

October 12, 2000

MEMORANDUM TO: Cynthia A. Carpenter, Chief
Generic Issues, Environmental, Financial
and Rulemaking Branch
Division of Regulatory Improvement Programs, NRR

FROM: Joseph Birmingham, Project Manager/**RA**
Generic Issues, Environmental, Financial
and Rulemaking Branch
Division of Regulatory Improvement Programs, NRR

SUBJECT: SUMMARY OF SEPTEMBER 28, 2000, MEETING WITH THE
NUCLEAR ENERGY INSTITUTE (NEI) REGARDING STEAM
GENERATOR TUBE BURST INTEGRITY

On September 28, 2000, members of the Nuclear Regulatory Commission (NRC) staff met with representatives of NEI and industry to discuss steam generator tube burst integrity. The meeting was a continuation of discussions from a July 6, 2000 meeting on the same subject. A list of meeting attendees is provided in Attachment 1. Slides presented by NEI are in Attachments 2 and 3.

Ted Sullivan began the meeting with introductions and stated that the purpose of the meeting was to continue discussions on the concern for steam generator tube burst test ramp rates. The concern is that tube burst test results may vary if different rates of pressurization are used. Jim Riley, NEI, gave a brief overview of the agenda for the meeting. The agenda included an update of the pressurization ramp rate study, the Steam Generator Review Board decisions, the status of the Steam Generator Program Generic License Change Package, and Senior Management Meeting planning. More details are in Attachment 2.

Kevin Sweeney, Arizona Public Service, and Dr. James Begley, E-Mech, presented a technical discussion of the results of the industry burst pressure ramp rate effect program. The program was conducted to address the in-situ pressure test results at ANO-2 which indicated the rate of tube pressurization may effect its burst pressure. Based on this program, the industry determined that the results at ANO-2 were a result of stress relaxation and time dependent tube deformation which effects primarily deep cracks (i.e., those with depths greater than approximately 90% through-wall). The effect would be negligible for through-wall cracks and cracks less than approximately 90% through-wall. Because of this observation, the industry recommended changes to the in-situ pressure test procedures to require hold points of at least 2 minute duration during specific in-situ testing, the pressurization rate be limited to no more than 200 psi/sec, and that all free span axial flaw leakage candidates should be proof tested.

With the results from this program, the industry reviewed existing burst correlation models to determine if these results affected the validity of these models. Industry concluded that its review of the burst pressure database indicated no need to change burst pressure correlations. Details of the industry presentation and the results of the program are in Attachment 3.

C. Carpenter

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After caucusing to discuss the industry presentation, the NRC staff thanked the industry for their presentation and inquired about the basis for the "90% threshold" and whether the industry was considering any verification testing to verify their conclusions. The industry indicated it would consider doing some verification testing. The staff indicated it would want to review the industry's report on their burst pressurization rate program before making any conclusions and/or processing alternate repair criteria proposals which could be affected by this issue (i.e., pressurization rate).

Jim Riley then discussed the Steam Generator Review Board Decisions. He indicated that the decisions are interpretations of EPRI Guideline requirements and that the review board decisions are being updated to reflect the EPRI Guideline revisions. All active Review Board decisions should be forwarded to NRC in October 2000. He also discussed the status of the Generic License Change Package and Revision 1 to NEI 97-06. He indicated that the revision would be submitted to NRC in October 2000. He then discussed the Senior Management Meeting agenda and the proposed schedule for the meeting. Details of the Generic License Change Package and the Senior Management Meeting are in Attachment 3. NRC staff indicated the meeting would be in late October or November 2000.

The meeting was adjourned

Project No. 689

Attachments: As stated

cc: See list

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*See previous concurrence

DOCUMENT NAME: G:\RGEB\jlb\MSUM NEI Steam Gnrtr Tube Integrity 9-28.WPD

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MSatorious, EDO
JHopenfeld
KKarwoski
FCoffman

**List of Meeting Attendees for September 28, 2000 Meeting
On Steam Generator Tube Burst Integrity**

NAME	ORGANIZATION
Jim Riley	Nuclear Energy Institute
Forrest Hundley	Southern Nuclear
Kevin Sweeney	Arizona Public Service
Jim Begley	E-Mech
Russ Cipolla	Aptech Engineering
Mati Merilo	EPRI
Mohamad Behraves	EPRI
A. E. Scherer	SCE
Richard A. Coe	SCE
Dan Mayes	Duke Power
R. F. Keating	Westinghouse
Ted Sullivan	NRC/NRR/EMCB
Emmett Murphy	NRC/NRR/EMCB
Ken Karwoski	NRR/DE
Joram Hopenfeld	NRC/RES
Joseph Birmingham	NRC/NRR/RGEB

Pressurization Rate Study Update

SGTF / NRC Meeting
September 28, 2000



Agenda

- **Pressurization Ramp Rate Study Update**
- **SG Review Board Decisions**
- **Status of SG Program Generic License Change Package**
- **Senior Management Meeting Planning**



Pressurization Ramp Rate Study

- Status update - Kevin Sweeney
- Program results - Jim Begley



SG Review Board Decisions

- Review Board decisions are interpretations of EPRI Guideline requirements
- Review Board decisions being updated to reflect EPRI Guideline revisions
- All active decisions should be forwarded to NRC in October



Generic License Change Package

- No technically significant changes. Major revisions:
 - TRM format changes
 - Op Leakage TS clarification
- Rev 1 to NEI 97-06
 - Removes tie to the proposed TS
 - Should be issued in October
- Revision to NRC in October
- NRC review schedule



Senior Management Meeting

- Ensure that industry and NRC are still on the same course
- Agenda items
 - Industry lessons learned
 - Revision to the Generic License Change Package
- Proposed dates





Burst Pressure Ramp Rate Effect Report Summary

EPRI



Agenda

- Background - Kevin Sweeney - APS
- Industry Program Results - Dr. Jim Begley - E-Mech
- Summary and Interim Recommendations - Kevin Sweeney

EPRI



Background

- Westinghouse tests on EDM notches simulating an ANO2 flaw indicated an effect of pressure ramp rate and hold times on the burst pressure that was achieved.
- NRC raised questions regarding the validity of industry burst pressure data
- Industry program with Westinghouse & E-Mech was initiated to address issue

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Review of ANO 2 Burst Tests

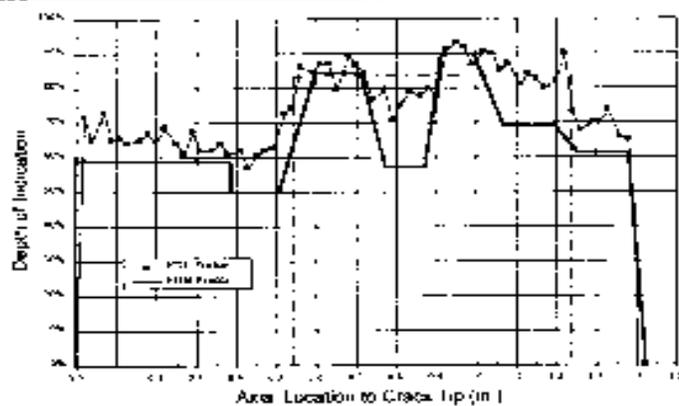
- Used EDM slot profiles to simulate R72C72 ECT depth and length profiles to duplicate in situ test results
- Most tests performed on Type 14 profiles with two deep sections
- Tests performed at fast pressurization rates with a foil reinforced bladder and slow rates with long hold times without a bladder

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ANO 2, SG B, R72C72 ECT Measured & EDM Simulated (Type 14) Crack Profiles



EPRI



Pressurization Test Procedures for Type 14

Conventional test system

- 2000 psi/s burst tests
- Post leakage burst pressure tests
 - after leakage, bladder with foil reinforcement added, and burst test performed at 2000 psi/s

Field system used in lab

- Ligament tearing tests with very slow approaches to ligament tearing

EPRI



Issues Raised by ANO Tests

- Is the burst pressure of degraded tubing a function of the pressurization rate, dP/dt ?
- Should changes be made to industry test procedures to account for potential dependence of the burst pressure on dP/dt ?
- Are there industry evaluation models that were empirically derived or qualified using data which might be dependent on dP/dt ?
- Do the industry evaluation models need to be modified to account for the possible dependence of the burst pressure on dP/dt ?

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Potential Reasons for Results

- Systematic differences in actual depth profiles of ANO samples
- Identification of burst pressure
 - Slow rate test results are not a true indication of burst pressure
- Use of metal foil reinforced bladders in fast rate tests and not slow rate tests
- Pressurization rate / hold time effect

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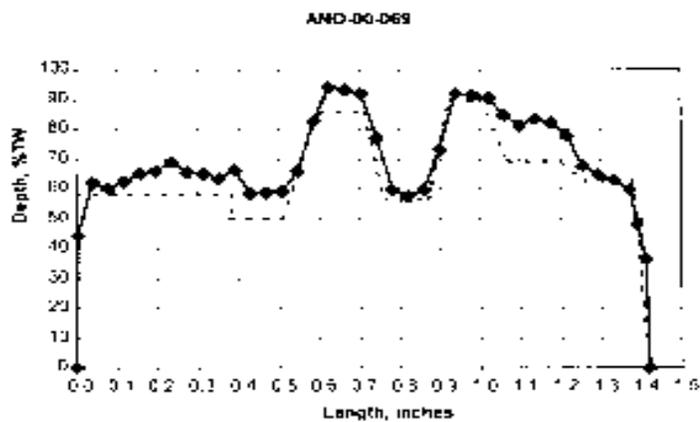
Industry Program Results

Jim Begley
E-Mech

EPRI



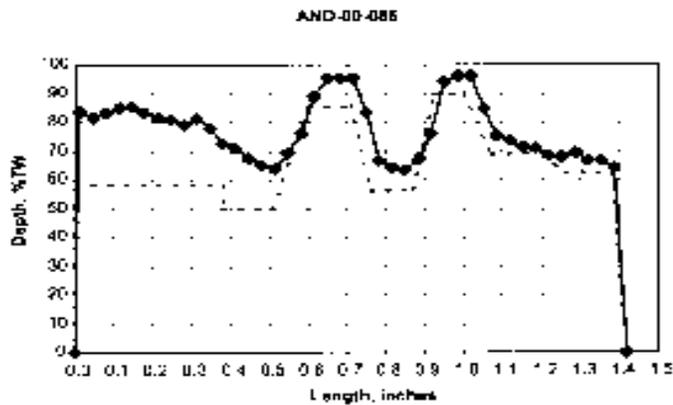
Typical Comparison Between Measured and Specified Crack Profile



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Greatest Discrepancy Between Designed and Measured EDM Profile



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Observations for Type 14 Specimens

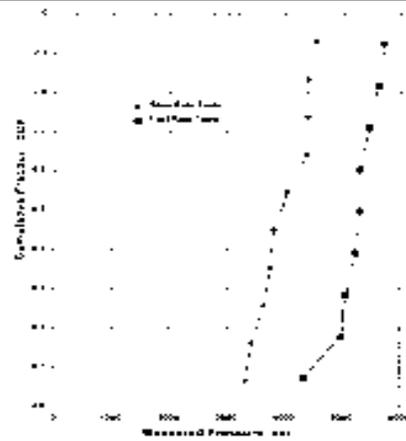
- Rate or hold time effects were observed for notch segments > 90% TW
- The maximum pressure in the leak tests is a good representation of the pressure bearing capacity of tubes with Type 14 flaws.
- Mean burst pressure for
 - fast rate tests 5216 psi with σ of 408 psi
 - slow rate tests 3976 with σ of 438 psi

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EPR2



Cumulative Distributions of Burst Pressures

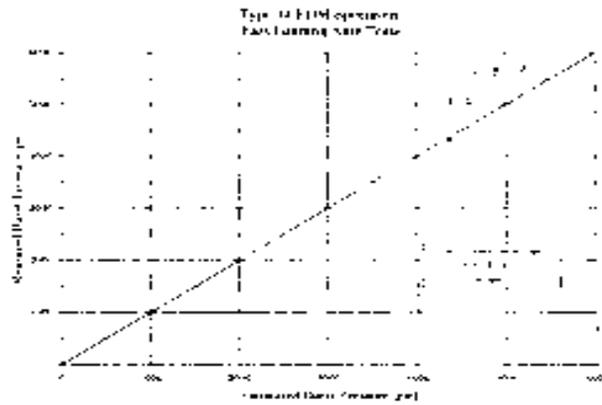


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Type 14 Fast Loading Rate

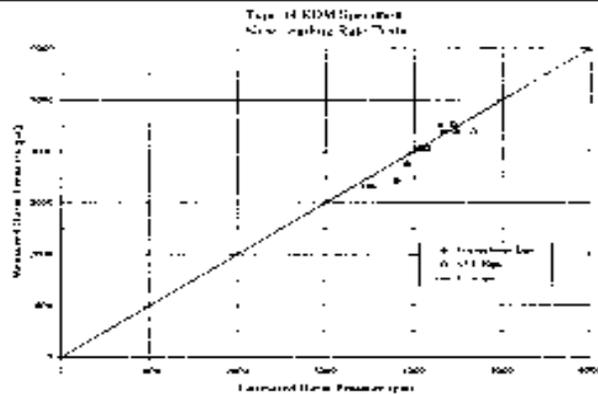


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Type 14 Slow Loading Rate



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Axial Partial Throughwall Cracking

- Type 14 profiles with a maximum depth of ~ 95 % TW show a definite dP/dt effect on burst pressure
- For crack tips in full wall thickness there is no dP/dt effect
- Cochet equation is sufficiently conservative to calculate ligament tearing or burst pressure
- The more conservative ANL equation for ligament tearing of axial cracks may be useful

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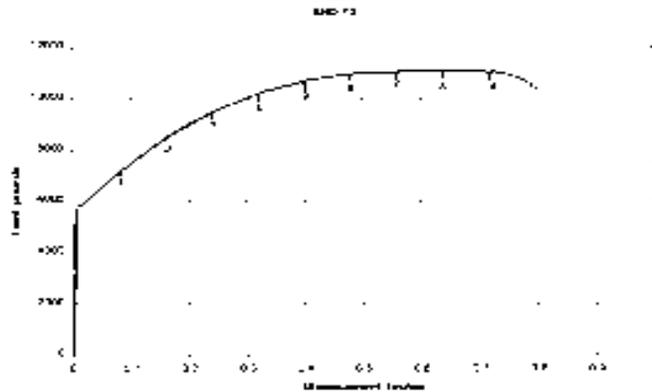
Material Property Effects

- Tensile tests with hold times and strain rate changes were performed in Alloy 600 at room temperature
 - Strain rate variation of a factor of 25 changed flow stress by ~ 2%
 - Hold times showed ~ 2% stress relaxation
 - Stress relaxation and time dependent deformation complete within 2 minutes

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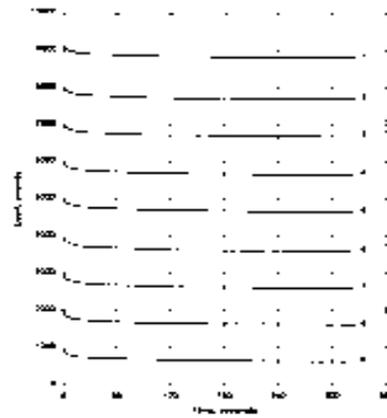
Stress Relaxation Curves



EPRI



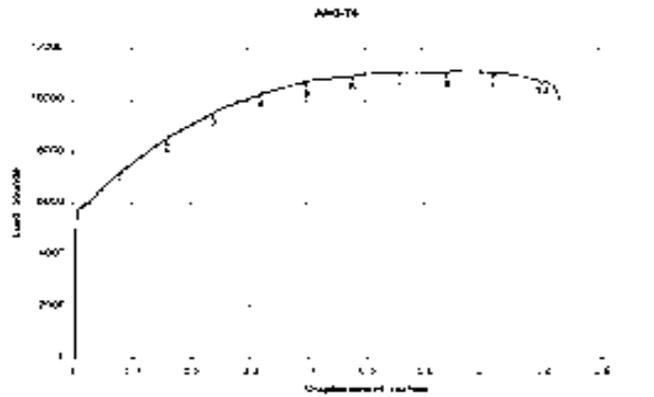
Stress Relaxation Curves



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Stress Relaxation Curves



EPRI



Pressurization Rates for Different Laboratories

Westinghouse PA	~ 2000 psi/s
Westinghouse CT (formerly ABB-CE)	~ 33 psi/s
Framatome VA	~ 1000 - 2000 psi/s
EdF	~ 20 - 60 psi/s
Laborelec	~ 30 psi/s
ANL & PNL	~ 30 psi/s

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Burst Pressure Database Review

- Data from different labs ranges from ~20 to ~2000 psi/sec
- Review found no effect of dP/dt on burst pressure
 - Full range of flaw geometries

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Industry Evaluation Model Data

- Are there industry evaluation models that were empirically derived or qualified using data which might be dependent on dP/dt , e.g. data used for ODSCC ARC?
- No specific evidence identified.
- Review of burst pressure database indicates no need to change burst pressure correlations

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Summary & Interim Recommendations

Kevin Sweeney

EPRI



Current In Situ Guidelines

- In Situ Guidelines recommend hold times for leakage tests ranging from 2 minutes (no leakage) to 5 minutes (leakage observed).
- Guideline hold points are:
 - NOΔP
 - MSLB
 - When leakage first encountered
 - Between NOΔP and MSLB if leakage detected
- No hold time specified for proof testing at 3 NOΔP

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Industry Test Procedures

- Should changes be made to industry test procedures to account for the potential dependence of the burst pressure on dP/dt ?
- Yes, for in-situ testing:
 - Require hold points of at least 2 minute duration:
 - MSLB and 3NO ΔP
 - Intermediate hold points recommended
 - Pressurization rate should be no more than 200 psi/sec
 - Proof test all free span axial flaw leakage candidates

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Burst Pressure Dependence on dP/dt ?

- Industry program indicates time dependent effects for Type 14 specimens
 - Based on tensile tests, there is a material stress relaxation effect, but it has limited time dependent deformation effects
 - Essentially complete within 1 minute
 - The time dependent effect appears to be limited to planar cracks that are greater than 90% TW
 - Burst pressure effect is not significant for flaws less than the through wall critical crack length

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Industry Evaluation Model Application

- Do the industry evaluation models need to be modified to account for the dependence of the burst pressure on dP/dt ?
- Analytical Modeling for Partial Throughwall Axial Cracks
 - Existing methods (EPR1 Flaw Handbook) are conservative, but improved methodologies could be developed to address burst pressure of axial flaws with throughwall portions

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EPR1



Conclusions

- A rate effect was found in the Type 14 data
- The potential for rate effects exists for planar axial cracks with maximum depths greater than about 90% throughwall.
- Rate effect does not affect industry burst correlations
- Interim guidance for in situ pressure testing will be issued to the industry by early October

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EPR