UNITED STATES
NUCLEAR REGULATORY COMMISSION
REGION IV
1600 EAST LAMAR BLVD
ARLINGTON, TEXAS 76011-4511

December 10, 2012

Mr. Peter Dietrich
Senior Vice President and
Chief Nuclear Officer
Southern California Edison Company
San Onofre Nuclear Generating Station
P.O. Box 128
San Clemente, CA 92674-0128

SUBJECT: MEETING SUMMARY FOR NOVEMBER 30, 2012, MEETING WITH SOUTHERN CALIFORNIA EDISON COMPANY

Dear Mr. Dietrich:

On November 30, 2012, NRC personnel met with representatives of Southern California Edison at The Hills Hotel in Laguna Hills, California, to discuss the Confirmatory Action Letter dated March 27, 2012, concerning actions required to be taken to address steam generator tube degradation.

The meeting was recorded and copies of the recorded video, as well as written transcripts of the meeting will be made available on the NRC's website at http://www.nrc.gov/info-finder/reactor/songs/tube-degradation.html.

In accordance with 10 CFR 2.390 of the NRC's "Rules of Practice," a copy of this letter and its enclosure will be available electronically for public inspection in the NRC Public Document Room or from the Publicly Available Records (PARS) component of NRC's document system (ADAMS). ADAMS is accessible from the NRC Web site at http://www.nrc.gov/reading-rm/adams.html (the Public Electronic Reading Room).

Sincerely,

/RA/

Ryan E. Lantz, Chief
SONGS Project Branch

Docket Nos.: 0500050361, 0500050362
License Nos.: NPF-10, NPF-15

Enclosures:
1. NRC Presentation
2. Southern California Edison Presentation

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ADAMS: ☐ No ☒ Yes	☐☒SUNSI Review Complete	Reviewer Initials:
	☒ Publicly Available	☒ Non-Sensitive
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San Onofre Nuclear Generating Station Unit 2 CAL Response Public Meeting

Nuclear Regulatory Commission - Region IV
November 30, 2012

1

Purpose of Today's Meeting

- Technical Presentation of SCE's Confirmatory Action Letter Response for Unit 2
- Discuss Activities Going Forward
- Answer Questions from the Audience

2

Agenda

- Introduction
- SCE Response to Confirmatory Action Letter
- NRC Remarks
- Path Forward
- Question and Answer Session

3

NRC Representatives

- Art Howell, Team Manager SONGS Special Project, Region IV
- Ryan Lantz, Branch Chief, SONGS Project Branch
- Greg Werner, Inspection and Assessment Lead Inspector
- Doug Broaddus, Branch Chief, SONGS Special Projects, NRR

4

NRC Representatives (Cont)

- Kenneth Karwoski, Senior Level Advisor, Division of Engineering, NRR
- Victor Dricks, Senior Public Affairs Officer
- Greg Warnick, Senior Resident Inspector, SONGS
- John Reynoso, Resident Inspector, SONGS
- Heather Hutchinson, NRC Administrative Assistant, SONGS

5

SONGS Representatives

- Peter Dietrich, Senior Vice President and Chief Nuclear Officer, SONGS, SCE
- Douglas Bauder, Vice President and Station Manager, SONGS, SCE
- Thomas Palmisano, Vice President of Engineering, Projects and Site Support, SONGS, SCE

6

ENCLOSURE 1

Methodology

- Engaged world class experts in Steam Generator construction, thermal-hydraulics, and vibration
- Based on finding of Unit 3 Tube-to-Tube contact, determined tube vibration mode
- Determined causes of excessive tube vibration
- Determined corrective actions based on physical cause of tube vibration
- Validated causes and corrective actions with independent experts
- Established substantial safety margin

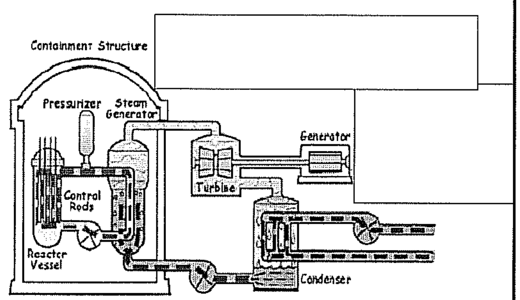
Technical Expertise Supporting SCE

- Mitsubishi Heavy Industries
- AREVA
- Westinghouse
- B&W Canada
- MPR Associates
- EPRI

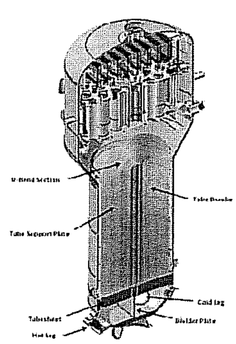
- Industry personnel, recognized academics and specialized consultants

STEAM GENERATOR OVERVIEW

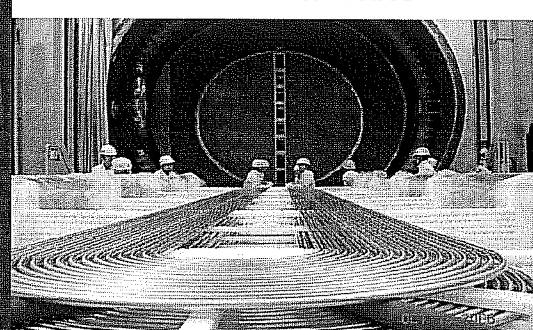
Pressurized Water Reactor Layout



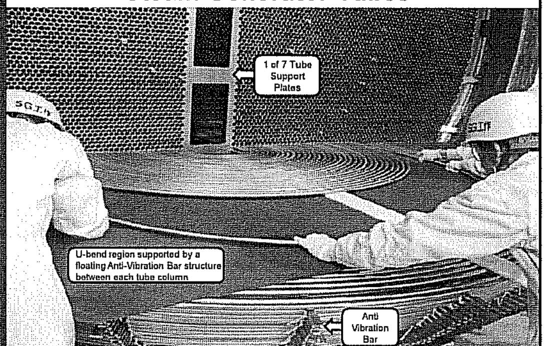
Steam Generator



Steam Generator Tubes



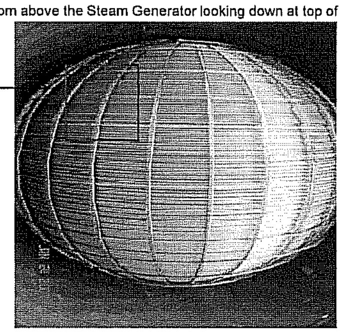
Steam Generator Tubes



Steam Generator U-Bend Section Detail

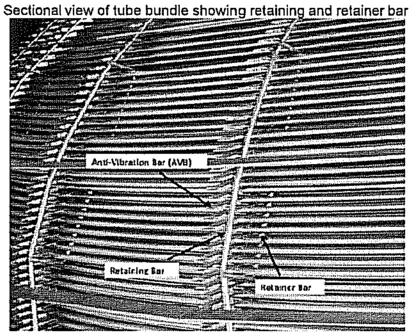
View is from above the Steam Generator looking down at top of tube bundle

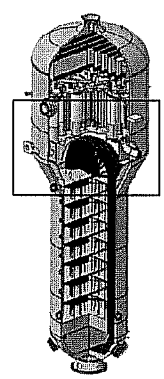
This section shown in next slide

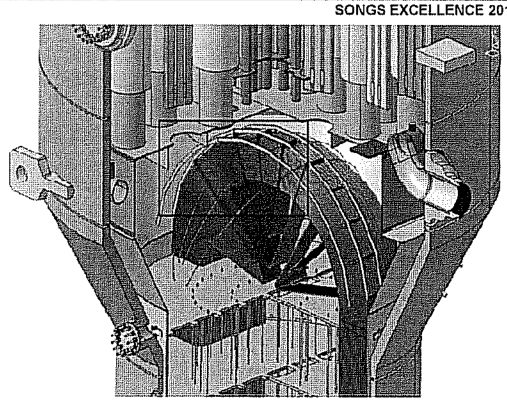


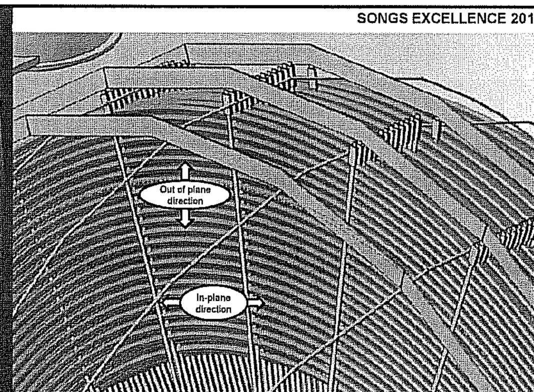
Steam Generator U-Bend Section Detail

Sectional view of tube bundle showing retaining and retainer bar









STEAM GENERATOR INSPECTION

Unit 2 Steam Generator Inspection

- Tube Inspections for Unit 2 Steam Generators
  - Eddy Current Bobbin Coil examinations of the full length of all tubes
  - Eddy Current Rotating Coil examinations
  - Full U-bend exam of tubes adjacent to retainer bars
  - Visual inspections
  - Specialty Eddy Current and Ultrasonic examinations

Unit 2 Steam Generator Inspection Results

- U2C17 Inspection Results
  - Steam Generator Technical Specification performance criteria were satisfied
  - Per industry guidelines, a single tube pressure test was required for Retainer Bar Wear and performed with satisfactory results
- Tube Wear Locations
  - Wear was detected at:
    - Anti-Vibration Bars (AVBs)
    - Tube Support Plates (TSPs)
    - Retainer Bar locations
    - Free-span Tube-to-Tube Wear (TTW)

Unit 2 Steam Generator Inspection Results

- Tube Wear at Anti-Vibration Bars (AVBs) and Tube Support Plates
  - Two tubes with wear above 35% limit were plugged
  - Preventatively plugged two tubes conservatively to add safety margin
- Tube Wear at Retainer Bars
  - Retainer bar size inadequate to prevent vibrating and contacting adjacent tubes
  - Vibration due to turbulent two-phase flow across retainer bars
  - Four tubes with wear above 35% limit were plugged
  - Preventatively plugged 182 tubes conservatively to add safety margin
- Tube-to-Tube Wear
  - Most likely caused by in-plane vibration
  - Two affected tubes with 14% wear depth were plugged
  - Preventatively plugged 321 tubes conservatively to add safety margin

Unit 3 Steam Generator Inspection

- Tube Inspections for Unit 3 Steam Generators
  - Leaking tube detected with leakage test
  - Eddy Current Bobbin and Rotating Coil examinations used to confirm location of leak
  - Eddy Current Bobbin Coil examinations of the full length of all tubes
  - Eddy Current Rotating Coil examinations
  - Full U-bend exam of tubes adjacent to retainer bars
  - Visual inspections
  - Specialty Eddy Current and Ultrasonic examinations

Unit 3 Steam Generator Inspection Results

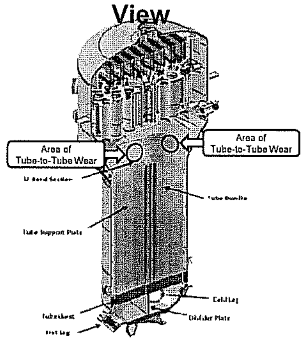
- U3 Mid-Cycle Inspection Results
  - Steam Generator Technical Specification performance criteria were not satisfied
  - Per industry guidelines, 129 tube pressure tests were required due to Tube-to-Tube Wear
  - Eight tubes did not meet performance criteria due to Tube-to-Tube Wear
- Tube Wear Locations
  - Wear was detected at:
    - Anti-Vibration Bars (AVBs)
    - Tube Support Plates (TSPs)
    - Retainer Bar locations
    - Free-span Tube-to-Tube Wear (TTW)

Unit 3 Steam Generator Inspection Actions

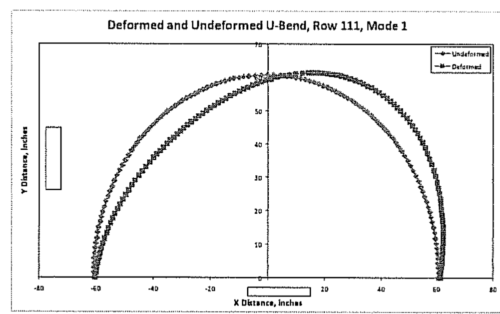
- Tube Wear at Retainer Bars
  - Similar causes and actions as taken for Unit 2 Steam Generators
  - 94 tubes adjacent to retainer bars plugged in each Steam Generator
- Tube Wear at Anti-Vibration Bars
  - Three tubes with wear above 35% limit were plugged
- Tube Wear at Tube Support Plates
  - 230 tubes with wear above 35% limit
  - Included in actions taken for Tube-to-Tube Wear
- Tube-to-Tube Wear
  - Caused by in-plane vibration
  - All affected tubes (326) plugged
  - Preventatively plugged additional 292 tubes

TUBE-TO-TUBE WEAR

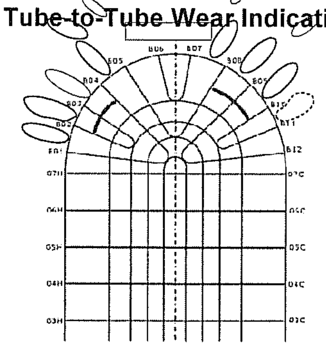
Steam Generator Cut-Away Elevation View



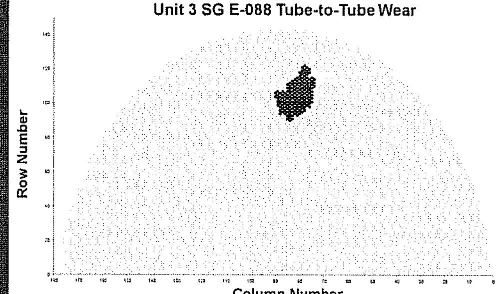
In Plane Motion and Tube-to-Tube Wear



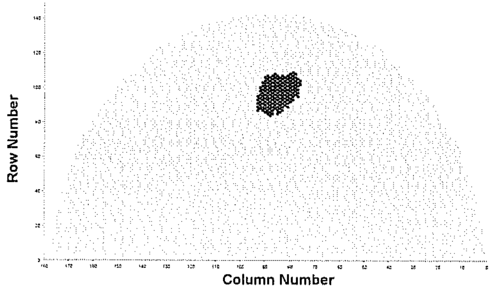
Unit 3 Steam Generator Tube-to-Tube Wear Indications



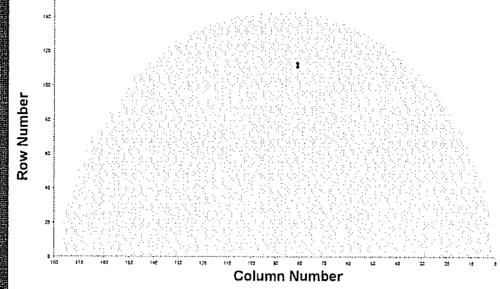
Unit 3 SG E-088 Tube-to-Tube Wear



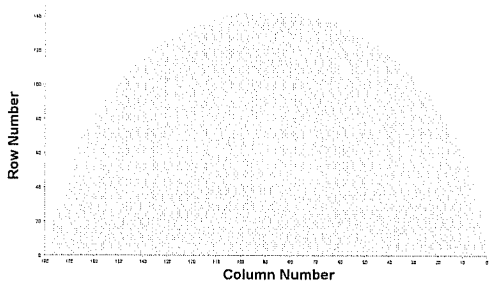
Unit 3 SG E-089 Tube-to-Tube Wear



Unit 2 SG E-089 Tube-to-Tube Wear



Unit 2 SG E-088 Tube-to-Tube Wear



Comparison of Tube-to-Tube Wear (TTW) Between Unit 2 and Unit 3

Description	Unit 2	Unit 3
TTW Indications	2	823
TTW Tubes	2	326
Max Depth (ECT %TW)	14%	100%
Max Length	~6"	~41"
TTW In-Situ Pressure Tests	0	129
TTW In-Situ Pressure Tests (Unsatisfactory)	0	8
Operating Period (Months)	21	11

Tube-to-Tube Wear Cause

- Fluid Elastic Instability (FEI): excessive tube vibration which occurs when a tube is subject to fluid velocities above a critical value
  - o Adverse Thermal-Hydraulic (T/H) Conditions
    - High fluid velocities: transfers energy to the tube
    - High localized void fractions: reduces tube damping
  - o Support structure unable to control resulting vibration
    - Anti-Vibration Bars unable to dampen tube vibration at full power
    - Combined with T/H conditions does not provide adequate damping to prevent FEI

ROLE OF THERMAL- HYDRAULIC CODE

Modeling Use Flow Chart

Operating Conditions → Thermal-Hydraulic Model → Structural/ Vibration Models → Results – Tube Wear and Stress Levels

Thermal-Hydraulic Codes

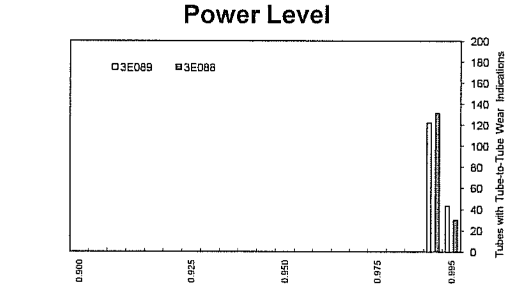
- FIT III used by MHI in design of Replacement Steam Generators
- FIT III under predicted critical Thermal-Hydraulic conditions such as fluid velocity and void fraction
- Use of ATHOS model during Replacement Steam Generator design would have identified reduced margin to fluid elastic instability
- All analysis supporting Unit 2 return to service uses ATHOS
- MHI's ATHOS model independently verified by AREVA and Westinghouse

CORRECTIVE ACTIONS

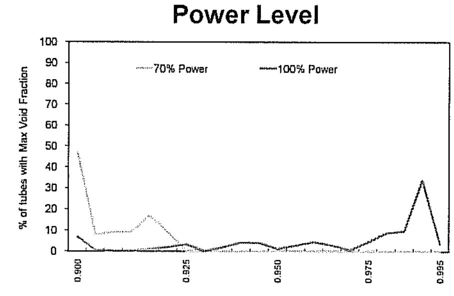
Preventing Fluid Elastic Instability (FEI)

- Reduce fluid velocity
  - o Velocity of fluid: transfers energy to the tube
- Improve tube damping
  - o Fluid film between tube and supports: function of void fraction/steam quality
  - o Fluid interaction with tube: function of void fraction/steam quality
- Reducing power level
  - o Reduces velocity
  - o Improves void fraction/steam quality
  - o Improves tube damping

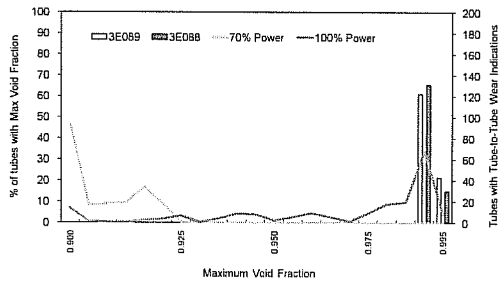
Maximum Void Fraction as a Function of Power Level



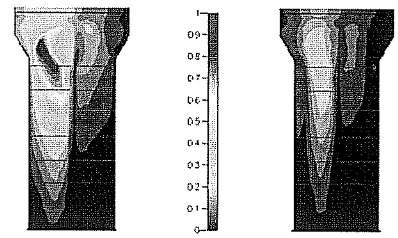
Maximum Void Fraction as a Function of Power Level



Maximum Void Fraction as a Function of Power Level



Steam Quality Contour Plots

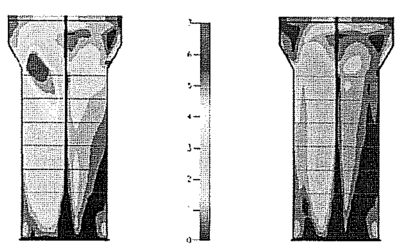


100% Power

70% Power

Prepared from ATHOS Thermal-Hydraulic Model

Velocity Contour Plots



100% Power

70% Power

Prepared from ATHOS Thermal-Hydraulic Model

Operational Assessments

- Forward looking analysis of Steam Generator performance
- Three assessments prepared using diverse methods by independent companies
- Demonstrate 16 -18 months of operation at 70% power until the next inspection
- More than three times longer than conservatively proposed five month operating period

Conservative Actions to Improve Safety Margin

- Power Reduction to 70%
  - Significantly reduces fluid velocities: less energy causing tubes to vibrate
  - Significantly reduces void fraction: better damping
  - Prevents Fluid Elastic Instability (FEI)
- Preventive Plugging of Tubes
  - Tubes most susceptible to FEI at 100% power
  - Eliminates possibility of tube leakage
- Short Operating Interval
  - Five month window is significantly shorter than analysis allows
  - 100% tube inspection during mid-cycle outage

Additional CAL Response Actions

- Improved ability to detect minor leakage
- Established more restrictive limits on primary to secondary leakage
- Enhanced radiation monitors on secondary system
- Upgraded vibration monitoring instrumentation
  - Sensors located above and below the tubesheet
  - Adjacent to top of tube bundle

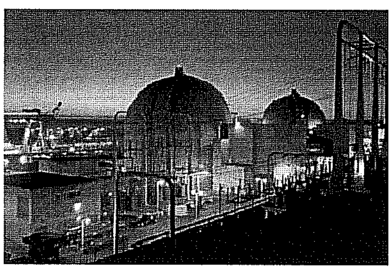
Conclusions

- SCE has performed a thorough investigation and determined the causes of the Tube-to-Tube Wear
- Corrective actions to prevent loss of integrity in Unit 2 Steam Generator tubes have been implemented
- Corrective actions are conservative with considerable safety margin
- SCE has met the requirements of the Confirmatory Action Letter
- SCE has taken a deliberate, conservative approach to restart of Unit 2 to assure public health and safety

Southern California Edison Commitment

We operate San Onofre Nuclear Generating Station (SONGS) safely and reliably to the highest standards to protect the health and safety of the public and our employees

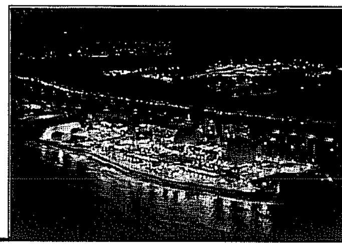
We will not restart either Unit 2 or Unit 3 until we and the NRC are satisfied it is safe to do



All materials are available on

www.SONGSCommunity.com

Follow us on Twitter on @ SCE_SONGS



Public Meeting with the Nuclear Regulatory Commission

Unit 2 Confirmatory Action Letter

November 30, 2012

Southern California Edison Commitment

We operate San Onofre Nuclear Generating Station (SONGS) safely and reliably to the highest standards to protect the health and safety of the public and our employees

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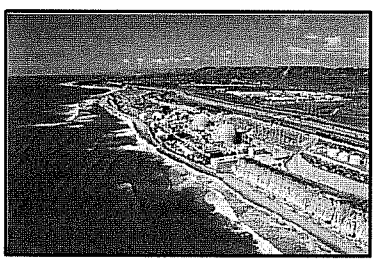


There is no timeline on safety

History of Replacement Steam Generators

- Replacement Steam Generators (RSGs) awarded to Mitsubishi Heavy Industries (MHI) in September 2004
  - Unit 2 RSGs installed in Fall 2009
  - Unit 3 RSGs installed in Fall 2010
- Replacement performed in accordance with NRC requirements
- Two license amendments were submitted and approved

Unit 3 Tube Leak and Tube-to-Tube Wear

- Steam Generator tube leakage occurred on Jan. 31, 2012
- Leakage was small and managed by plant operators using established plant operating procedures
- Approximately 11 months of full power operation following installation of Replacement Steam Generators
- Inspections found unexpected Tube-to-Tube Wear

Conservative Approach

- SCE recognized significance of Unit 3 condition
- SCE recognized susceptibility of Unit 2
- SCE engaged the best world-wide expertise and took a deliberate, thorough approach to the investigation
- SCE delayed restart of Unit 2 as a prudent, conservative action to ensure public health and safety
- SCE has ensured significant safety margin exists prior to restart of Unit 2

ENCLOSURE 2

NRC Opening Remarks

Ryan Lantz

Branch Chief
SONGS Project Branch
Region IV

SONGS Technical Presentation

Thomas Palmisano

Vice President of Engineering,

Projects and Site Support, SONGS, SCE

NRC Remarks

Art Howell

Deputy Regional Administrator
Region IV

Region IV SONGS Organization

Elmo Collins, Regional Administrator

Art Howell, Team Mgr, SONGS Special Project

TBD, Dep. Team Mgr, SONGS Special Project

Ryan Lantz, Branch Chief

Greg Werner, Inspection Lead

Nick Taylor, Senior Project Engineer

Michael Bloodgood, Reactor Inspector

Brian Parks, Project Engineer

SONGS Resident Inspectors

HQ SONGS Organization

Eric Leeds, Director Office of Nuclear Reactor Regulation (NRR)

Dan Dorman, NRR Deputy Director for Engineering and Corporate Support

Division of Operating Reactor Licensing
SONGS Special Projects Branch
Doug Broaddus, Chief

Division of Engineering
SG Tube Integrity & Chemical Engineering Branch

Division of Safety Systems
Technical Specifications Branch,
Reactor Systems Branch

Division of Policy & Rulemaking
Generic Communications Branch

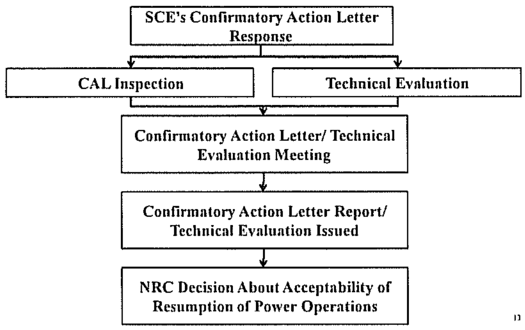
Office of Nuclear Regulatory Research
Reactor Systems Code Development Branch

Path Forward – Key NRC Activities

Ryan Lantz

Branch Chief
SONGS Project Branch
Region IV

Path Forward – Key NRC Activities



15 Minute Break

Questions and Answers

Contacting the NRC

- Report an Emergency
  - (301) 816-5100 (24/7 NRC Headquarters' Operation Center) (call collect)
- Report a Safety Concern:
  - (800) 695-7403 (Toll-free Safety Hotline)
  - Allegation@nrc.gov
- General Information or Questions
  - www.nrc.gov
- Victor Dricks, Public Affairs Officer, RIV
  - 817-200-1128
  - Victor.Dricks@nrc.gov