

UNITED STATES
NUCLEAR REGULATORY COMMISSION
OFFICE OF NUCLEAR REACTOR REGULATION
WASHINGTON, D.C. 20555

February 18, 1994

NRC BULLETIN 93-02 SUPPLEMENT 1: DEBRIS PLUGGING OF EMERGENCY CORE COOLING
SUCTION STRAINERS

Addressees

For Action:

All holders of operating licenses or construction permits for boiling-water reactors.

For Information:

All holders of operating licenses or construction permits for pressurized-water reactors.

Purpose

The U.S. Nuclear Regulatory Commission (NRC) is issuing this bulletin supplement:

- (1) to inform Action and Information addressees about the vulnerability of emergency core cooling system (ECCS) suction strainers in boiling-water reactors (BWRs) and containment sumps in pressurized-water reactors (PWRs) to clogging during the recirculation phase of a loss-of-coolant accident (LOCA).
- (2) to request that Action addressees take the appropriate actions to ensure reliability of the ECCS in view of the information discussed in this bulletin supplement regarding the vulnerability of the ECCS strainers to clogging.
- (3) to require that Action addressees report to the NRC whether and to what extent the requested actions will be taken and to notify the NRC when actions associated with this bulletin supplement are complete.

Background

The NRC staff concerns related to the potential loss of post-LOCA recirculation capability due to insulation debris were discussed in Generic Letter 85-22 (December 3, 1985), "Potential for Loss of Post-LOCA Recirculation Capability due to Insulation Debris Blockage" which documented the NRC's resolution of Unresolved Safety Issue (USI) A-43, "Containment Emergency Sump Performance." Although the staff concluded at that time that no new requirements would be imposed on licensees and construction permit holders, the staff did recommend that Regulatory Guide 1.82, Revision 1, "Water Sources for Long-Term

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Recirculation Cooling Following a Loss-of-Coolant Accident," be used as guidance for the conduct of 10 CFR 50.59 reviews dealing with the modification of thermal insulation installed on primary coolant system piping and components. NUREG-0897, Revision 1, "Containment Emergency Sump Performance" (October 1985), contained technical findings related to USI A-43, and was the principal reference for developing the revised regulatory guide.

Since 1985, the NRC staff has issued several information notices on this subject because of new developments.

On May 19, 1988, the NRC issued Information Notice 88-28, "Potential for Loss of Post-LOCA Recirculation Capability due to Insulation Debris Blockage," which discussed an item reported under 10 CFR Part 21 concerning the deterioration of drywell insulation and the potential for the aluminum foil coating of the insulation to block ECCS strainers during a LOCA.

On January 30, 1990, the NRC issued Information Notice 90-07, "New Information Regarding Insulation Material Performance and Debris Blockage of PWR Containment Sumps," which discussed experiments exposing NUKON insulation to high temperatures and alkaline conditions. The results of these tests indicated that head loss across the insulation material increases significantly after about 24 hours due to a reduction in flow area caused by compaction of the fiberglass material at elevated pH conditions.

On September 30, 1992, the NRC issued Information Notice 92-71, "Partial Plugging of Suppression Pool Strainers at a Foreign BWR," which reported on the plugging of two ECCS strainers at the Barseback Unit 2 BWR in Sweden on July 28, 1992. The strainers were plugged by mineral wool insulation that had been dislodged by steam from a pilot-operated relief valve that opened while the reactor was at 3100 kPa [435 psig]. Two of the five strainers on the suction side of the containment spray pumps were in service and became partially plugged with mineral wool. Following an indication of high differential pressure across both suction strainers 70 minutes into the event, the operators shut down the reactor and backflushed the strainers.

Information Notices 93-34 and 93-34 Supplement 1, "Potential for Loss of Emergency Cooling Function due to a Combination of Operational and Post-LOCA Debris in Containment," were issued on April 26, 1993, and May 6, 1993, respectively. They described several instances of clogging of ECCS pump strainers including two that occurred at the Perry Nuclear Plant, a domestic BWR 6. The first Perry event entailed clogging of residual heat removal strainers by operational debris. The second Perry event involved the deposition of filter fibers on residual heat removal strainers. The debris consisted of glass fibers that had been inadvertently dropped into the suppression pool from temporary drywell cooling filters, and corrosion products that had been filtered from the pool by the glass fibers adhering to the surface of the strainer. On May 11, 1993, in response to this event, the staff issued NRC Bulletin 93-02, "Debris Plugging of Emergency Core Cooling Suction Strainers," which requested that both PWR and BWR licensees (1) identify fibrous air filters and other temporary sources of fibrous material in containment not designed to withstand a LOCA and (2) take prompt action to remove the material and ensure the

functional capability of the ECCS. All licensees have responded to the bulletin and the staff has reviewed their responses. Discussions are continuing with several licensees. Resolution of the bulletin is anticipated for all licensees in the near future.

In response to these two events, the Perry Nuclear Plant licensee took several actions. These included an increase in the suction strainer area from 1.9 to 3.9 m² [20 to 42 ft²], provisions for a suction strainer backflush capability, and improved measures to maintain a high level of cleanliness in the suppression pool.

Description of Circumstances

After learning of the Barsebäck event, the staff performed approximate calculations for all domestic BWRs, based partly on information obtained from resident inspectors on the design of each BWR and partly on approximations based on general BWR features (such as the close proximity of steam lines leaving the drywell). These calculations showed the potential for loss of net positive suction head (NPSH) of ECCS pumps in some large-break LOCA scenarios in U.S. BWRs.

In the meantime, the regulatory authorities of Sweden and other northern and central European countries have viewed the Barsebäck incident as a precursor event related to potential loss of ECCS cooling due to LOCA-generated debris. They initiated a safety reanalysis effort, coupled with experiments directed at estimating the following: (1) amount of insulation destroyed by the steam jet, (2) resulting composition of debris, (3) amount of debris transported to the suppression pool, (4) extent of insulation debris buildup on strainers, and (5) resultant pressure drop across the blocked strainer under the postulated conditions. The staff compared the recently obtained results of this work with information in NUREG/CR-2982, Revision 1, "Buoyancy, Transport, and Head Loss of Fibrous Reactor Insulation" (July 1983), which was developed as part of the resolution of USI A-43. This comparison showed that the method of fragmenting insulation materials used in U.S. experiments done in support of USI A-43 may not be representative of the scenario following a large LOCA, and that the extent of debris generation due to the jet resulting from a postulated pipe break as reported in NUREG-0897 (1985) was underestimated. Also, the second event at the Perry Nuclear Plant described in IN 93-34 demonstrated that small particles, in combination with debris fibers, significantly increased the pressure drop across the strainers.

Upon completion of the approximate calculations, the staff contracted for a plant-specific study using a BWR 4 as a model to more accurately quantify the effect of LOCA-generated debris on available NPSH. A draft report, "Parametric Study of the Potential for BWR ECCS Strainer Blockage Due to LOCA Generated Debris," was published on January 20, 1994. Initial results from this study indicated that the available NPSH margin for the ECCS pumps may be inadequate following dislodging of insulation caused by a LOCA and transport of insulation debris to the suction strainers. This study presently does not consider (1) the effect of corrosion products and other particulates (which were demonstrated in the second Perry event and in experiments to significantly increase the pressure drop across the strainers), (2) the dense packing of debris on the surface of the

strainers (which was observed in the Barsebäck incident and in experiments performed in Europe), and (3) the loss of insulation from any pipe but the pipe postulated to break (that is, loss of insulation due to impact of the steam jet on adjacent piping). While the modeling of the transport of debris to the strainers may be conservative, and no credit was taken for accident containment pressure in calculating the available NPSH margin, the staff would expect the analysis results to yield a net reduction in the available NPSH had all these effects been included. Work is now being done to include these effects in the BWR 4 model.

Members of the NRC staff and representatives of domestic BWR licensees attended an OECD/NEA workshop on the Barsebäck incident held in Stockholm, Sweden, on January 26 and 27, 1994. Representatives from other countries at this conference discussed actions taken or planned to prevent or mitigate the consequences of BWR strainer blockage. These actions including changes in insulation materials in containment from mineral wool to fiberglass or a reflective metallic insulation, increasing the (total) area of BWR strainers from 5 m² to more than 100 m², providing instrumentation to monitor the differential pressure across the strainers during an accident, providing or improving the capability to backflush the strainers, and providing guidance in the emergency operating procedures concerning the correct response to this problem.

The NRC staff has met on two occasions with the Boiling Water Reactor Owners' Group (BWROG) on this issue. These meetings have been productive and both sides have expressed their intent to continue a discussion of the resolution of this issue using the meeting format. Further meetings are anticipated soon and the BWROG has informed the staff of interim actions it is planning to address this issue. In addition, the BWROG has presented two analyses to the NRC staff which form the basis for continued operation while this issue is being resolved. These are discussed further below.

Discussion

10 CFR 50.46 requires that each BWR and PWR must have an ECCS that is designed so that the calculated cooling performance following a postulated LOCA conforms to the acceptance criteria set forth in the regulation. These calculations are done assuming a single failure. Experience from recent operating events, as discussed above, demonstrates that excessive buildup of debris from thermal insulation, corrosion products, and other particulates on ECCS pump strainers has the potential to cause a common-mode failure of the ECCS. The staff presently considers these concerns plant specific because there is such variability of insulations installed, strainer or debris screen sizes and NPSH margins available.

Based on the operating events at Barseback and Perry and information from on-going domestic and foreign programs, the staff considers it important to address the issue of strainer blockage. In particular, the results of the recent plant-specific BWR 4 analysis done for the NRC staff and information from the recently completed OECD/NEA conference in Stockholm, discussed above, indicate that immediate interim actions are warranted and prudent until the NRC staff and the BWROG complete studies of the recently identified phenomena and until appropriate actions, based on these studies, can be implemented. The recently

identified phenomena include the increased pressure drop across the ECCS strainers due to corrosion products and other particulate matter, and the effect of compaction of debris on the strainers to a greater extent than measured in the work leading to resolution of USI A-43.

Because of the larger surface area of the screens surrounding PWR sumps, the staff considers it acceptable to wait until further studies are performed before determining the need for further action at PWRs.

The NRC considers the interim actions given below to be adequate based on the low probability of the initiating event.

Actions Requested

The NRC requests that pending final resolution of this issue, Action addressees take the following interim actions to enhance the capability to prevent or mitigate loss of the ECCS following a LOCA due to strainer clogging.

- Provide training and briefings to apprise operators and other appropriate emergency response personnel of the information contained herein and in the referenced information notices regarding the potential for suppression pool strainer clogging.
- Assure that the emergency operating procedures make the operator aware of possible indications of ECCS strainer clogging and provide guidance on mitigation.
- Institute procedures and other measures to provide compensatory actions to prevent, delay, or mitigate a loss of available NPSH margin under LOCA conditions. Such measures should be consistent with providing the design basis emergency system functions for core and containment cooling. Actions to assure sufficient core and containment cooling may include:
 - . Reduction of flow (consistent with delivering the required ECCS flow) through the strainers to reduce head loss and extend the time for debris deposition
 - . Operator realignment of existing systems to allow backflushing of clogged strainers
 - . Operator realignment of existing systems to allow injection to the core from water sources other than the suppression pool
 - . Intermittent operation of the containment sprays, when possible, to reduce the transport of debris to the strainers
 - . Other plant-specific measures which assure availability of sufficient core and containment cooling to meet the design basis of the plant

Action addressees should complete these requested interim actions within 90 days of the date of this bulletin supplement.

Action addressees are encouraged to work with the BWROG to obtain a final resolution of this issue.

Reporting Requirements

All Action addressees are required to submit the following written reports:

- (1) Within 60 days of the date of this bulletin supplement, a report indicating whether or not the addressee intends to comply with the actions requested above, description of planned actions, and the schedule for completing them. If an addressee chooses not to take the requested actions, the report shall contain a description of a proposed alternative course of action, the schedule for completing this alternative course of action, and a justification for any deviations from the requested actions.
- (2) Within 30 days of completion of the requested actions, a report confirming completion.

Address the required written reports to the U.S. Nuclear Regulatory Commission, ATTN: Document Control Desk, Washington, D.C. 20555, under oath or affirmation under the provisions of Section 182a, Atomic Energy Act of 1954, as amended, and 10 CFR 50.54(f). In addition, submit a copy to the appropriate regional administrator.

Backfit Discussion

Adequate flow from the ECCS is required to meet a condition of a plant operating license and the requirements of 10 CFR 50.46. The actions requested by this bulletin supplement represent a new staff position and are necessary to ensure that licensees are in compliance with existing NRC rules and regulations where these conditions are applicable. Therefore, this bulletin supplement is being issued as a compliance backfit under the terms of 50.109(a)(4).

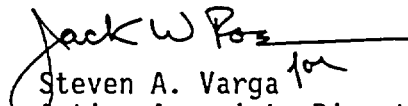
Paperwork Reduction Act Statement

The information collections contained in this request were approved by the Office of Management and Budget, clearance number 3150-0011, which expires June 30, 1994. The public reporting burden for this collection of information is estimated to average 200 hours per response, including the time for reviewing instructions, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing the collection of information. Send comments regarding this burden estimate or any other aspect of these collections of information, including suggestions for reducing this burden to the Desk Officer, Office of Information and Regulatory Affairs, NEOB-3019, (3150-0011), Office of Management and Budget, Washington D.C. 20503, and to the U.S. Nuclear Regulatory Commission, Information and Records Management Branch, (MNBB-7714), Washington, D.C. 20555.

Compliance with the following request for information is voluntary. The information would assist the NRC in evaluating the cost of complying with this bulletin supplement:

- (1) the licensee staff time and costs to perform requested procedure reviews and implementation of changes;
- (2) the licensee staff time and costs to prepare the requested reports and documentation;
- (3) the additional short-term costs incurred to address the changes, such as the costs of the corrective actions or the costs of down time; and
- (4) an estimate of the additional long-term costs that will be incurred as a result of implementation commitments.

If you have any questions about this matter, please contact one of the technical contacts listed below or the appropriate NRR project manager.


Steven A. Varga for
Acting Associate Director for Projects
Office of Nuclear Reactor Regulation

Technical contacts: Rob Elliott, NRR
(301) 504-1397

John B. Hickman, NRR
(301) 504-3017

Attachment:
List of Recently Issued NRC Bulletins

LIST OF RECENTLY ISSUED
 NRC BULLETINS

| Bulletin No. | Subject | Date of Issuance | Issued to |
|----------------|--|------------------|---|
| 93-02 Sup. 1 | Debris Plugging of Emergency Core Cooling Suction Strainers | 02/18/94 | All holders of OLs or CPs for boiling-water reactors All holders of OLs or CPs for pressurized-water reactors |
| 93-03 | Resolution of Issues Related to Reactor Vessel Water Level Instrumentation in BWRs | 05/28/93 | All holders of OLs or CPs for boiling water reactors (BWRs) with the exception of Millstone, Unit 1, and Big Rock Point. |
| 93-02 | Debris Plugging of Emergency Core Cooling Suction Strainers | 05/11/93 | All holders of OLs for nuclear power reactors. |
| 93-01 | Release of Patients After Brachytherapy Treatment with Remote Afterloading Devices | 04/20/93 | Brachytherapy Licensees Authorized to Use After-loading Brachytherapy Unit(s) Capable of Delivering Dose Rates Greater than 500 RADS (centigray) per Hour at 1 Centimeter |
| 90-01, Supp. 1 | Loss of Fill-Oil in Transmitters Manufactured by Rosemount | 12/22/92 | All holders of OLs or CPs for nuclear power reactors. |
| 92-03 | Release of Patients after Brachytherapy | 12/08/92 | <u>For Action</u> - Brachytherapy Licensees Authorized to use the Omnitron Model 2000 High Dose Rate (HDR) Afterloading Brachytherapy Unit <u>For Information</u> - None |

OL = Operating License
 CP = Construction Permit

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original signed by
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Steven A. Varga
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SEE PREVIOUS CONCURRENCES

| | | | | | |
|----------|----------|----------|----------|----------|--------------|
| OGCB* | TECH ED* | PDIII-1* | SCSB* | SCBS* | C:SCSB/DSSA* |
| PCWen | RSanders | JHickman | RElliott | RMLobel | RBarrett |
| 02/16/94 | 02/16/94 | 02/16/94 | 02/16/94 | 02/16/94 | 02/16/94 |

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|-----------|-----------|-----------|----------|----------|----------|
| DD:DSSA* | D:DSSA* | OIP* | OGC* | AC:OGCB | D:DORS* |
| MVirgilio | ACThadani | CRStoiber | SHLewis | AJKugler | BKGrimes |
| 02/16/94 | 02/16/94 | 02/16/94 | 02/17/94 | 02/26/94 | 02/18/94 |

| | |
|-----------|----------|
| ADT* | AANDP |
| WTRussell | SAVarga |
| 02/16/94 | 02/16/94 |

DOCUMENT NAME: 93-02, Supp. 1.BL

issued which will provide final resolution for BWR licensees. The staff expects to issue another supplement to the bulletin to PWR licensees at a later time. It is estimated that the future work will require one year of further effort.

The Office of the General Counsel reviewed this bulletin supplement and has no legal objection.

This bulletin supplement is sponsored by Ashok C. Thadani, Director, Division of Systems Safety and Analysis.

Original signed by

Frank J. Miraglia, Deputy Director
Office of Nuclear Reactor Regulation

Enclosures:

1. Proposed Bulletin 93-02, Supplement 1
2. Response to CRGR Charter Questions

Distribution:

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|--------|----------|----------|----------|----------|----------|--------------|
| NAME | PCWen | RSanders | JHickman | RElliott | RMLobel | RBarrett |
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| ADT* | AADPR #1 2117 | DD:NRR |
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DOCUMENT NAME: BU9302S1.COV