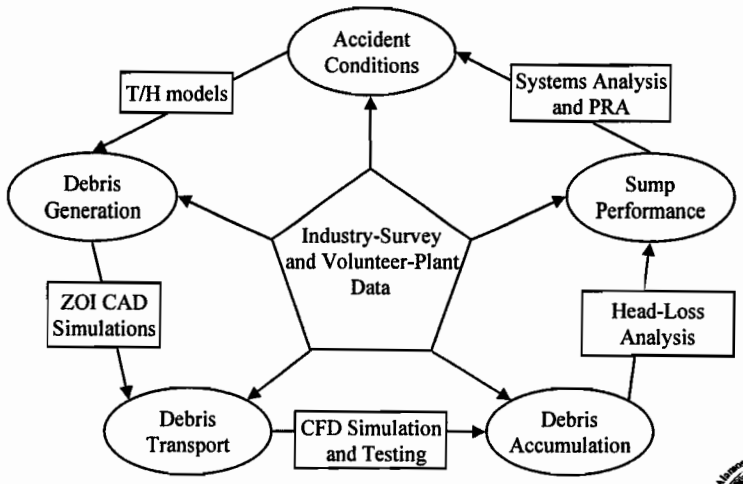
Accident Progression







GSI-191 Program Overview



GSI-191 Documentation

- Thermal-Hydraulic Response of PWR Reactor Coolant System and Containments to Selected accident Sequences (NUREG/CR-6770)
- Separate-Effects Characterization of Debris Transport in Water (NUREG/CR-6772)
- The Impact of Debris Induced Loss of ECCS Recirculation on PWR Core Damage Frequency (NUREG/CR-6771)
- Parametric Evaluations for Pressurized Water Reactor Recirculation Sump Performance (NUREG/CR-6762, Vol. 1)
- Summary and Analysis of U.S. Pressurized Water Reactor Industry Survey Responses and Responses to GL 97-04 (NUREG/CR-6762, Vol. 2)
- Development of Debris Generation Quantities in Support of the Parametric Evaluation (NUREG/CR-6762, Vol. 3)
- Development of Debris Transport Fractions in Support of the Parametric Evaluation (NUREG/CR-6762, Vol. 4)
- Knowledge Base for the Effect of Debris on PWR ECCS Performance
- The Impact of Recovery from Debris-Induced Loss of ECCS Recirculation on PWR Core Damage Frequency

Debris Generation: Break Location

Guidance

- **Break Locations to be Considered:**
  - Hot leg, cold leg, intermediate leg, and (if needed) main steam, and main feedwater with the largest amount of potential debris
  - Large breaks with largest variety of debris (two or more types)
  - Breaks in areas with most direct path to sump
  - Medium and large breaks with largest particulate to fiber mass ratio
  - Breaks that lead to a minimum uniform bed (1/8-inch) to filter particulate debris

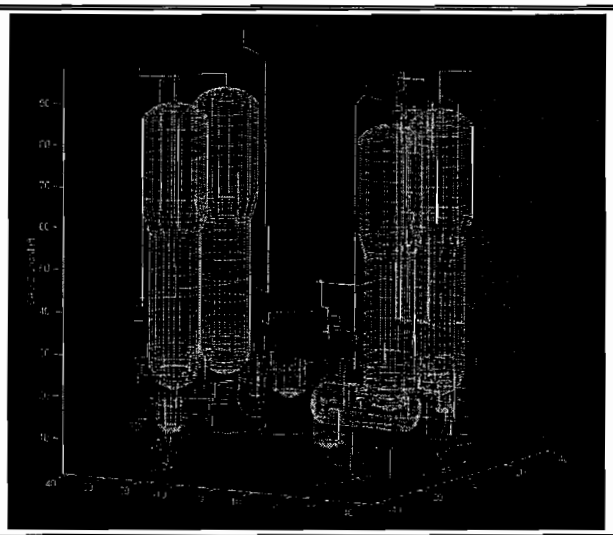
Spatial Plant Model Needed for Debris Source Issues

- **Realistic spatial configuration of insulated piping and equipment is important:**
  - Proper distribution of potential break sizes **(debris volume)**
  - Defines regions of high insulation density **(debris volume and composition)**
  - Presence of structure and equipment offers confinement and sheltering **(debris volume)**
  - Spatial correlation between insulation types and break sizes **(debris composition)**
  - Break location relative to sump **(debris transport)**
- **A flexible, efficient model can be used for parameter studies: insulation type, effective damage volume, directional impingement, postulated break location, barriers, etc.**

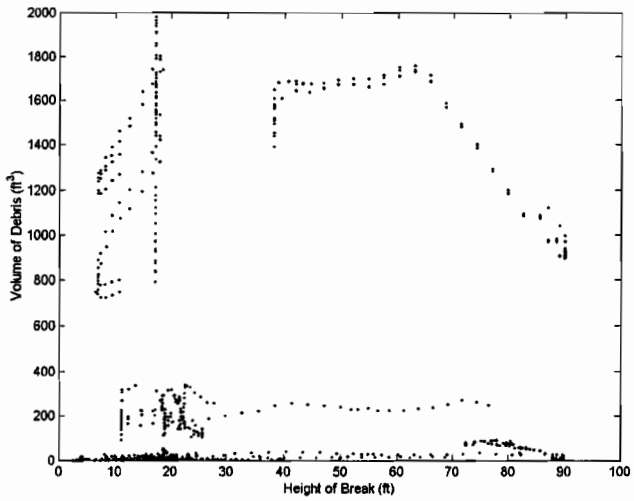
CASINOVA Source-Term Analysis

- **Containment Accident Sequence INsulation Outcome Verification Analysis (CASINOVA) model:**
  - Accepts spatial pipe and equipment data cross referenced by reactor system, insulation type, and pipe diameter (ASCII data files)
  - Discretizes insulated pipes into linear segments that are then represented as point targets on the centerline
  - Discretizes equipment blankets into panels represented as point insulation targets
  - Maps spherical damage pressure zones on spatial insulation data
    - BWR URG correlations specific to each insulation type and breakdiam.
  - Postulates Guillotine breaks at any set of locations
    - Table of welds correlated with specific pipe sizes and reactor systems
  - Performs CAD-like simulations and compiles statistics on break size, reactor system, debris volume, and debris composition.
  - Developed in MATLAB® to run on a high-end desktop PC
    - Potential for standalone distribution, GUI development, C++ interface

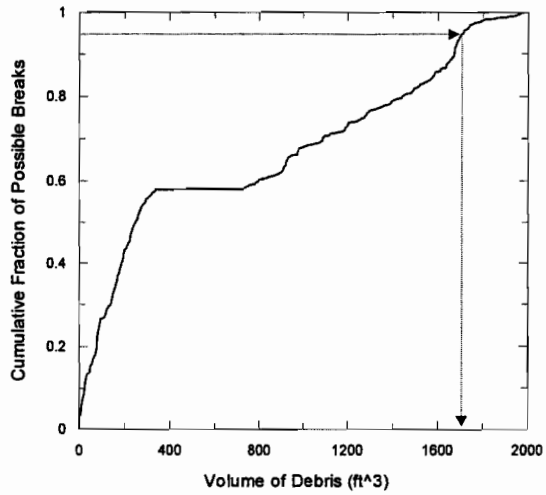
CASINOVA Debris Simulation



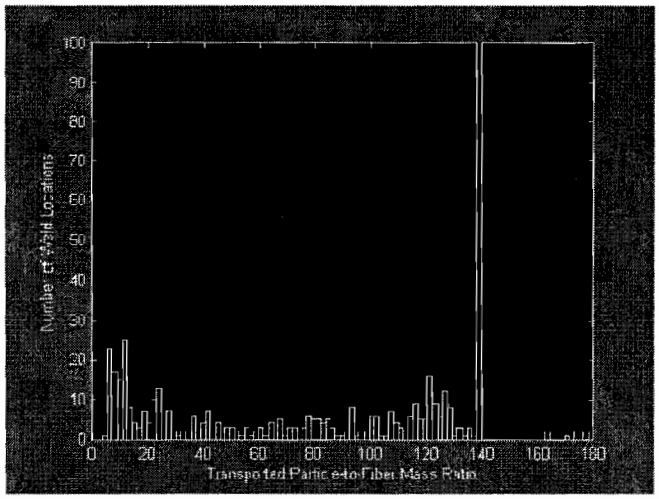
Break Locations



Dist. of LLOCA Debris Volumes



CASINOVA Summary Statistics

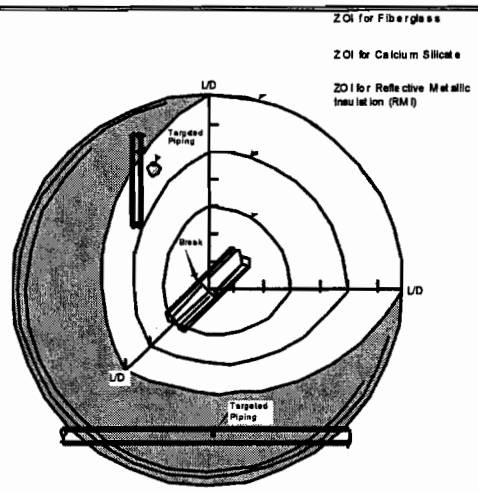


Debris Generation: Zone of Destruction

Guidance

- **Spherical Zone of Influence (ZOI) defined by destruction pressure of each insulation type**
  - Examples provided in NUREG/CR-6224 and BWROG URG and Staff Evaluation of BWROG response to NRC bulletin 96-03
- **The size and shape of ZOI should be supported by analysis or experiments specific to break size and target (destruction pressure)**
- **The volume of debris contained in ZOI should be used to estimate the amount of debris generated**
- **The size distribution of debris should be determined by analysis or experiment**
- **The shock wave and subsequent jet should be the basis for estimating amount and size generated in ZOI (pressure equivalent spherical volume)**

Pressure Equivalent Spherical ZOI

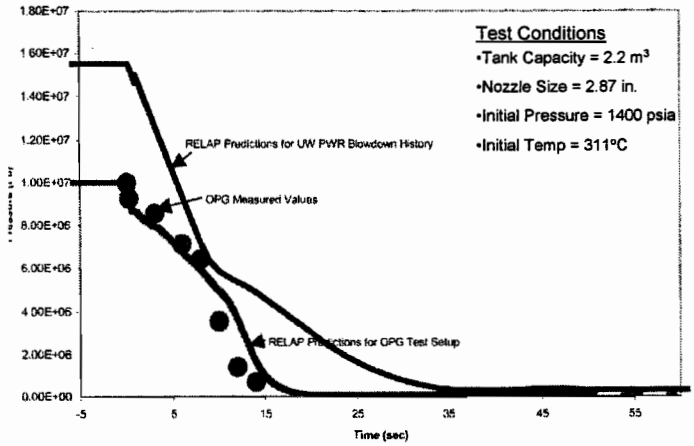


Note:
L = Distance from break to target
D = Diameter of broken pipe

BWROG Data

Selected Insulation Destruction Pressures		
Insulation Material	**BWROG Recommendation**	**NRC Confirmatory Analysis Recommendation**
Calcium Silicate with Aluminum Jacket	160	150
K-Wool	40	40
Temp-Mat with SS Wire Retainer	17	17
Knaupf®	10	10
Jacketed NUKON®	10	6
Unjacketed NUKON®	10	6
Min-K	4	<4

OPG Calcium-Silicate Tests



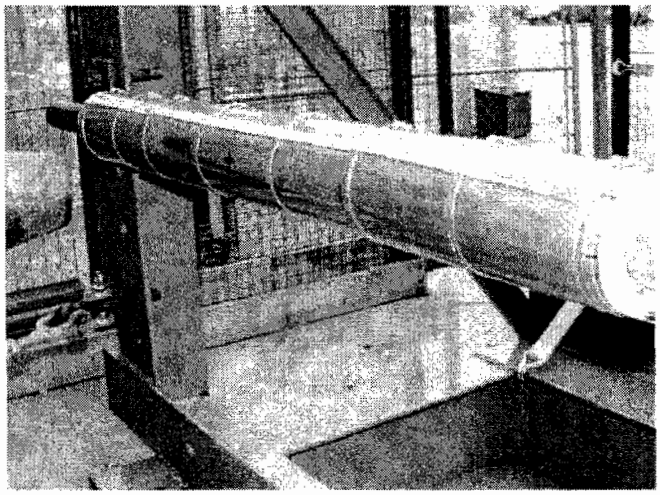
Scaling Analysis

- **PWR blowdown begins @ 2300 psig**
  - Initially flashing water ($x \sim 0$) at stagnation
  - After 10 s stagnation $x = 0.2$. Jets are steam continuum with suspended droplet field
- **Scaling must account for**
  - Higher stagnation pressure compared to BWR
  - Lower quality compared to MSLB of BWR
- **ANSI/ANS-58.2 and EPRI models formed the basis for scaling**

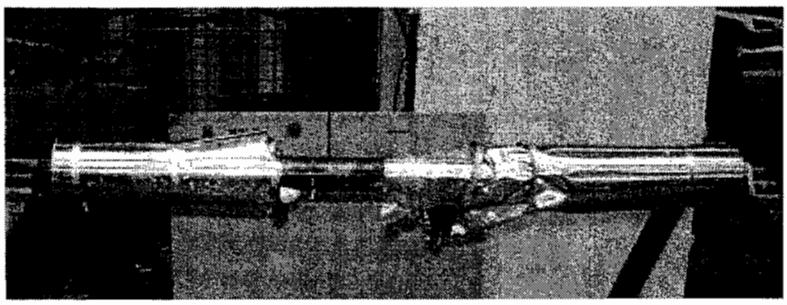
Rederived ZOI for Cal-Sil

- **Rederived using OPG data and analysis approach similar to BWR study**
- **Slightly increased ZOI size**
  - Nukon: 12-D (PWR) vs 10-D (BWR)
  - Cal-Sil: 8-D (PWR) vs 6- D (BWR)
- **Higher fraction of fines**
  - Nukon: 29% (BWR) vs 40% (PWR)
  - Cal-Sil: ≈ 0% (BWR) vs 30% (PWR)

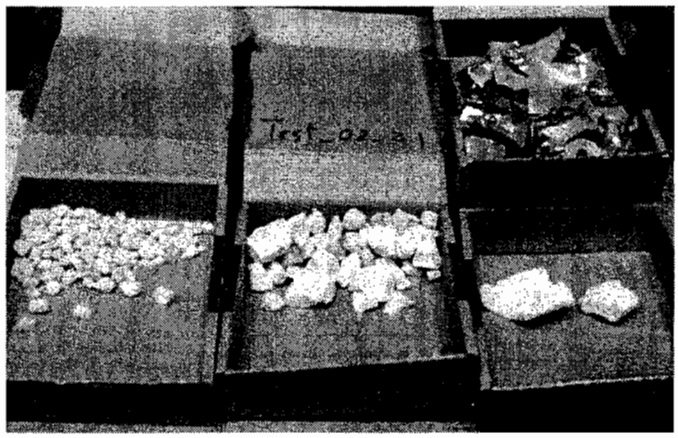
OPG Calcium-Silicate Tests



OPG Calcium-Silicate Tests



OPG Calcium-Silicate Tests

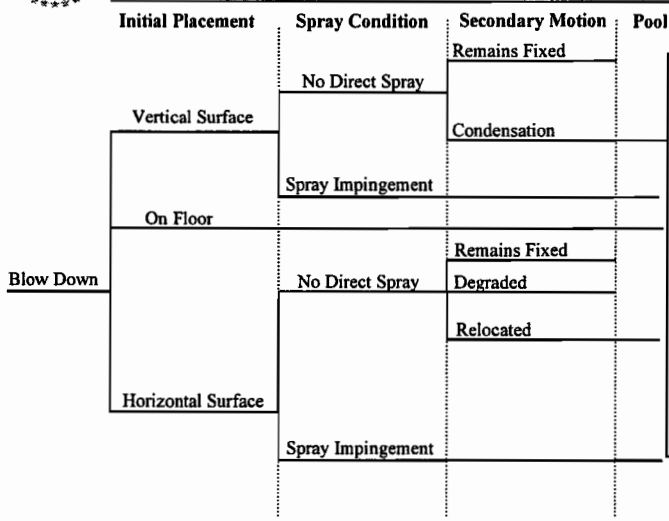


Blow-Down/Wash-Down Debris Transport

Blowdown/Washdown Transport of Debris to Sump Pool

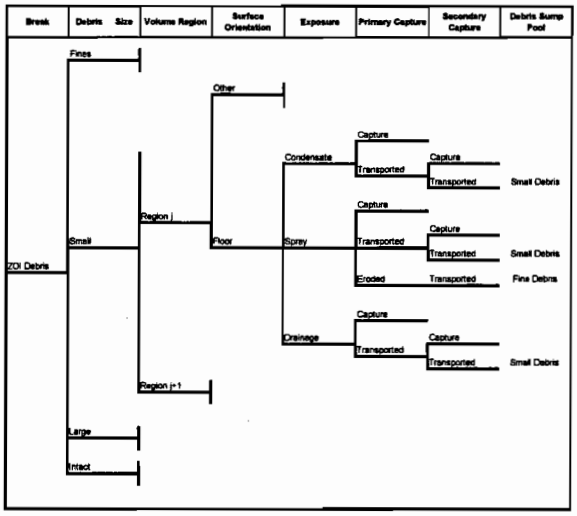
- **Debris Initially Dispersed Throughout Containment by Depressurization Flow**
  - Primary Modes of Debris Deposition
    - Inertial Capture When Flows are Dynamic (e.g., near break)
    - Gravitational Settling as Flows Slow and Turbulence Dissipates (e.g., dome region)
- **Transport by Containment Spray Drainage**
  - Spray Transport Processes
    - Capture of Remaining Airborne Debris
    - Debris Washed from Structures
      - Some Areas of Containment Not Directly Impacted by Sprays
    - Debris Entrained by Drainage Flows
    - Entrained Debris Can Be Trapped (e.g., Floor Drains)
    - Trapped Fibrous or Particulate Debris Subject to Erosion

Logic Chart for Transport Fractions (NUREG-6762 Vol 4)

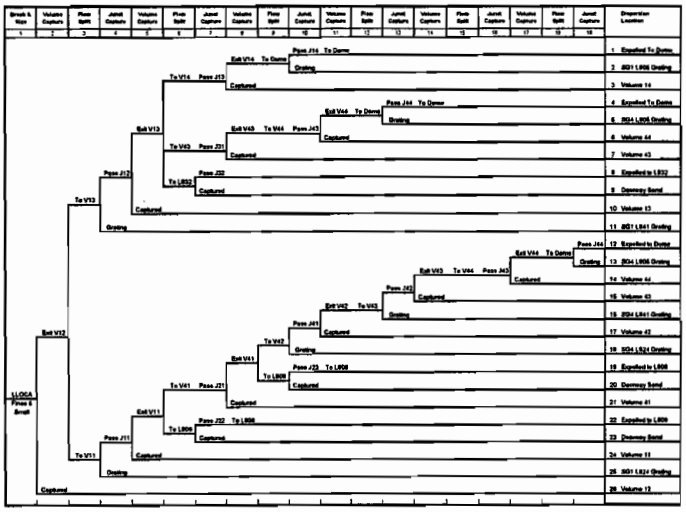


- Logic charts for each debris type and size
- Use different tools for each phase of transport
- Engineering judgment and simple calculations used to quantify branches
- Demonstrates systematic and traceable approach to vulnerability assessment
- Degree of conservatism can be compared to plausibility of physical mechanisms

Example Section of Debris Transport Chart



Transport Chart for Steam Generator Compartment with Break



Pool Transport

Debris Transport Analysis (NUREGs 6772 and 6773)

Basic Assumptions:

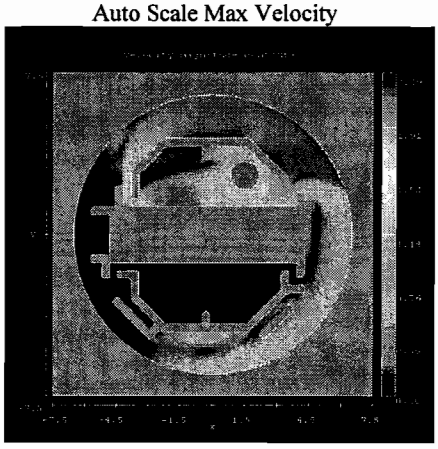
1. Linear flume tests characterized the incipient flow and settling velocities of various debris types and sizes
2. CFD can predict local water velocities (speed and direction)

Approach: (for a given debris size and initial location)

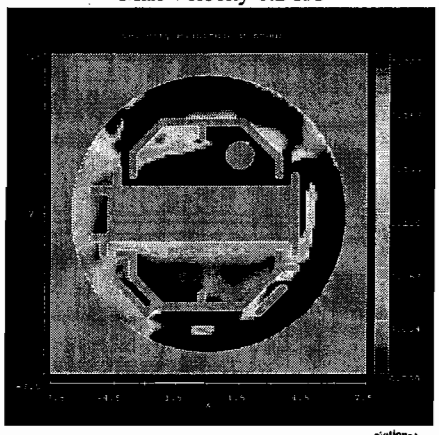
1. Consider contiguous areas with velocities higher than incipient velocity as regions susceptible to transport
2. Conservatively assume migration to boundary of the incipient velocity contour and release from pool surface
3. Consider settling time from surface as an opportunity to drift into another contour or into a stagnant zone (velocity < incipient)
4. Any debris reaching the contiguous contour surrounding the sump is assumed to eventually collect on the screen

Steady-State Velocity Maps (Upper)

Auto Scale Max Velocity

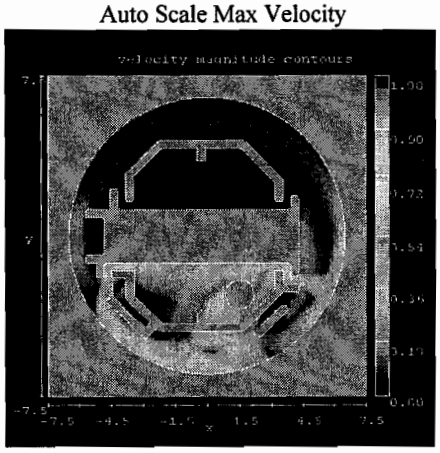


Max Velocity 0.2 ft/s

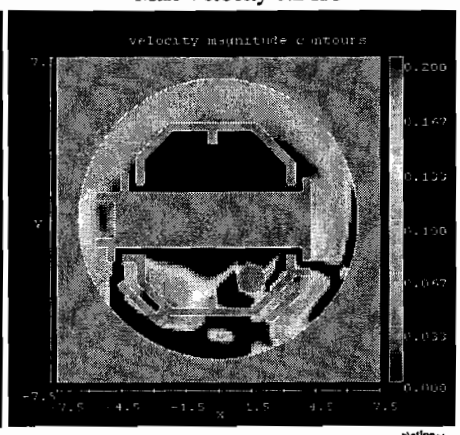


Steady-State Velocity Maps (Lower)

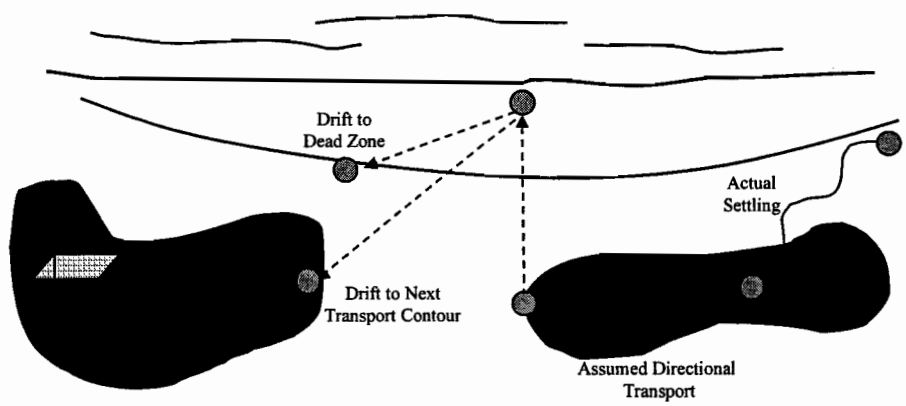
Auto Scale Max Velocity



Max Velocity 0.2 ft/s



Schematic of Pool Transport



Observations Regarding CFD

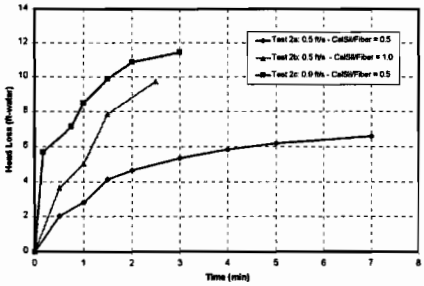
- **Good qualitative agreement between CFD models of fill/steady-state velocities and Tank Experiments**
- **Ancillary sources representing containment spray return paths should be added**
  - Particular interest in effect of annular wash down of walls to pool
- **Current suite of desktop PCs will permit ~10 break simulations per volunteer plant**
- **Quantitative flow maps provide access to an approximate, yet tractable estimate of transport fraction**
  - Logic maps and engineering judgment will be needed to consider fractions and characteristics of debris returned to the pool via various paths
- **Uncertainties in location and timing of debris entering pool limit the need for a high fidelity model of debris transport**

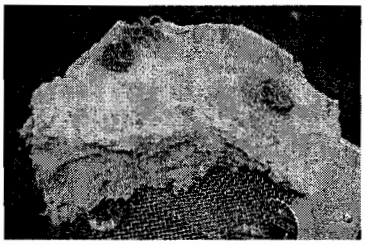
Debris-Bed Head Loss

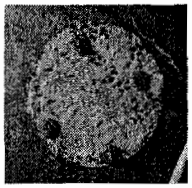
UNM Head-Loss Testing

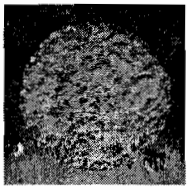
- **Confirmed that BWR head-loss correlation is robust**
  - Vertical screens
  - Square mesh vs. perforated plate
- **Obtained additional data**
  - Cal-sil
  - Aluminum RMI
  - Al RMI + fiber
- **Provided template of analytic technique and accessible facility**
- **MUST use appropriate material properties for head-loss estimates**
  - Sludge density
  - Bed porosity
  - Interstitial velocities

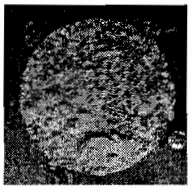
Cal-Sil + Fiber Head Loss







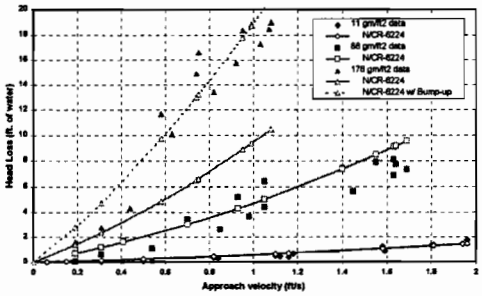




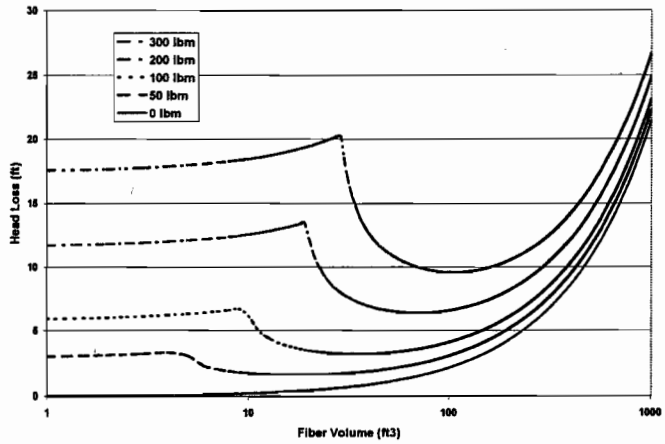
BLOCKAGE Head-Loss Estimation

- BLOCKAGE PC-utility useful for assessing sump-screen vulnerability as a function of debris composition, volume and flow velocity
- Assumes debris bed of uniform thickness and composition
- Head-loss correlations in current BLOCKAGE being updated to include recent tests of additional debris types
- All head-loss correlations in BLOCKAGE will also be incorporated in CASINOVA

Empirical Head-Loss Correlations for Calcium Silicate



BWR Head-Loss Correlation (NUREG-6224)

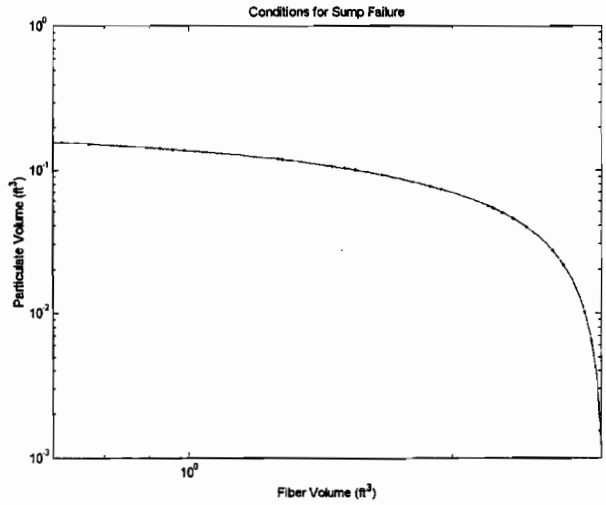


Integrated Vulnerability Assessment

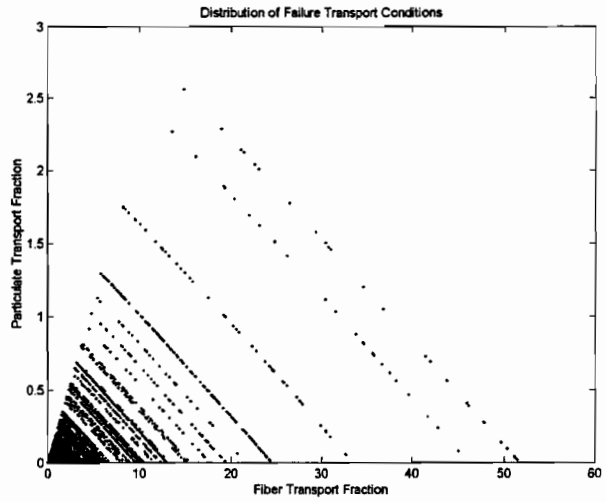
Available Analysis Resources

- **Debris Generation and Transport Test References**
- **Knowledge-Base Report (Sump-Blockage Source Book)**
- **Comprehensive Composite Plant Analysis**
  - Spatial Logic Diagrams
  - CFD examples
  - Application of Transport Estimation
  - Application of CASINOVA and BLOCKAGE
- **CASINOVA Debris Volume Simulation**
- **BLOCKAGE Head-Loss Estimation Utility**

Conditions for Sump Failure



Transport Required for Failure



Industry Activities to Address PWR ECCS Sump Performance

Advisory Committee on Reactor Safeguards
Thermal-hydraulic Phenomena Subcommittee
February 4, 2003

John Butler
Senior Project Manager
Nuclear Energy Institute
(202)739-8108
jcb@nei.org

NEI

Industry GSI-191 Activities

- PWR industry is taking the lead in developing methodology for plant-specific assessments of ECCS sump performance
- Presentation will address:
  - **Who** is involved in industry activities?
  - **What** activities are underway?
  - **When** activities are scheduled to be completed?

NEI

Industry GSI-191 Activities

- Industry activities are a coordination of efforts
  - NEI PWR Sump Performance Task Force
  - WOG/CEOG
  - B&WOG
- NEI Task Force includes representatives from
  - PWR Owners Groups
  - PWR utilities
  - EPRI
  - EDF
  - consultants

NEI

Industry GSI-191 Activities

- Activities currently underway fall into three general categories:
  - Coordination, collection and evaluation of data applicable to ECCS sump performance
  - Development of ECCS sump performance evaluation methodology for application by PWR plants
  - Communication of industry and regulatory activities to PWR plant operators

NEI

Data Collection and Evaluation

- Coordination, collection and evaluation of data applicable to ECCS sump performance is an ongoing effort performed in parallel with methodology development
- Research data (Industry, NRC, International) must be evaluated to determine its applicability to U.S. PWR conditions
  - Identified data gaps will need to be filled by obtaining additional data or be addressed in conservative manner

NEI

Data Collection and Evaluation

- Plant data covering debris sources, programs and designs are needed to support methodology development as well as plant-specific implementation of guidance
  - NEI 02-01, Condition Assessment Guidelines: Debris Source Inside PWR Containments addresses potential debris sources

NEI

NEI-02-01, Debris Sources Inside PWR Containments

- Issued to all PWR plant operators
- Document offers guidance to:
  - Identify, locate and characterize potential sources of debris that could challenge the post-accident operability of the containment sump
  - Perform containment walkdown surveys to verify or supplement design or maintenance documentation
- Revision 0 issued in April 2002
  - Pilot application at several plants
- Revision 1 issued in September 2002
  - Addressed comments received from pilot plants and NRC

NEI

NEI-02-01, Debris Sources Inside PWR Containments

Purpose

- Document information to support plant-specific sump performance assessments
- Identify potential debris sources inside containment resulting from affected design basis events
- Perform supporting walk-downs:
  - Verify current as built conditions
  - Focus on location and amount of insulation materials, unqualified coatings, foreign materials

NEI

ECCS Sump Performance Evaluation Methodology

- Guidance will address methods for assessment of sump performance and actions that can be taken to address assessment findings
  - Develop analytical tools, methods and guidance for debris generation, debris transport, debris accumulation and pressure drop across the sump screen
  - Perform sensitivity analysis
  - Develop decision analysis tools

NEI

ECCS Sump Performance Evaluation Methodology

- Completion of Evaluation Methodology is scheduled for September 2003
  - Plant-specific implementation would follow
- Frequent status meetings held with NRC during development period
- "Ground rules" provide outlines of methodology development to facilitate discussions
- Impact of Regulatory Guide and Generic Letter on methodology development and schedule will be evaluated following release for public comment

NEI

Industry Communication

- **Written correspondence:**
  - Provides updates on ongoing task force and regulatory activities
  - Distribute draft documents for comment and review
  - Issue finalized guidance along with recommendations for use
- **PWR Sump Performance Information Forum website**
  - Internet based website used to augment more traditional communication tools
  - Provides benefit of easy access by all staff levels within a company
  - Facilitates distribution of GSI-191 research reports and NEI PWR Sump Performance Task Force guidance materials
  - Provides a forum for discussion among PWR plant operators

NEI

Industry Communication

- **Industry Workshops**
  - Workshops are being conducted to provide forums for instruction and use of guidance and transfer of information
  - First workshop conducted July 30-31, 2002 and focused on NEI 02-01
  - Second workshop tentatively scheduled for Summer 2003
  - Implementation workshop following issuance of evaluation methodology being considered

NEI

REPORT

ACRS Thermalhydraulics Phenomena Subcommittee Meeting
February 4, 2003
NRC, Washington, DC

Sanjoy Banerjee

1. Introduction

The meeting was devoted to discussion of GSI-191—Assessment of Debris Accumulation on PWR Sump Performance. The safety issue relates to information that suggests that more and finer debris could be generated during pipe-break incidents and that sump clogging could occur due to both the amount of debris and its nature, i.e., potentially finer and fibrous. The overall effect would be on long-term re-circulation cooling. The assessment indicated that there could be a factor of 170 increase in core damage frequency in the absence of operator action, with a reduction of about an order of magnitude to something like a factor of 17 increase taking credit for operator actions. Therefore, this is a significant problem, and the NRC staff propose to revise Regulatory Guide 1.82 and issue a Generic Letter to deal with it.

In parallel, there is a PWR industry initiative to develop guidance for plant-specific evaluations. This effort appears to be spearheaded by NEI, which issued a condition assessment guideline in September 2002. NRC justifies interim operation until this GSI is resolved, based on the low probability of LOCA requiring re-circulation and several other factors. Nonetheless, it is important that the work move forward rapidly. A schedule was presented to the ACRS Subcommittee that included issuing a Draft Regulatory Guide for public comment in February 2003, with the Regulatory Guide being revised and issued in September 2003. In parallel, a draft generic letter would be issued for public comment in the first quarter of 2003 and issued finally in summer 2003. NEI is expected to issue plant-specific evaluation guidance in fall 2003.

This is quite an ambitious schedule, but it is justified in view of the potential impact of this issue. Nonetheless, I am skeptical about NEI meeting this schedule, in view of the work that has apparently been accomplished to date. The condition assessment guidelines that NEI has already issued to locate debris sources inside PWR containments does not appear to be very detailed and mainly appears to be related to preparing inventories of debris sources through walk-downs performed on various plants.

At the outset, it is worth stating that ACRS and NRC should do whatever is necessary to resolve the issue rapidly and encourage industry to respond in a timely fashion. Apparently, this has been done by the BWR Owners' Group, and similar action should be taken for PWRs. The stumbling block for PWRs is apparently the qualitative differences between different plants, which makes resolution of the generic issue more

difficult. I believe this is more a question of degree compared to BWRs and not a substantive difference, as I will discuss later.

2. Comments

The work done on this issue by NRC staff and their contractor, Los Alamos National Laboratory, in particular, are commendable. The Los Alamos work has addressed debris generation, transport and accumulation/head loss in some detail and ultimately integrated this in a vulnerability analysis. The main conclusions are that more and finer debris could be generated in a pipe-break incident than previously estimated, and that sump clogging could be aggravated due to what is called "the thin bed effect". There is also some concern about debris being carried into the re-circulation system and causing blockage downstream of the sumps, e.g., HPSI throttle valves. I have several specific comments associated with these scenarios.

1) Filters can undoubtedly be designed to eliminate or reduce the "thin bed effect". This is probably what is done for BWRs, but we need more information on how they deal with this problem.

2) It was not clear from the presentation whether the temporal buildup of debris on the filters was modeled as part of the CFD calculations. It would be expected that the fine debris would be suspended and transported to the filters first, and then perhaps through the filters, before the large chunks arrived. I don't know what happens to the fibers, but perhaps they would be suspended and transported with the fine debris. In any case, a clarification of this point is required.

3) It was mentioned that separating the sumps for the two ECC trains was not a simple matter and that current designs did not provide such capability. In view of this, it would be interesting to know whether it is feasible to draw water into the existing sumps from distant locations through ducts that have screened areas around their open ends. We are talking of relatively low flow rates of water, so these pipes or ducts would not have to be very large, and hydroclones could be attached to their ends to separate out the fines and fibers. In any case, it would be interesting to know if such measures have been considered and what their costs would be.

4) We were told that fibers exist in small quantities, however clean the plant, and that it is difficult to prevent small quantities of fines from forming. Furthermore, it appeared that rather small volumes, as small as a cubic foot, was sufficient to give severe head loss due the "thin bed effect". In view of this, I conclude that, while there may be something to be gained by improving housekeeping and cleanliness in the plant and reducing the amount of insulation that is likely to form fines, these measures cannot by themselves eliminate the sump-clogging problem. Am I correct in this conclusion?

If so, the only way to deal with the problem is to design the sump system to take out the fines and fibers before they get to the re-circulation pump and downstream

valving. While different plants might propose different methodologies for doing this, nonetheless this is the crux of the generic problem, and there should be at least one generic solution worked out—perhaps the BWR owners have already done this!

3. Conclusions

Sump clogging by debris generated during pipe breaks appears to be a significant issue in terms of its effect on long-term re-circulation and core cooling. I feel that there is much to be learned from what the BWR Owners' Group has done to deal with this problem, even though the PWR issues might be different in degree. Furthermore, from what was presented, I don't think the problem can be dealt with by changing insulation to prevent generation of fines and reduced debris or by housekeeping and other measures to reduce fibers. These measures can help, but, ultimately, rather small quantities can prevent effective re-circulation, if we believe the technical results presented. Therefore, a generic solution in terms the filter design to take out fines and fibrous materials would appear to be at the heart of this generic issue, and research in this direction is something the ACRS could recommend.

In view of all this, it is also desirable that NRC issue the generic letter and draft guide according to the schedule and encourage industry to think about the problems, particularly the results of the technical work carried out by Los Alamos National Laboratories. The NEI document circulated with regard to application of leak-before-break technology to pipe-break debris generation does not have much effect on this issue, as small amounts of fibrous debris and fines can lead to significant problems. Therefore, industry should be encouraged to respond to this issue in a more innovative way.