

August 21, 1997

LICENSEE: GPU Nuclear Corporation

FACILITY: Three Mile Island, Unit 1

SUBJECT: SUMMARY OF JULY 25, 1997, MEETING RE: INSPECTION OF KINETICALLY EXPANDED JOINTS IN THE STEAM GENERATOR UPPER TUBESHEET

On July 25, 1997, the NRC staff held a meeting at the NRC offices in Rockville, Maryland, with GPU Nuclear Corporation, the licensee for Three Mile Island, Unit 1 (TMI-1), to discuss the licensee's plans for inspecting steam generator tubing in an upcoming refueling outage. Specifically, the focus of the meeting was to discuss the licensee's plans for inspecting kinetically expanded joints in the upper tubesheet. The licensee for TMI-1 will complete steam generator tube inspection during the upcoming refueling outage (12R Outage) scheduled for September 1997. The list of meeting attendees is included as Enclosure 1. Enclosure 2 is a copy of the slides presented by the licensee at the meeting.

In 1981, a primary coolant chemistry excursion damaged a number of tubes in the upper tubesheet area in the TMI once-through steam generators. A repair method was implemented that involved kinetically expanding tubes in the upper tubesheet to return degraded tubes to service. The licensee's presentation during the meeting focused on its plans for inspecting the kinetic expansion joints in the upper tubesheet and dispositioning indications identified during these inspections. To support the inspection acceptance criteria, the licensee completed analyses to assess the structural integrity of degraded kinetic expansion joints. In addition to presenting the details of the structural assessment, the licensee also discussed the planned scope of inspection for the 12R Outage.

At the conclusion of the licensee's presentation, the NRC staff stated that the licensee's efforts to address degradation in the kinetic expansion joints are encouraging. The staff requested that the licensee submit, when completed, details of the structural assessment presented during the meeting and the leakage assessment that was ongoing at the time. Also, the licensee was requested to submit a license amendment as soon as possible to address a revision to the offsite dose calculation to address potential leakage from degradation in the kinetic expansion joints.

Original signed by

Bart C. Buckley, Senior Project Manager
Project Directorate I-3
Division of Reactor Projects - I/II
Office Of Nuclear Reactor Regulation

Docket No. 50-289

Enclosures: As stated

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List of Attendees
GPU MEETING - TMI-1
July 25, 1997

<u>NAME</u>	<u>AFFIL</u>
Bart Buckley	NRC/NRR
S. D. Leshnoff	GPUN
Ted Sullivan	NRC/NRR/DE
Ken Karwoski	NRC/NRR/DE
Phillip Rush	NRR/DE/EMCB
Stephanie Coffin	NRR/DE/EMCB
Bob Knight	GPUN Licensing
Gene Navratil	GPUN NDE/ISI
Rick Barley	GPUN
Nick Trikouros	GPUN
Julien Abramovici	GPUN
David Stellfox	McGraw Hill
Jeff Brown	FTI
Rich Freeman	GPUN
Patrick Walsh	GPUN
Bonnie Williamson	Nucleonics Week

Meeting Objectives

- TMI Plans for Kinetic Expansion Examinations and Disposition of Indications During 12R
- Demonstrate Assurance that the OTSG Kinetically Expanded Region Satisfies Safety Criteria for MSLB Accident

Agenda

- **Background**
Pat Walsh - Director, Equipment Reliability
- **Strategy for 12R**
Pat Walsh - Director, Equipment Reliability
- **Structural and Leakage Criteria**
Steve Leshnoff - Consulting Engineer, Engineering Support
- **NDE Plans**
Gene Navratil - ISI Specialist
- **Material Condition Assessment**
Steve Leshnoff - Consulting Engineer, Engineering Support
- **Summary**
Pat Walsh - Director, Equipment Reliability
- **Discussion**

Background

- Present Tech Specs and NUREG-1019 did not require continued examinations of the expanded area after 6R
- NRC evaluations in 1984 recognized that the “repaired and remaining tubes” contain ECT indications but did not require continued examinations after 6R
- 5M and 6R Examinations of the Kinetic Expansion Area showed indications in expanded zone
- GPUN agreed to additional inspections within the upper tubesheet during the 12R Outage and to define acceptable criteria for these inspections

Strategy for 12R

- Since we expect indications in the expanded region of the tubesheet, our analysis justifies the presence of flaws
- The length of the qualified zone and the extent of indications that are allowed to remain in service will meet the structural integrity required and leakage criteria for a MSLB

Kinetic Expansion Inspection Criteria Development

GPUN Has Developed Inspection Criteria
for Use During ECT Inspection of TMI-1
OTSG Tubes Within the Kinetically
Expanded Regions.

Four Tasks Are Involved:

Kinetic Expansion Inspection Criteria Development

1. Structural Integrity
 - A. Minimum Intact Expansion Determination
 - B. Maximum Acceptable Defect Determination
2. NDE Performance Evaluation
3. Primary-To-Secondary Leakage Analysis
4. Material Condition Assessment

Kinetic Expansion Inspection Criteria Development

1. Structural Integrity

“No Slip” for tube within joint

“No Parting” for circumferential defect

2. NDE

Conservative Disposition & Determination of Leakage
Contributors

3. Primary-To-Secondary Leakage

Maintain Possible Accident Leakage To Within a “Small
Fraction” of 10 CFR 100 Limits

4. Material Condition

No Predicted Growth Of Indications During Operating Cycle

Structural Integrity- Minimum Intact Expansion to Ensure 'No Slip' Condition

"No Slip" condition means no relative movement between expanded tube and tubesheet

Analysis Model Results Conservatively Predicts Original Qualification Test Results.

- Contact Interference = 0.0003", Coef. Of Friction = 0.2
- Accident Axial Load From SER (NUREG-1019)
 - 3140 lbs_f used in this analysis
 - 1402 lbs_f derived in more recent FTI calculation

Joint Performance

Contact Pressure Is Reduced Under Accident Axial Load

- Reduction Is Greatest Near Expansion Transition
- Poisson Contraction
- Contribution of Friction Reaction
- Yield Strength Limited Performance for Longer Expansions at Maximum Load
- Friction Limited Performance for Shorter Expansions at Loads Less than or Equal to the Yield Strength

Joint Performance

Accident Condition Produces Displacement Controlled Load. For Lower Yield Strength Tube Material Use Axial Load at 0.16% Axial Strain.

- Reduction in Applied Axial Load
- Include Tube Internal Pressure (Pressure Tightening)
- Minimum Necessary Intact Length Is Much Less Than Qualification Length

Joint Performance

Example: Impact of Axial Flaw on Contact Pressure

- Direct and Indirect Influence for Through -Wall Flaw
- Equivalent 4" Expansion Is Formed by 2" Axial Flaw in 6" Expansion
- Basis for Consideration of Circumferential Flaws, Also, in Terms of Pull-out resistance
- Edge Effect

Joint Performance

Impact of Tubesheet Bow on Contact Pressure

- Tubesheet Bow Enlarges Hole and Reduces Contact Interference
- Largest Reduction Occurs at Center of Tube Bundle
- Reduction Is Greater for 22" Expansion Than for 17" Expansion
- Apply Inspection Criteria Developed for 17" Expansion to 22" Expansion
- Apply Free Span Criteria to Lower 5" of 22" Expansion

Structural Integrity - With Respect to Circumferential Flaws

Maximum Acceptable Circumferential Flaw to Ensure "No Parting" Condition

- Ductile Failure of Through -Wall Flaw (0.64")
- Separation Criteria for Multiple Flaws (>1.0" Elevation Difference)
- Conservative: No Credit is Taken for Benefit of Friction Reaction in Reducing Axial Load Above Transition

Kinetic Expansion Inspection Criteria

The Inspection Criteria Ensures the Adequacy of the Joint Independent of the Original Qualification Length.

Table 1**Inspection Acceptance Criteria for OTSG Kinetic-Expansion Region**

Tube Bundle Location	Defect Type	Required Intact Expansion
Periphery	Axial	For single tube defects, allowable defect length is 4.4 inches so that the <u>required intact expansion</u> is $(6''-4.4''=)1.6''$. For multiple defects, $\frac{1}{4}$ -inch shall be added to the length of each defect, except the first defect, and the combined defect length shall be 4.4 inches or less. Also, for each circumferential defect, a defect length of $\frac{1}{4}$ -inch shall be added.
	Circumferential	For single defects, the allowable defect length is 130 degrees or 0.64 inches. For multiple defects: <ul style="list-style-type: none">◆ If separated axially by less than 1-inch, their length should be combined, and the total shall be less than 0.64-inch.◆ If separated axially by more than 1-inch, the individual defects shall each be less than 0.64-inch in extent.

Table 2
Inspection Acceptance Criteria for OTSG Kinetic-Expansion Region

Tube Bundle Location	Defect Type	Required Intact Expansion
Mid-Radius	Axial	The combined allowable defect length is 3.2 inches so <u>that the required intact expansion is 2.8 inches.</u> For each circumferential defect, a defect length of ¼-inch shall be added.
	Circumferential	Same as for the tube bundle periphery, as specified above.
Center	Axial	The combined allowable defect length is 2.8 inches <u>so that the required intact expansion is 3.2 inches.</u> For each circumferential defect, a defect length of ¼-inch shall be added.
	Circumferential	Same as for the tube bundle periphery, as specified in Table 1.

Volumetric Indication

Bounded by Separate Analysis Results for
Axial and Circumferential Defects

Transition Region

- Use Free Span Disposition Criteria

KINETIC EXPANSION

NDE PLANS

Examination Implementation

- Plan to Use Rotating Technique With “Super Probe” Head (Plus Point, 0.115” Pancake, and 0.080” HF)
- Acquisition of Data From 9” Below Primary Face Through Kinetic Expansion Transition
- Analyze Data From Lowest Point Acquired Through Uppermost Required Distance

Examination Implementation (Continued)

- Length/Width Sizing Error For Techniques Bounds All Other Errors and Is Reliable For Structural Disposition
- Depth Sizing Will Be Used For Qualitative Evaluation In Leak Rate Calculations (Segregate Leak Contributors From Non-Contributors)
- In-Situ Leak Testing In Freespan Will Further Confirm Qualitative Leak Contributors

Examination Scope

- Initial Sample:
 - 100% Of All Inservice 22" Expansions
 - 21% Of All Inservice 17" Expansions

Examination Scope (Continued)

- Scope Expansion
 - If More Than 1% of Tubes In 3%, 6%, or 12% Sample Require Repair for Structural Integrity, Increase to 100%
 - If Leak Rate Evaluation Determines Unacceptable Results, Increase As Determined by Evaluation

Primary-to-Secondary Leakage

Conservative Assumptions Used in Calculation of Total P/S Leakage

- All Defects Determined to Be Through-Wall by ECT, Regardless of Location, Are Assumed to Leak As If Located in the Tube Free-Span.
- No Credit Is Taken for Remaining Contact Pressure Below the Elevation of the Defect As Added Resistance to Leakage.

Primary-to-Secondary Leakage Evaluation

- Off-site Dose Will Be Limited to a “Small Fraction” of 10 CFR 100 As Is Presently Included in the Standard Review Plan (SRP 15.1.5, Appendix A). This is the Licensing Basis at Other Plants.
- A License Change Request Will Be Submitted Requesting an Increase in Off-site Dose to a “Small Fraction” of 10 CFR 100, (e.g., 30 Rem Thyroid) for MSLB.

Material Condition Assessment

- The Kinetic Expansion Formation Process Results in Bi-Axial Compression in the Intact Joint
- Residual Compression Is Not Overcome by Service Loads
- Enlargement of Circumferential Defects by Fatigue During Normal Operation Can Be Neglected Even Near the Expansion Transition
- A Representative Sample of Tubes Left in Service With Defects Will Be Re-Inspected In Subsequent Outages in Order to Support Condition Monitoring and Operational Assessment

Repair Techniques

- Reroll
- Sleeve
- Plug

Meeting Summary

- Kinetic Expansion Inspection Repair Criteria Assure Tube Structural Integrity
- PSLR Criteria to Satisfy “Small Fraction” of 10 CFR 100 Dose Limit (License Change Submittal)
- Material Condition Assessed; No Degradation Growth Expected; Continued Monitoring to Assure Inactivity
- Inspect 21% of Kinetic Expansions (Including All 22” Expansions) in 12R
- Sample Escalation If $> 1\%$ Require Repair or MSLB Leakage Unacceptable
- NRC Support Will Be Needed to Implement These GPUN Initiatives in 12R