UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D.C. 20555-0001

August 1, 2000

LICENSEE: Entergy Operations, Inc.

FACILITY: Arkansas Nuclear One, Unit 2

SUBJECT: SUMMARY OF JUNE 8, 2000, MEETING TO DISCUSS THE LICENSEE'S DETERMINISTIC OPERATIONAL ASSESSMENT AND PROPOSED RISK-INFORMED LICENSE CHANGE REGARDING STEAM GENERATOR TUBING FOR THE REMAINDER OF CYCLE 14 (TAC NOS. MA1951 AND MA8418)

On June 8, 2000, the Nuclear Regulatory Commission (NRC) met with Entergy Operations, Inc. (the licensee) and the licensee's contractors to discuss the licensee's February 11, 2000, deterministic operational assessment (as supplemented) and the licensee's March 9, 2000, proposed risk-informed license change (as supplemented) regarding steam generator (SG) tubing for the remainder of Cycle 14. Enclosure 1 is a list of meeting attendees. Enclosure 2 is the licensee's handout used during the meeting.

Regarding the deterministic operational assessment, the licensee presented the results of testing and analysis conducted on tubing with manufactured defects that mimic the most limiting flaw (Tube R72C72) detected during the last mid-cycle outage (2P99). The licensee concluded that their previous position of a 500 psi difference between the tube ligament tearing pressure and burst pressure is still valid, that tube R72C72 met 3ΔP with margin, and that plant operation until the September 2000 outage remains justified.

Regarding the proposed risk-informed license change, the licensee proposed additional compensatory actions in response to insights from their risk evaluation. The licensee proposed an administrative SG leakage limit of 25 gallons-per-day (gpd) in any one steam generator. The licensee also discussed the compensatory actions already taken to further reduce risk by maintaining secondary pressure through Emergency Operating Procedure and Severe Accident Management Guideline (SAMG) changes, and the compensatory actions that will be taken to depressurize the primary side through hardware and additional SAMG changes. The licensee's risk assessment concluded that the plant is safe to operate considering the risks presented by design basis events and severe accidents.

The licensee's overall operational assessment is that they have low level and diverse leakage detection capability, the operators are trained on mitigating actions in the event of SG tube leakage, they established an administrative SG leakage limit of 25 gpd, they have insights from their risk evaluation that further reduce risk, all six tube indications that were pressure tested during 2P99 met 1.43 times main steam line break pressure, and the one tube that did not meet 3ΔP by testing met 3ΔP by analysis. Therefore, the licensee concluded that ANO-2 is safe to operate until the September 2000 outage and that their analysis demonstrates that ANO-2 will be in full compliance with their operating license and their commitment to Nuclear Energy Institute 97-06 (Steam Generator Program Guidelines). The licensee indicated that another mid-cycle SG inspection is not desirable due to the additional risk during mid-loop operations and the additional exposure to plant workers.

The NRC provided feedback on the deterministic operational assessment and indicated that it had concerns with the test program that would need to be resolved. However, even if these concerns were resolved, the NRC staff stated that they do not believe that the licensee's test results and analysis demonstrate that Tube R72C72 met 3ΔP. One concern that was discussed was that laboratory burst pressure testing under high ramp rates presents new concerns that have not been addressed. On the risk-informed application, the NRC indicated that the proposal to depressurize the primary side during severe accidents appeared to be a reasonable approach towards mitigation, but that the NRC would have to review the details of that approach. For example, the licensee's thermal-hydraulic analyses using the Modular Accident Analysis Program would need to be reviewed.

In closing, the NRC indicated that it would review the information presented at the meeting, and provide the licensee with a list of additional information that the NRC needs to complete its reviews of the SG tubing.

/RA/

Thomas W. Alexion, Project Manager, Section 1
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Office of Nuclear Reactor Regulation

Docket No. 50-368

Enclosures: As stated (2)

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ATTENDANCE LIST

PUBLIC MEETING HELD ON JUNE 8, 2000

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D. Meatheany	Entergy
D. Harrison	Entergy
M. Smith	Entergy
R. Lane	Entergy
B. Bement	Entergy
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G. Taylor	Entergy
M. Lloyd	Entergy
M. Krupa	Entergy
B. Keating	Westinghouse
T. Pitterle	Westinghouse
B. Woodman	Aptech
P. Jackson	Tetra Engineering
M. Kenton	Creare
J. Riley	NEI
D. Stellfox	McGraw-Hill
T. Alexion	NRC
S. Long	NRC
E. Murphy	NRC
E. Sullivan	NRC
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C. Nolan	NRC
T. Reis	NRC
L. Ellershaw	NRC (via telephone)

Enclosure 1

ANO Unit 2 Steam Generator Evaluation

June 8, 2000

Enclosure 2

Introduction

Craig Anderson

Vice-President Operations, ANO

ANO-2 Steam Generator Evaluation

Introduction..... Craig Anderson

Safety and Operational

Assessment Overview..... Robert Bement

Operational Assessment (OA)..... Darol Harrison

- Background
- Continued Testing
- Deterministic OA

Risk Assessment..... Mark Smith

Conclusions .....Craig Anderson

Safety and Operational Assessment Overview

Robert Bement

General Manager, ANO

ANO-2 Operational Assessment

- Safety Perspective
  - All in-situ pressure tested tubes exceeded MSLB pressures
  - Low probability of tube failure under MSLB pressure for remainder of current cycle
  - Limiting eggcrate flaws in-situ tested during last four outages
    - No leakage at MSLB pressure
    - One failure to meet $3\Delta P$
    - Corrective action taken

ANO-2 Operational Assessment

- Safety Perspective (Continued)
  - Low level and diverse leakage detection capability
  - Operators trained on mitigating actions
  - Administrative limit established
    - 25 GPD verified leakage
  - Insights from risk evaluation (severe accident)
    - Compensating actions already taken to further reduce risk
      - Steps to maintain secondary pressure
    - Compensating actions to be taken to further reduce risk
      - Depressurize primary side

ANO-2 Operational Assessment Overview

- 2P99 In-situ Test Results
  - Tested a total of 6 indications
    - All met MSLB pressure with zero leakage
    - All six met 1.43 MSLB
    - Five met 4650 psi (3ΔP plus additional margin)
  - 1 flaw (72-72) taken to 4147 psi due to leakage in excess of pump capacity
    - Bladder could not be installed
    - Further analysis required to determine tube structural integrity

ANO-2 Operational Assessment Overview

- 2P99 In-situ Test Results (continued)
  - NEI 97-06 provides for the completion of tube structural integrity by analysis
  - Analysis supported by additional lab testing of notched tubes concludes that 72-72 did meet structural integrity requirements with margin

ANO-2 Operational Assessment Overview

- ANO-2 is safe to operate until 2R14
- Analysis demonstrated the unit can operate until the mid-September SG replacement outage in full compliance with our operating license and commitment to NEI 97-06

Operational Assessment

Darol Harrison

Supervisor, Engineering Programs

ANO-2 Deterministic Operational Assessment

- Deterministic Operational Assessment
  - Background
  - Review of previous data
    - Limited to eggcrate axial indications
    - In-situ results
  - Discuss continued testing
  - Original analysis still bounding

ANO-2 Operational Assessment

- Eggcrate Axial Cracking
  - 1st detected in 1991 (2R8)
  - Leaker in 1996 (2F96)
  - Began plug on detection in 1997 (2R12)
  - 1998 (2R13) eliminated resolution analysis from leaving flaws in service
  - 1999 (2P99) calibration standard improvement

ANO-2 Operational Assessment

- 1998 Extensive SSPD Performed
  - Utilized pulled tube data
  - Performed under same conditions as during outage
    - Replicated 2R13 issue
    - Allowed quantification of POD in the field
  - Results showed POD improvement above 50% TW of about 20 points
    - Information incorporated in analyst training and testing program

ANO-2 Operational Assessment

- 1999 Calibration Standard Change
  - Flaw voltages increased
  - Increased number of flaws detected due to this improvement
- Growth Rate Evaluations
  - Several growth rate studies conducted
    - Over different operating intervals
    - Compared to other CE plant data
  - Result is growth behavior is known
    - Growth rate has not changed in this operating period

ANO-2 Operational Assessment

- Margin of 3 to burst during normal operation
  - $3\Delta P = 4050$ (4369 psid at room temperature)
    - ASME design code required $S_m < S_u/3$
    - Basis for repair limit
    - NEI 97-06 performance criteria
  - Design Basis Accident ΔP
    - 2500 psid for MSLB
    - Probability of MSLB very low

ANO-2 Operational Assessment
2P99 Condition Monitoring

- Conclusions From Initial Work
  - 72-72 did not burst
    - Post in-situ condition equivalent to ligament tearing to permit significant leakage
    - No crack extension (required for a burst)
  - Evaluation based upon Argonne National Lab (ANL) ligament tearing and Westinghouse burst pressure models
    - Objective to predict ΔP between ligament tearing and burst
    - Based on results, ~500 psi pressure increase above 4147
  - EDM Testing
    - Based on ΔP between complete and incomplete burst tests
    - Supported >500 psi pressure increase

ANO-2 Operational Assessment

- Continued testing to support deterministic Operational Assessment
  - Test objectives
    - Match 72-72 leakage
    - Determine ΔP between ligament tearing and burst
  - More complex EDM samples
    - Leakage and burst
  - Analytical model
    - ANL model
    - WCAP

ANO-2 Operational Assessment

- EDM Sample Results
  - Produced very low ligament tearing values (~2500 psi)
    - No leakage prior to tearing
    - Could not repressurize post ligament tearing
  - Concluded that the ECT profile was giving overly conservative estimates for depth
    - Supported by pulled tube results
    - Calculations estimate 8% TW correction would result in comparable pressures that 72-72 exhibited

ANO-2 Operational Assessment

- EDM Sample Results
  - Next - Produced flaws that were reduced in depth by 7% and 10%
  - Resulted in increased ligament tearing pressures
    - No leakage prior to ligament tearing
    - Could not repressurize
    - Flaw lengths were ~ 1 inch
  - Leakage still in excess of 72-72
  - Modified profile in an attempt to get more accurate leakage profiles

ANO-2 Operational Assessment

- EDM Sample Results
  - Adjusted peak depths to get a correct pressure/leakage response
  - Adjusted ligament depth to obtain the flaw length matching the test results
  - Ligament failure pressure close to predicted
    - Length of the opening and leakage still not similar

ANO-2 Operational Assessment

- EDM Sample Results
  - Next - Altered the angle of the peak depths
    - Resulted in a shorter flaw opening
    - Leakage response representative of 72-72
    - Able to repressurize two samples similar to 72-72

ANO-2 Operational Assessment

Type 14 Test Results				
	Specimen #	Ligament Tearing Pressure	Specimen #	Burst Pressure
	66	4010	75	5238
	67	4350	77	5140
	68	3956	87	4791
	69	3350	88	4654
	74	3855	93	4865
	76	3488	94	4865
	83	3442	95	4570
	84	3488	96	5011
	85	3689		
	Average	3736		4892
Standard Deviation		331		229
	Avg + 1 SD	4067	Avg - 1 SD	4663
Delta Pressure at 1SD		4663 - 4067 = 595		

ANO-2 Operational Assessment

- EDM Sample Test Conclusions
  - 72-72 ECT profile over conservative
  - Post in-situ opening ~1/2" long
    - < critical crack length
  - Refined profiles based on model and test results
    - Able to produce flaw profile with a leak response that behaved like 72-72
  - Objective was to match leakage and estimate ΔP
    - Leakage results very similar
    - ΔP confirms analytical model result of ~500 psi above 4147 is conservative

ANO-2 Operational Assessment

PARAMETER	SGTI Guidelines
POD Value	**95%**
Structural Depth Equivalent	56.6%
Growth Rate	**95% Struct. Depth**
Growth Equivalent	15%
Length Value	**90% (2P99 data)**
Length Equivalent	0.98
Burst Correlation	**90% Value**
Material Properties	125,900
Material Equivalent	**90%**

ANO-2 Operational Assessment

- Summary of Deterministic Analysis
  - The original 500 psi delta is still valid
  - Tube 72-72 met 3ΔP with margin
  - Operation until September 2000 remains justified

Risk Assessment

Mark Smith

Manager, Engineering Programs

ANO-2 SGTR Risk Assessment

Objective and Scope

- Objective
  - Evaluate the effect of continued operation to 2R14 on both Core Damage Frequency (CDF) and Large Early Release Frequency (LERF)
  - Scope of risk assessment consistent with NUREG-1570
    - Spontaneous Steam Generator Tube Rupture (SGTR)
    - Pressure Induced (PI) SGTRs
    - Temperature Induced (TI) SGTRs

ANO-2 SGTR Risk Assessment

Pressure Induced SGTR Risk

- Dominant PI SGTR Risk Contributors:
  - MSL Break-Induced SGTRs
  - ATWS-Induced SGTRs
- PI SGTR Risk Results:

$\Delta CDF = 4E\text{-}9/rx\text{-}yr$

$\Delta LERF = 4E\text{-}9/rx\text{-}yr$

ANO-2 SGTR Risk Assessment

Severe Accident Risk

- Important Factors Affecting TI-SGTR Risk:
  - RCS Pressure
  - SG Inventory
  - SG Pressure
- TI-SGTR Risk Results

$$\Delta CDF = 0/rx\text{-}yr$$

$$\Delta LERF = 1.9E\text{-}7/rx\text{-}yr$$

ANO-2 SGTR Risk Assessment
Analysis Features

- Flaw Population Based on Realistic POD
- ANL Flawed Tube Failure Model (NUREG/CR-6575):
  - Creep Analysis of Ligament Failure as in NUREG-1570
  - Flow Stress Model to Predict Failure Mode

ANO-2 SGTR Risk Assessment
Sensitivity Analysis

- Assume Ligament Failure Leads to Rupture - Δ LERF Remains in Region II
- Credit for RCS Depressurization - Δ LERF Drops to Region III

ANO-2 SGTR Risk Assessment
Conclusions

- Continued Plant Operation to 2R14 is Safe
  - Design basis events
  - Severe accidents
- Actions Being Taken to Further Improve Safety
  - Maintain Secondary Pressure
    - EOP and SAMG Changes
  - Depressurize Primary Side
    - Hardware and SAMG Changes

Conclusions

Craig Anderson
Vice-President, ANO