September 16, 2004

MEMORANDUM TO: Ledyard B. Marsh, Director
Division of Licensing Project Management
Office of Nuclear Reactor Regulation

FROM: Patrick W. Baranowsky, Chief */RA/*
Operating Experience Risk Analysis Branch
Division of Risk Analysis and Applications
Office of Nuclear Regulatory Research

SUBJECT: TRANSMITTAL OF PRELIMINARY DAVIS-BESSE ASP ANALYSIS FOR INTERNAL AND LICENSEE PEER REVIEW

Attached is the preliminary Accident Sequence Precursor (ASP) analysis of multiple conditions that existed at Davis-Besse from February 2001 until the plant was shutdown in February 2002. The conditions included in the analysis are the degraded vessel head, the cracking in the control rod drive mechanism (CRDM) nozzles, the unqualified coatings and debris in containment, and the potential failure of high pressure injection (HPI) pumps during recirculation. The purposes of this memorandum are to provide a copy of the preliminary analysis for internal review at the same time it is sent out for licensee review, and to summarize the results. Preparation and transmittal of this analysis have been coordinated with staff from the Office of Nuclear Regulatory Research, the Office of Nuclear Reactor Regulation and Region III.

Results of the Preliminary ASP Analysis: The ASP analysis calculated a change in core damage probability (ΔCDP) of six in one thousand (6×10^{-3}) from the degraded conditions that existed at Davis-Besse before February 2002. Based on the preliminary analysis, this event would be a "significant" precursor (i.e., an increase in core damage probability of greater than one chance in a thousand) in the Agency's annual Performance and Accountability Report to Congress.

NRC peer review requested. Please review the preliminary ASP analysis and provide us with any comments that you may have. We are requesting that NRR/DLPM coordinate reviews from SPSB, IIPB, and Region III. In order to facilitate incorporation of licensee and staff comments and preparation of the final report in a timely manner, consistent with the NRR and RES agreement on peer review, please provide your comments to us within 60 calendar days from the date of this memorandum.

Licensee peer review requested. We are also requesting NRR/DLPM to send the preliminary ASP analysis to the licensee for peer review. Since each preliminary ASP analysis undergoes an in-house independent review before it is sent out by OERAB, peer review by NRR and the region can be performed concurrently with the licensee's review. This process is also consistent with the NRR/RES peer review agreement. The analyses and a transmittal letter will be provided separately to NRR/DLPM. This letter reflects the modifications made by NRR/DLPM based on recent preliminary analyses sent to licensees, as well as the instruction

added to the letter regarding the transmittal of comments by the licensee that may contain potentially sensitive information.

Summary of the Condition at Davis-Besse: During an inspection of the control rod drive mechanism (CRDM) nozzles in February 2002, the licensee discovered that three nozzles were leaking through axial cracks, and that one of the leaking nozzles had begun to develop a circumferential crack. During repair of one of the leaking nozzles, the nozzle became loose in the reactor pressure vessel (RPV) head. Subsequent investigation revealed that a cavity had formed around that nozzle in the low-alloy steel portion of the RPV head, leaving only the stainless steel-clad material as the reactor coolant pressure boundary over an area of approximately 16.5 square-inches (Reference 1).

On September 4, 2002, with the reactor defueled, the licensee determined that the existing amount of unqualified containment coatings and other debris (e.g., insulation) inside containment could have potentially blocked the emergency sump intake screen, rendering the sump inoperable following a postulated loss of coolant accident (LOCA) (Reference 2).

On October 22, 2002, with the reactor defueled, a deficiency was identified for the High Pressure Injection (HPI) pumps. During the recirculation phase of a postulated LOCA, the HPI pumps may be damaged due to debris entrained in the pumped fluid. An evaluation by the licensee determined that the pump would be inoperable during any postulated accidents in which the pump would be required to pump water that contained fibrous debris (Reference 3).

The conditions at Davis-Besse were identified by the licensee and reported to the NRC before any radioactive material was released or any accident or event occurred. The NRC required the plant to remain shutdown until all significant deficiencies had been corrected. The simultaneous existence of multiple degraded conditions caused a loss of safety margin (i.e., a significant increase in the probability of an accident) at Davis-Besse. The reactor vessel head, one of the three barriers engineered to prevent the release of radioactive materials was degraded but did not fail. The other two barriers, the fuel cladding and the containment structure were not affected.

Summary of the Preliminary ASP Analysis: The ASP analysis used the Standardized Plant Analysis Risk Model (SPAR) model of the Davis-Besse plant. The ΔCDP of 6×10^{-3} was calculated by using increased small, medium and large LOCA frequencies, as well as sump failure and HPI pump failure probabilities that reflect the conditions found at the plant.

The analysis considered small, medium or large LOCAs that could result from a postulated failure of the degraded vessel head or from a postulated failure of a cracked CRDM nozzle. LOCA probabilities and sizes are based on an assessment of the possible conditions of the head and the degradation rates that existed over the year prior (February 2001 to February 2002) to discovery of the degraded head (see Reference 4). CRDM nozzle failure probabilities are calculated from models developed by the NRC supported by Argonne National Laboratory. These probabilities are based on alternative damage scenarios that could have progressed undetected during the year prior to discovery.

Adjustments to sump failure probabilities for unqualified coatings and debris in containment are based on insights and considerations researched as part of GSI-191. The assumptions that HPI pumps would fail during the recirculation phase of emergency core cooling are based on results from licensee's testing of the pump.

Since the analytic approaches outlined above do not produce parameter uncertainty distributions that can readily be used for standard PRA uncertainty analysis, an extensive set of sensitivity analyses was performed. The sensitivity analyses were systematically performed by varying one major parameter (LOCA probability, sump failure probability and HPR unreliability) at a time. Based on the sensitivity analysis, the ΔCDP for the integrated ASP analysis is in the range between low 10^{-3} and low 10^{-2}. Figure 1 shows the best estimate of the change in core damage probability and summarizes the results of the sensitivity analyses.

> The analysis of the vessel head (Reference 4) included a detailed sensitivity analysis that was performed by varying assumptions and data about the materials and the phenomena associated with vessel head failure. This resulted in a range of LOCA frequencies for each break size. Using results from Reference 4, the ΔCDP cases shown in Figure 1 vary from 3×10^{-3} to 2×10^{-2}.
>
> The baseline sump failure probabilities, which differ for small, medium and large LOCAs, for this ASP analysis were determined using the approach developed and information collected for the resolution of GSI-191. Varying the assumptions in the analysis will result in different sump failure probabilities. The ΔCDP cases shown in Figure 1 vary from 2×10^{-3} to 3×10^{-2}.
>
> Sensitivity cases were analyzed for HPI pump performance ranging from nominal to postulated failure of the pumps for all recirculation scenarios, including water from the PORV relief tank. Since the condition of the sump and vessel head dominate the analysis, all HPI pump sensitivity cases gave results high in the 10^{-3} range.

The results of change in core damage probability calculations done for individual conditions are shown in the 'Vessel Head Only' and 'Sump and HPR' sections of Figure 1. Taken individually, the vessel head degradation increased the core damage probability significantly more than the sump or HPR conditions taken separately.

Comparison to the Significance Determination Process: As part of the Reactor Oversight Process (ROP), the Agency has previously evaluated the risks from three of the above conditions at the Davis-Besse plant. The degradation of the reactor vessel head event led to a RED Significance Determination Process (SDP) finding, the unqualified coatings and debris that could potentially lead to sump failure led to a YELLOW finding, and the design deficiency in the HPI pumps led to a WHITE finding. It should be noted that according to SDP guidance, concurrent multiple degraded conditions are usually analyzed individually (so that the significance of each inspection finding can be determined). Since these conditions are combined in the ASP evaluations (so that potential accident precursors can be identified for the actual plant operating condition), the ASP evaluation calculates a much higher risk than the individual SDP evaluations. As shown in Figure 1, when the conditions are taken individually, the SDP risk evaluations are similar to the ASP evaluations.

Implications of the Preliminary ASP Analysis: The NRC established the ASP Program in 1979 in response to the Risk Assessment Review Group report (see NUREG/CR-0400, dated September 1978). The primary objective of the ASP Program is to systematically evaluate U.S. nuclear power plant operating experience to identify, document, and rank the operating events that were most likely to lead to inadequate core cooling and severe core damage (precursors), if additional failures had occurred. The ASP Program has the following additional objectives:

- Provide a measure for trending nuclear power plant core damage risk.

- Provide a partial check on dominant core damage scenarios predicted by probabilistic risk assessments (PRAs).

The NRC also uses the ASP Program to monitor performance against the Safety Goal established in the agency's Strategic Plan.

The ASP analysis calculated a ΔCDP of six in one thousand (6×10^{-3}) from the degraded conditions that existed at Davis-Besse before February 2002. Based on the preliminary analysis, this event would be a "significant" precursor which is the highest category (i.e., an increase in core damage probability of greater than one chance in a thousand) in the Agency's annual Performance and Accountability Report to Congress. This risk at Davis-Besse represents one of the higher risk conditions analyzed by the ASP program. In the past ten years, we have had two significant precursors - the Wolf Creek drain down event of 1994 when operators inadvertently transferred water from the reactor coolant system to the refueling water storage tank and the Catawba Loss of Offsite Power event of 1996 when one emergency diesel generator was unavailable. Since 1979, we have had 18 events that would be classified as significant precursors under today's guidance. Of these 18 events, four had risk measures higher than this condition at Davis-Besse.

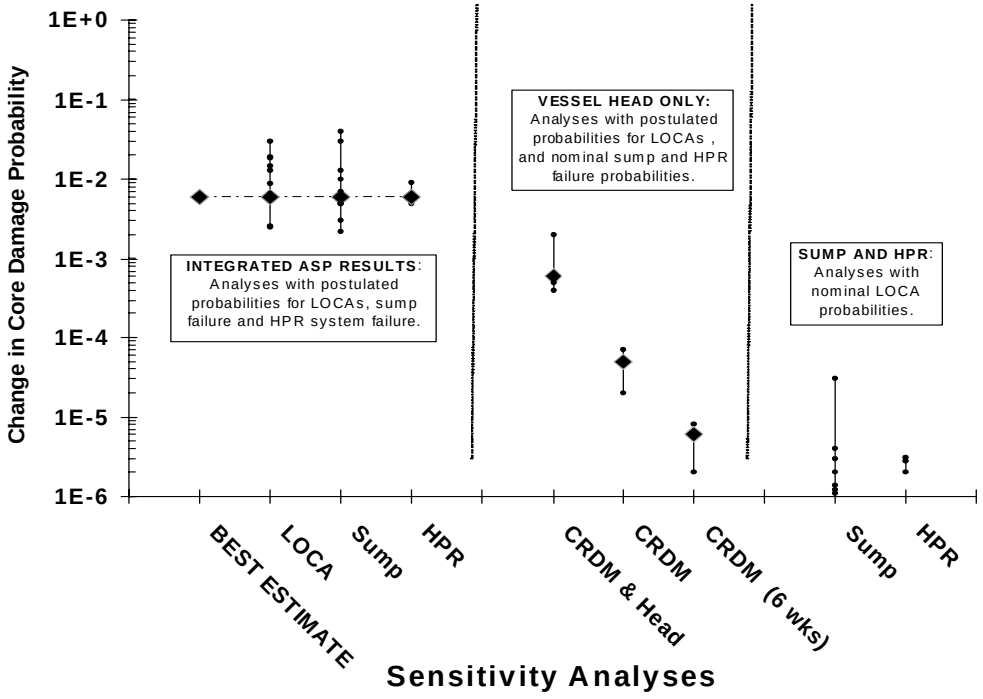
Sensitive information. The detailed ASP analysis is classified as "SENSITIVE - NOT FOR PUBLIC DISCLOSURE." This classification is based on the guidance provided by the EDO in the memorandum to the Commission (dated April 4, 2002) concerning the release of information to the public that could provide significant assistance to support an act of terrorism. In particular, Criteria 1 was determined to apply to ASP analysis reports:

> Plant-specific information, generated by NRC, our licensees, or our contractors, that would clearly aid in planning an assault on a facility. An example might be drawings depicting the location of certain safety equipment within plant buildings. Examples may include portions of Final Safety Analysis Reports (FSARs), Individual Plant Examination (IPE) material, and other risk and facility vulnerability information.

This classification could change in the future based on revised Agency guidance and office (NRR and RES) procedures in response to the Staff Requirements Memorandum, "Staff Requirements - COMSECY-02-0015 - Withholding Sensitive Homeland Security Information From the Public," dated April 4, 2002. Future changes in the transmittal of ASP analyses will be coordinated with the NRR ASP Program liaison. The sensitive ASP analyses are referenced in Adams for NRC staff use only.

The ASP analysis can be found at ML042590583. If you have any questions about the analysis, please contact Gary DeMoss (415-6225).

FIGURE 1: SUMMARY OF ASP ANALYSIS RESULTS



References

1. LER 50-346/02-002-00, *Reactor Coolant System Pressure Boundary Leakage Due to Primary Water Stress Corrosion Cracking of Control Rod Drive Mechanism Nozzles and Reactor Pressure Vessel Head Degradation*, April 29, 2002 (ADAMS Accession No. ML021220082)

2. LER 50-346/02-005-02, *Potential Clogging of the Emergency Sump Due to Debris in Containment*, May 21, 2003 (ADAMS Accession No. ML031470074)

3. LER 50-346/03-002-00, *Potential Degradation of High Pressure Injection Pumps Due to Debris in Emergency Sump Fluid Post Accident*, May 5, 2003 (ADAMS Accession No. ML031330187).

4. Williams, P. T., Yin, S., and Bass, B. R., *Probabilistic Structural Mechanics Analysis of the Degraded Davis-Besse RPV Head*, ORNL/NRC/LTR-04/15, Oak Ridge National Laboratory, September 2004 (ADAMS Accession No. ML042600455).

References

1. LER 50-346/02-002-00, *Reactor Coolant System Pressure Boundary Leakage Due to Primary Water Stress Corrosion Cracking of Control Rod Drive Mechanism Nozzles and Reactor Pressure Vessel Head Degradation*, April 29, 2002 (ADAMS Accession No. ML021220082)

2. LER 50-346/02-005-02, *Potential Clogging of the Emergency Sump Due to Debris in Containment*, May 21, 2003 (ADAMS Accession No. ML031470074)

3. LER 50-346/03-002-00, *Potential Degradation of High Pressure Injection Pumps Due to Debris in Emergency Sump Fluid Post Accident*, May 5, 2003 (ADAMS Accession No. ML031330187).

4. Williams, P. T., Yin, S., and Bass, B. R., *Probabilistic Structural Mechanics Analysis of the Degraded Davis-Besse RPV Head*, ORNL/NRC/LTR-04/15, Oak Ridge National Laboratory, September 2004 (ADAMS Accession No. ML042600455).

***See previous concurrence**

To receive a copy of this document, indicate in the box: "C" = Copy wo/encl "E" = Copy w/encl "N" = No copy

OFFICE	OERAB	E	OERAB	E	OERAB	E	DRAA	E
NAME	GDeMoss*		MCheok*		PBaranowsky*		CAder*	
DATE	9/14/04		9/15/04		9/15/04		9/16/04	

OFFICIAL RECORD COPY

OAR in ADAMS? (Y or N)	**Y**	**Publicly Available? (Y or N)**	**Y**

Template Number: RES-006 Accession Number: ML042600532 RES File Code: 2C-3

MEMORANDUM DATED: 9/16/04

SUBJECT: TRANSMITTAL OF PRELIMINARY DAVIS-BESSE ASP ANALYSIS FOR INTERNAL AND LICENSEE PEER REVIEW

Distribution:

OERAB RF
DRAA RF
File Center
MSnodderly, ACRS
JCraig/CPaperiello, RES
DLew, RES
MCunningham, RES
FEltawila, RES
MGamberoni, RES
DMarksberry, RES
MMayfield, RES
AHiser, RES
NChokshi, RES
MKirk, RES
RBarrett, NRR
SBlack, NRR
MTschiltz, NRR
MFranovich, NRR
DMatthews, NRR
RMatthew, NRR
TMendiola, NRR
FMReinhart, NRR
WBeckner, NRR
BBoger, NRR
SRichards, NRR
DCoe, NRR
WRuland, NRR
HChernoff, NRR
SSands, NRR
SLong, NRR
WLanning, RI
VMcCree, RII
BClayton, RIII
SBurgess, RIII
CLipa, RIII
JGrobe, RIII
AHowell, RIV
SThomas, (SRI)

DOCUMENT NAME: A:\MEMO–DB ASP (REV. 2GD).WPD