

April 16 6998

LICENSEE: Northeast Nuclear Energy Company (NNECO)

FACILITY: Millstone Nuclear Power Station, Unit 3

SUBJECT: APRIL 7, 1998, MEETING REGARDING MODIFICATIONS TO THE
MILLSTONE UNIT 3 RECIRCULATION SPRAY SYSTEM

On April 7, 1998, the Special Projects Office staff of the Office of Nuclear Reactor Regulation met with representatives from Northeast Utilities (NU) and Sargent & Lundy in a publicly observed meeting to discuss modifications to the Millstone Unit 3 Recirculation Spray System (RSS) described in Design Change Request M3-97045, "RSS Pump Restriction Orifices to Prevent Suction Line Flashing." During postmodification testing, the system experienced higher than expected vibration. NU indicated the cause of the excessive vibration was unexpected cavitation downstream of the orifice plate. The vibration and cavitation resulted in damage to the downstream expansion joint liner.

NU discussed the purpose of the modification, options considered to resolve pump inlet line flashing, the time line for identification of cavitation problems, testing of the RSS modification, discovery of the failed expansion joint liners, the loose parts evaluation, options to resolve the failure of the expansion joint liners, and a description of revision 1 to the modification. NU indicated that, based on its examination of the damaged expansion joint liners, the possibility exists that up to nine slivers may not have been recovered. NU conducted a loose parts evaluation to assess the impact of the slivers on safe plant operation. NU concluded that if the slivers exist, their introduction, while undesirable, is acceptable and is not an unreviewed safety question.

NU's final resolution was to install a hard pipe section in place of the expansion joints. This caused an increase by a factor of five in one direction for the bending loads on the pump nozzles. While the nozzle loads increased substantially in one direction, NU stated that the pump vendor concluded that the pump nozzle loads were acceptable and that the pumps were operable. Also, the results of the postmodification testing indicated that overall system vibration decreased with the installation of the hard pipe section.

Enclosure 1 provides a list of meeting attendees. Enclosure 2 provides the handout used by NU during the meeting.

Original Signed by:

John A. Nakoski, ICAVP Program Coordinator
ICAVP Oversight Branch
Special Projects Office
Office of Nuclear Reactor Regulation

Docket No. 50-423

Enclosures: As stated (2)

cc w/encls: See next page

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LIST OF ATTENDEES**April 7, 1998**

NAME	ORGANIZATION	POSITION
Eugene Imbro	NRC	Deputy Director, ICAVP Oversight, SPO, NRR
Wayne Lanning	NRC	Deputy Director, Inspection, SPO, NRR
Steve Reynolds	NRC	Chief, ICAVP Oversight Branch, SPO, NRR
Jacque Durr	NRC	Chief, Inspection Branch, SPO, NRR
Tony Cerne	NRC	Senior Resident Inspector, Millstone Unit 3
Harold Eichenholz	NRC	ICAVP Site Coordinator, SPO, NRR
Don Schopfer	Sargent & Lundy	Verification Team Manager
Tony Neri	Sargent & Lundy	System Review Group Lead
Ken Bass	Sargent & Lundy	Operations, Maintenance, and Testing Review Group Lead
David Feingold	Sargent & Lundy	Lead RSS System Reviewer
Jack Wakeland	Sargent & Lundy	RSS System Reviewer
Paul Olson	Sargent & Lundy	Piping Design Reviewer
Marty Bowling	NU	Recovery Officer, Millstone Unit 2
Raymond Necci	NU	Director, Configuration Management Plan
Richard T. Laudent	NU	ICAVP Project Director
Paul Grossman	NU	Millstone Unit 3 Director, Engineering
Ray Deconto	NU	Millstone Unit 3 Design Engineering

MILLSTONE UNIT 3

RSS MODIFICATION DCR M397045

**“RSS PUMP RESTRICTION ORIFICES TO PREVENT
SUCTION LINE FLASHING”**

January 7, 1998

DCR M3-97045, REVISION 0: PURPOSE

- Resolve Inlet Line Flashing (CR M3-97-1029)
 - Identified by CMP
- Resolve RSS Heat Exchanger Baffle Plate Water Hammer (GL 96-06 - CR M3-97-0128)
 - Identified During Review of GL 96-06
- Resolve RSS Pump Suction Line Loop Seal (ACR M3-96-0496 & CR M3-97-2769)
 - Identified by Oversight
- Resolve Containment Sump Initial Water Level (Vortex Suppressor Lack of Submergence - ACR M3-96-0409)
 - Identified by CMP

OPTIONS CONSIDERED TO RESOLVE INLET LINE FLASHING

- Credit Containment Subcooling (Including Changing Minimum Operating Containment Pressure)
- Delay RSS Pump Start Time
- Divert QSS Flow to Containment Sump (Provide Subcooling Directly to Sump)
- Throttle RSS Pump Discharge Flow:
 - Install Motor-Operated Valve and Bypass Orifice in RSS Pump Discharge
 - Install Orifice
- Increase Suction Line Piping Diameter (Where Accessible)
- Relocated Pump Nozzle on Pump (Drop Several Feet Closer to Floor from Original Location)
- Cross Connect Suction Lines (Run One Pump off of Two Suction Lines)

CAVITATION DISCUSSION - TIME LINE

- Summer 1997 - Discussion with SWEC on Cavitation as Part of DCR M3-97045, Revision 0
 - Low Pressure Drop
 - Relatively Low Temperature (Low Temperature Long Term (>24 Hrs))
 - Substantial Backpressure due to Water Column to Spray Header
- 11/17/97 - PORC Presentation of DCR M3-97045
- 11/18/97 - Based on PORC Discussion, and Additional Questions Raised by the Small Break LOCA Safety System Functional Review: Westinghouse is Contracted to Perform Confirmatory Cavitation Assessment at the Orifice
 - Only an Input Flow Rate of 2200 GPM (@ 260 °F) Was Provided to Westinghouse.
 - RSS Flow Calculation, US(B)-361, Revision 0 (Revision addressed test loop (2550 GPM @ 45 °F, but was not considered to be a bounding case.)
 - 12/17/97 - Westinghouse Concludes that Incipient Cavitation Exists at 2200 GPM & 260 °F (Small Bubbles Float in Dead Space Downstream of Orifice). Westinghouse Concludes Cavitation Will Decrease With Decreasing Temperature .
- 12/23/97 - CR M3-97-4815: Oversight Documents Concern with Orifice / Expansion Joint Configuration
 - Orifice Location Will Result in Significantly Higher Velocities at the Expansion Joints Which Could Cause Fatigue Failure of the Expansion Joints
- 1/9/98 - Telecon with NU / SWEC / Sr. Flexonics Conducted Prior to RSS Flow Testing:
 - NU / SWEC: No Cavitation
 - Sr. Flexonics: Orifice Bolted to Expansion Joint is Acceptable (Assuming No Cavitation)

CAVITATION DISCUSSION - TIME LINE

- Initial CR M3-97-4815 Evaluation / Disposition
 - Took Credit for Westinghouse Evaluation
 - Based on Discussions Between NU / SWEC / Sr. Flexonics, Bulk Flow Velocities Expected Will not be Detrimental to Expansion Joint
 - Testing Will Monitor for Vibration
- 1/14/97 - Initial RSS Testing is Conducted
 - Test Flows (Test Loop Flow and Range of Possible Flow Rates)
- 2/10/98 - Revision 1 to Calculation US(B)-361 is Finalized Documenting Increased Flow for Direct Injection
 - Limited Passive Failure Flow (DCR M3-97102): 2510 GPM ($< 125^{\circ}\text{F}$)

RSS TESTING FOR DCR M3-97045, Rev. 0

- Flow Testing to Confirm Orifice is Sized Correctly for Flow (Orifice Bolted to EJ)
- Vibration Monitoring (Testing) to Assess Impact to:
 - Pump / Motor Assembly
 - Vent Line Piping
 - Expansion Joint
- Pump / Motor Assembly Within OM - 6 Limits
- Vent Line Piping Unacceptable
- Expansion Joints Axial Vibration Displacements (EJs Preliminarily Accepted by Condition Based Maintenance Group Based on Communication From Vendor)

FAILURE OF EXPANSION JOINT LINERS DISCOVERED

- Comment Provided During Owner's Review of EJ Vendor Calculation for Vibration by Nuclear Materials Engineering Identified that Only Axial Vibration was Considered (Only Axial Displacement (Vibration) Data Were Gathered)
- Therefore, Testing for Transverse Vibration was Conducted
- 3RSS*P1A is Selected (History of Highest Vibration)
- Combination of Axial and Transverse Displacements Exceeds Vendor Limits for Joint 3RSS*EJ1A
- When The Same Transverse Displacement is Assumed to Exist on the Remaining Joints All Joints Exceed Vendor Limits. Therefore, A Change to System Vibration is Sought to Correct Issue on All Four EJs
- Temporary Modification is Developed to Swap Location of Expansion Joint and Orifice: Damage is Discovered on 3RSS*EJ1A and Subsequently on B, C and D

LOOSE PART EVALUATION

- Liners and Large Pieces of Liners Located and Recovered
- Up to Nine Slivers Unaccounted for (1/16" x 3/16" x 0.050 " to 5/32" x 1-1/2" x 0.050")
- Transport Testing & Analysis by Create Concludes: Transportability of Large Pieces and Slivers Essentially Equal
- Slivers Probably Don't Exist
- If Slivers Exist, Most Likely in RSS Heat Exchanger
 - Torturous Path (28 Baffle Plate and 1380 Tubes)
 - Low Velocity in RSS Heat Exchanger (Too Low to Lift Pieces into Flow Stream)
- If Slivers Exist, Second Most Likely Settling Location is the RWST
 - Test Return Discharge Nozzle is Approximately 80' Horizontally from Quench Spray System (QSS) Nozzles on Bottom of RWST
 - 18" Weir Exists Around QSS Suction Nozzles (The Only Nozzles on the Bottom of the RWST)
- Safety Evaluation (SE) Performed Conservatively Assuming Slivers Exist
 - Westinghouse Provides Significant Input (SECL) for Potential Impact to NSSS Components
 - SE Concludes That the Introduction of the Nine Slivers Is Undesirable, But Is Safe and Is Not an Unreviewed Safety Question

OPTIONS CONSIDERED TO RESOLVE EXPANSION JOINT LINER FAILURES

- Replace Orifice Plate with One or Two Multi-Hole Orifices
- Replace Dual Bellows Expansion Joint with Single Bellows Expansion Joint
- Relocate Single Hole Orifice Plate
- Relocate Expansion Joint
- **Replace Expansion Joint with Hard Pipe Section**
 - Expansion Joints Were Installed to Accommodate Structural Displacements (not for Vibration)
 - Vibration Testing With Hard Pipe Resulted in Lower Overall System Vibration
- Various Combinations of the Options Listed Above

PERSONNEL INVOLVED: ROLES AND RESPONSIBILITIES

- C. K. McDonald, PHD, PE - Pump Equipment Specialist - Subcontractor to Sulzer-Bingham
- J. P. Tullis, PHD - Cavitation Expert (Author of NUREG/CR 6031 - Cavitation Guide for Control Valves)
- P. Rothe, PHD - Create Flow Expert - Evaluated Transport of Various Liner Pieces
- R. Talbot, Sulzer-Bingham - Pump Vendor Responsible for Overall Pump Operability
- D. Anderson - Senior Flexonics - Field Engineer Expansion Joint Vendor
- A. Stein - SWEC - Materials Specialist
- J. Hall - SWEC - Testing Specialist

DCR M3-97045, REVISION 1 ANALYSIS / TEST RESULTS HARD PIPE IN PLACE OF EXPANSION JOINT

- Cavitation - Per J. P. Bullis is Categorized as Moderate and Acceptable for the Specific RSS Installation:
 - Moderate Cavitation Will not Result in Pipe Wall Loss
 - Heavier Wall Pipe Is Not Required
 - Multi-Hole Orifice Is Not Required
 - Multiple Orifices Are Not Required
- Pump Vibration Meets OM-6 Requirements and Is at Acceptable Levels
- Small Bore Piping Vibration Evaluations for Fatigue Indicated that 2 to 1 Taper Transitions Were Required and Were Implemented to Assure Adequate Fatigue Life
- Large Bore Piping Vibration Was Evaluated for Fatigue and Was Found to be Acceptable Without Modification
- Pump Nozzle Loads in One Bending Direction Increased by a Factor of Five (Others Remained within Previous Allowables)
 - A Vertical Restraint Was Removed in Each Piping Loop and Was Replaced with a Spring Hanger to Minimize Thermal Moment Loadings
 - Existing Structural Reinforcement of the Nozzle Which Was Not Previously Credited Was Credited
 - FSAR Allowables for SWEC Scope of Supply Pumps Were Utilized
 - ANSYS Beam Model Was Utilized
 - Testing Will Monitor for Vibration
 - Code Utilized ASME III, 1971 Edition Through Winter of 1972 Addendum
- Sulzer-Bingham Concluded That Pump Nozzle Loads Are Acceptable and That the Pump Is Operable

DCR M3-97045, REVISION 1 GENERAL OVERVIEW OF CHANGES

- Spool Piece Replaces Pump Discharge Expansion Joint
- Nozzle Loads Increase But Are Acceptable
- Pipe Support Modifications are Required: A Rigid Vertical is Replaced with a Spring Hanger in Each Loop
- Single Hole Orifice is Retained
- Cavitation Exists (Moderate) and Will Not Cause Pipe Wall Loss (Neither at the Spool nor at the Elbow)
- Vibration Due to Cavitation / Pump Operating Point
- Pump Vibration is Acceptable (OM - 6)
- Small Bore Piping Socket Weld Required 2 to 1 Tapers for Fatigue Strength and are now Acceptable
- Large Bore Piping Was Evaluated and Was Found to be Acceptable
- Diesel Sequencer Failure / 125 vdc Control Power Failure (Smart Failures)
- Result: 2 RSS Pumps Supply 4 ECCS Pumps and Must Support Containment Heat Removal
- Not A New Failure. These Failure Were Previously Bounded, But Are Now Limiting For EEQ Due to the Dual Function of the RSS Pump (i.e. 3RSS*MOV20 Remains Open)
- Header Pressure is Reduced on Dual Function RSS Pump
- Lechler (Spray Nozzle Vendor) Retested the Spray Nozzles at the Lower Pressure
- SWEC Evaluated the Lechler Results and Concluded that the Overall RSS Efficiency was 99%
- EEQ Profile Exhibited Slight Increase Over DCR M397045 Revision 0 Results. Results Are Acceptable
- RSS Pump Suction Line Loop Seal & Pump Casing Vent Line Performance
- Oversight Identified: Insufficient Documented Detail on the Performance / Operation of the Pump Casing Vent Line
- A Tech Eval Was Generated to Document Pump Casing Vent Line Operation; No Modification was Required
- Radiological Calculations Were Revised to Address RSS Performance and S&L Comments
- Update of Dose Calculations Concluded That There Was No Increase to Calculated Dose Levels

FIGURE 3

