GSI-191:
Proposed RES Recommendation for Resolution

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ACRS Presentation
Rockville, MD
September 5, 2001

Overview of GSI-191

- Determine whether debris accumulation on sump screens will cause loss of net positive suction head (NPSH) margin following a loss-of-coolant accident (LOCA).

- Determine if further action needs to be taken for pressurized water reactors beyond what was done during the resolution of Unresolved Safety Issue A-43.

Overview of Generic Issue Process

- Why is GSI-191 being transitioned to new process?

Stages in Old Process

- Identification
- Prioritization
- Resolution
- Imposition
- implementation
- Verification

Stages in New Process

- Identification
- Initial Screening
- Technical Assessment
- Regulation and Guidance Development
- Regulation and Guidance Issuance
- Implementation
- Verification

☛ ACRS issued a letter regarding new process on May 18, 2001.

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Overview of Generic Issue Process

◆ Key Differences

- "Resolution" is not an interim step in new process
  - Closed or Excluded From Further Consideration

- Generic issue designation is kept until issue is excluded from further consideration (i.e., closed) in new process

Status of GSI-191

- GSI-191 has been transitioned from the old generic issue process to the generic issue process described in Management Directive 6.4

- GSI-191 is near the end of the Technical Assessment Stage of the Generic Issue Process

- RES will transmit its recommendation to the Director, NRR, by the end of September 2001.
  - NRR will have lead for GSI-191.

Proposed RES Recommendation for Resolution

- Plant-specific analyses be conducted to determine whether debris accumulation in containment will impede or prevent ECCS operation during recirculation.
  - Loss of NPSH Margin
  - Long-Term Cooling
- If it is determined that debris accumulation will impede or prevent ECCS operation, then appropriate corrective actions should be implemented.

Technical Bases for Proposed Recommendation

- Parametric Evaluation
  - Credible technical basis for making a determination that sump blockage is a generic concern for PWRs.

- **Risk and Cost-Benefit Considerations**
  - Substantial safety benefit from making fix .
  - Increasing the sump screen surface area is cost beneficial.

☛ On July 26 and 27, 2001, the NRC staff presented the parametric evaluation results, core damage frequency contribution estimates, and benefit estimates at a public meeting.

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Overview of Parametric Evaluation

- Analyses addresses debris generation, debris transport, debris accumulation, and the resulting head loss across the sump screen.
- Analyses addresses variability in relevant plant features such as screen area, sump configuration, debris sources, etc.
- Some relevant plant features could not be addressed such as debris location, containment configuration, etc.
- Provide a reasonable representation of operating PWRs, so the results form a credible technical basis for making a determination of whether sump blockage is a generic concern for PWRs.

☛ ACRS briefed on parametric evaluation on July 12, 2001.

Overview of Parametric Evaluation

- Very little fibrous and particulate debris is needed to cause loss of NPSH margin
  - Small NPSH margin
  - Small Sump Screen Area
- Most of parametric cases analyzed for Large LOCA resulted in loss of NPSH margin
- Some of the parametric cases analyzed for Small LOCA resulted in loss of NPSH margin

RISK AND COST-BENEFIT CONSIDERATIONS ASSOCIATED WITH GSI-191,

"ASSESSMENT OF DEBRIS ACCUMULATION ON PWR SUMP PERFORMANCE"

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PRESENTED TO ACRS ON SEPTEMBER 5, 2001

SCOPE OF WORK

-- CALCULATE THE DECREASE IN CORE DAMAGE FREQUENCY FROM FIXING THE SUMP-SCREEN CLOGGING PROBLEM

-- AS PER REG. ANALYSIS GUIDELINES (NUREG/BR-0058,rev. 3), CALCULATE THE MONETIZED BENEFITS FROM FIXING THE SUMP-SCREEN CLOGGING

-- ESTIMATE COSTS ASSOCIATED WITH FIXING THE PROBLEM

-- COMPARE COSTS WITH BENEFITS

-- LIMITED UNCERTAINTY ANALYSIS

OUTLINE OF APPROACH FOR CORE DAMAGE FREQUENCY CONTRIBUTION

The core damage sequence associated with sump screen clogging is:

LOCA(n)*RECIRC*SUMP-CLOGS*NON-RECOVERY

Here the n indexes the various size LOCAs.

LOCA(1)= Large LOCA=A

LOCA(2)=Medium LOCA=S1

LOCA(3)=Small LOCA=S2

LOCA(4)=RCP Seal LOCA

RECIRC= Event that ECCS recirculation is required

SUMP-CLOGS= Event that the sump screen clogs to the point that ECCS recirculation fails

NON-RECOVERY= Event that recovery actions fail

INITIATING EVENT FREQUENCIES

-- OBTAINED FROM NUREG/CR-5750 ("Rates of Initiating Events at U.S. Nuclear Power Plants: 1987-1995", February 1999)

INITIATING EVENT FREQUENCIES

	Mean	(5%, 95%) bounds
Large LOCA (> 6 inches)	**7E-6/yr**	**(3E-7/yr, 3E-5/yr)**
Medium LOCA (2 to 6 inches)	**4E-5/yr**	**(1E-6, 1E-4/yr)**
Small LOCA (0.5 to 2 inches)	**5E-4/yr**	**(1E-4/yr, 1E-3/yr)**
Very Small LOCA	**6.2E-3/yr**	
Stuck-Open Safety Relief Valve	**5E-3/yr**	
Reactor Coolant Pump Seal LOCA	**2.5E-3/yr**	

(Large LOCA frequency updated to take into account V.C. Summer event)

Seismic contribution calculated for Surry, and was small, when the revised LLNL hazard curves were used. Was neglected.

EVALUATION OF "RECIRC" AND "NON-RECOVERY"

- Three different types of plants considered for SLOCA:
  - Plants with large dry containments, emergency fan coolers, and large refueling water storage tanks (RWSTs)
  - Plants with sub-atmospheric containments
  - Plants with ice-condenser containments

EVALUATION OF "RECIRC" AND "NON-RECOVERY"

-- For medium LOCAs and large LOCAs, it was judged that it was certain to need to go to sump recirculation, and no credit was given for recovery; containment sprays will be actuated, and RWST will be depleted.

-- For very small break LOCAs it was judged that the chance of needing to go to recirculation was negligible; these LOCAs can be mitigated with charging pumps alone.

-- For stuck-open pressurizer safety valves, the probability of sump clogging was considered to be so small that the sequences could be neglected; the discharge into containment is from the quench tank rupture valve, and little debris would be generated.

-- Distinction between plant types enters only for SLOCAs and RCP seal LOCAs

PROBABILITY OF SUMP CLOGGING

The LANL draft technical letter report, "GSI-191: Parametric Evaluations for Pressurized Water Recirculation Sump Performance", July 2001, rev. 0, [the LANL parametric report] gives the likelihood of the potential for sump blockage, for each "case" ID.

These likelihoods were translated into probabilities as follows:

"very likely" P=1

"likely" P=0.6

"possible" P=0.3

"unlikely" P=0

THREE AGGREGATES OF PLANTS CONSIDERED

23 plant case: P(sump-clogs)=1, all size LOCAs

- -- 18 large drys
- -- 5 sub-atmospherics

32 plant case: P(sump-clogs)=1, for LLOCA and MLOCA

- -- 24 large drys
- -- 5 sub-atmospherics
- -- 3 ice condensers

40 plant case: P(sump-clogs)=1, for LLOCA, either 1 or .6 for MLOCA

- -- 32 large drys
- -- 5 sub atmospherics
- -- 3 ice condensers

AVERTED CORE DAMAGE FREQUENCY ESTIMATES FOR THE THREE AGGREGATES

23 PLANT AGGREGATE: Psump=(1,1,1) for LLOCA, MLOCA, SLOCA

? (CDF)= 9E-5/YR

32 PLANT AGGREGATE: Psump=(1,1, ANYTHING)

? (CDF)= 1E-4/YR

40 PLANT AGGREGATE: Psump= (1, 1 or 0.6, ANYTHING)

? (CDF)= 9E-5/YR

SUBSTANTIAL SAFETY BENEFIT FROM MAKING THE FIX

MONETIZED BENEFITS FROM AVERTING ACCIDENTS ASSOCIATED WITH SUMP CLOGGING

Generally, NUREG/BR-0184, "Regulatory Analysis Technical Evaluation Handbook", was followed.

BENEFITS CONSIST OF:

- **EXPECTED AVERTED POPULATION DOSE TO 50 MILES, MONETIZED AT $2000 PER PERSON-REM (~17% of benefit)**
- **EXPECTED AVERTED OFFSITE FINANCIAL COSTS**
- **EXPECTED AVERTED ONSITE COSTS (CLEANUP AND DECONTAMINATION; REPLACEMENT POWER)**
  (These dominate-- about 80% of benefit)
- **EXPECTED AVERTED ONSITE OCCUPATIONAL DOSE, MONETIZED AT $2000 PER PERSON-REM**

Benefits, continued

-- Results, for various combinations of the probabilities of sump clogging for the types of plants considered were generated. (For example, results were generated for a sub-atmospheric containment plant with a probability of unity for sump screen clogging for all size LOCAs.)

-- Then results for 3 aggregates of plants were generated. These aggregates corresponded to sets of plants which had various probabilities of sump clogging according to the LANL parametric report.

COST ANALYSIS FOR GSI-191

- Data Sources Used
  - BWR STRAINER BLOCKAGE EXPERIENCE
  - SUMP DEBRIS FIXES PERFORMED BY PG&E
  - CONTRACTOR/VENDOR ESTIMATES
- Cost Elements
  - Up-front analytical activities
    - Revise Reg. Guide and Issue Generic Communication
    - Develop Uniform Guidelines
    - Perform Reactor Specific Analysis
  - Physical modification (increase sump screen areas)
  - Other cost elements (audits/inspections)

COST-BENEFIT COMPARISON

The cost of fixing N plants is:

($6.12E5)*N+ $9.221E6 (year 2001 dollars; year 2001 present value)

For the purposes of the cost-benefit analysis it was assumed that 50% of the plants would seek license renewal, and that the benefits could here be adequately approximated by taking the average of the benefits for plants with t=14 years and t=34 years, where t = no. of years of operating life remaining with the fix in place. Fourteen years is the average remaining lifetime for a PWR with the fix in place (in about 3 years from now). With a 20 year license renewal period, the average lifetime would be 34 years.

COST-BENEFIT COMPARISON, CONTINUED

Case	Benefit	Cost	Benefit-Cost
23 plant case	$50E6	$23E6	$27E6
32 plant case	$85E6	$29E6	$56E6
40 plant case	$92E6	$34E6	$58E6

Year 2001 dollars; 2001 present value

CONCLUDE THAT IT IS COST EFFECTIVE TO REQUEST PLANT-SPECIFIC ANALYSES ON THE PART OF THE LICENSEES

UNCERTAINTIES

1. LOCA frequencies

Large LOCA

Assuming lognormal distribution with error factor of 10, as in NUREG/CR-5750:

95th percentile:	**3E-5/yr**
Mean:	**7E-6/yr**
Median:	**3E-6/yr**

Medium LOCA

95th percentile:	**1.5E-4/yr**
Mean:	**4E-5/yr**
Median	**1.5E-5/yr**

UNCERTAINTIES, CONTINUED

Small LOCA

95th percentile:	**1E-3/yr**
Mean:	**5E-4/yr**
Median:	**4E-4/yr**

2. Probability of Sump Screen Clogging

-- Assessment of likelihood of loss of sump recirculation took into account the fact that the operator may shut off one pump if there is loss of net positive suction head (NPSH), but it is unclear whether the likelihood assigned to this action was realistic.

-- LANL used licensing criteria for loss of NPSH; unclear what effect this has.

UNCERTAINTIES, CONTINUED

3. **Human error probabilities for recovery actions given sump recirculation failed were based on two IPEs, without additional analysis.**

4. **The assumption was made that the likelihood of having to go to sump recirculation for a small LOCA, for a plant with a large dry containment, was the same as for a Westinghouse plant like Callaway or Comanche Peak, which have emergency fan coolers and large RWSTs. May be optimistic for some plants with large dry containments.**

5. **Offsite consequences, given core damage**

   Very likely overestimated chance of early containment failure, but offsite health effects do not dominate the benefits. Also, chance of early containment failure only 2%.

NET EFFECT OF UNCERTAINTIES ON AVERTED CDF

-- **Did uncertainty analysis for large dry containment case**

-- **Most plants have large dry containments**

-- **Used Saphire code, performing uncertainty analysis on the expression used for the averted CDF, namely**

$\sum$ LOCA(N)*RECIRC*SUMP*NON-RECOV

-- **OBTAINED:**

95th percentile upper bound=	**1.8E-4/yr**
Mean=	**6.7E-5/yr**
Median=	**4.0E-5/yr**
5th percentile lower bound=	**1.2E-5/yr**
standard deviation=	**8.6E-5/yr**

UNCERTAINTIES FOR LARGE DRY CONTAINMENT PLANT

-- **This is the uncertainty in averted CDF for <u>one</u> large dry plant. The percentage uncertainty in the sum over a set of plants is less. For example, if the 18 large dry plants had their averted CDFs drawn randomly and independently from the same distribution, and if the sum of the 18 CDFs were nearly normally distributed (central limit theorem) then the median would be equal to the mean (which is the sum of the means), and the 5% lower limit on the average CDF would be**

$$6.7\times10^{-5}-2s/\sqrt{18}$$

or about 2.7E-5/yr. This implies that even with consideration of uncertainties it is cost-effective to request plant specific analyses.

-- **Uncertainties are likely larger for subatmospherics and ice condensers**

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