



Unit 1 Cook Nuclear Plant Turbine Event Status Report

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***Nuclear Regulatory Commission
Presentation
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Agenda



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- Opening Remarks – Joe Jensen, Senior Vice President and Chief Nuclear Officer
 - Unit 1 Event & Damage Summary - Larry Weber, Site Vice President
 - Root Cause – Ray Hruby, Site Services Vice President
 - Initiating Event
 - Equipment Root Cause
 - Recertification Report
 - Corrective Actions
 - Current Repair Status – Larry Weber
 - Modifications
 - Repairs Completed
 - Lower Exhaust Hood Details
 - Repairs Remaining
 - Rotor Support Testing
 - Restart Readiness – Larry Weber
 - Readiness Validation, Testing and Start-up
 - Closing Remarks and Questions – Joe Jensen

Event Description



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- On Saturday, September 20, 2008 at 2005 hours, the control room experienced simultaneous high-high vibration readings on all main turbine bearings with severe vibration and rumbling felt coming from outside the control room.
 - The reactor operator manually tripped the reactor within 5 seconds, all control rods fully inserted, and major systems functioned as designed (Good operator response).
 - Turbine generator went from 1800 RPM to 0 RPM in less than 2 minutes.

Event Description

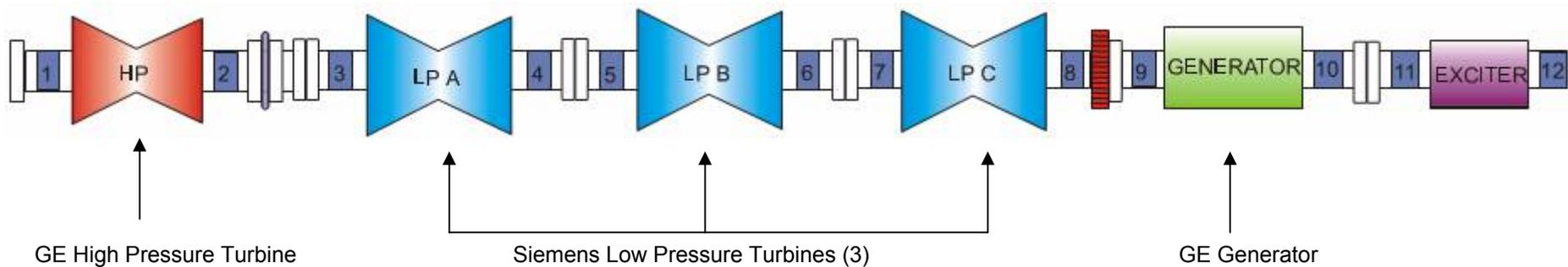


- A main generator fire was caused by a failure of the hydrogen seal. The shift manager initiated the Emergency Plan based on the fire in the protected area.
- The fire was extinguished at 2028 hours.
- The Technical Support Center was functional at 2113 hours.
- The Unusual Event was terminated on Sunday, September 21, 2008 at 0409 hours.

Event Description



Unit 1 Main Turbine-Generator Overview



Damage Summary



- Fire damage to main generator/exciter housing
- Turbine damage
- Piping insulation damage
- Visible concrete damage around turbine
- Oil spills
- Damaged hangers and supports on various pipe systems



Excellent Response to Event- No Injuries

Damage Summary



- LP turbine exhaust hoods
 - LP turbine exhaust hoods display evidence of blade impact
 - All blades were contained within turbine hoods
 - Bearing housings were displaced

Damage Summary



- Turbine shafts
 - No coast down or turning gear operation
 - Significant shaft scoring
 - Bearing damage evident at all 12 main bearing locations

Damage Summary - Fire



- Fire due to failure of generator hydrogen seal
- Fire brigade responded and extinguished fire within 23 minutes
- Excellent local fire department assistance

Damage Summary - Fire



- The Fire Water System experienced complications including a breach of the piping on the West side of the plant, draining of the South Fire Water Tank and failure of the East Diesel Fire Pump.
- The NRC sent a fire protection inspector to the site on September 21, 2008, to launch a Special Inspection Team (SIT).
- The on-site NRC resident inspectors and SIT inspectors monitored activities associated with full restoration of the site-wide fire protection system and conducted an investigation into the causes of both the turbine failure and the fire suppression system failure.
- A number of enhancements were identified and entered into the Corrective Action Program.

Initiating Event



- Blade #40 on LP turbine B, turbine side (LP B TS) is liberated due to high cycle fatigue
- Blade #56 on LP B TS also exhibited high cycle fatigue and is liberated during the event
- Blade #189 on LP turbine C TS also exhibited high cycle fatigue and is liberated during the event
- Blades #29 and #64 on LP B TS fracture in overload during the event
- The loss of 5 L-0 blades creates a severe unbalance condition on the rotor



- The high vibration of the unbalanced turbine causes extensive damage to connected systems.

Initiating Event



LP B and LP C Blade Failures



Equipment Root Cause

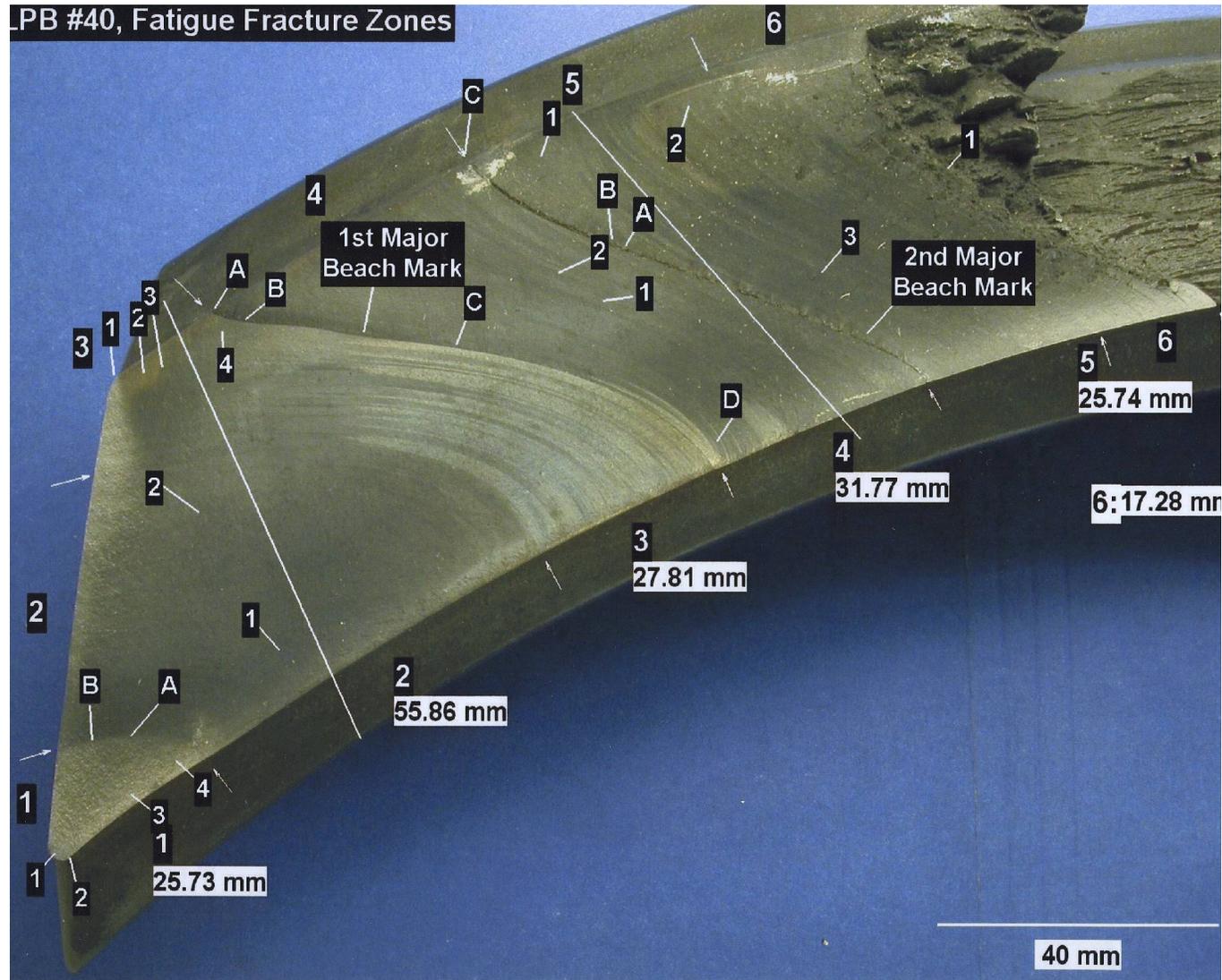


A Blade-Rotor System Design Which Failed to Provide Adequate Stress Margin in at Least Three L-0 Blades

Findings:

- Blade vibrations
- Indications of non-uniform loading in root engagement
- Normal electrical grid variations correlate to fracture beach marks

LPB Blade #40 Fracture Surface Distinctive Zones and Beach Marks



Recertification Report



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- Single comprehensive document
 - Revision 0 provided to the NRC
 - Complete discussion of:
 - Damage to the turbine system
 - Repairs performed
 - Technical basis for restart
 - Revision 1 will be approved prior to applying steam to the turbine

Corrective Actions



- Interim repaired LP turbines without L-0 blades
- Replace LP turbines with proven design in 2011
- Design to be validated by a third party review
- Additional turbine monitoring instrumentation

Current Repair Status

Design Modifications



- L-0 blades removed from LP turbines and baffle plates installed to mimic turbine pressure drop
- LP rotor - #3 disc reshaped to address rotordynamic resonance
- Exhaust hood and bearing housing stiffening struts installed to move shaft resonant speed away from operating speed.
- Several other minor changes in dimensions and materials were made

Current Repair Status

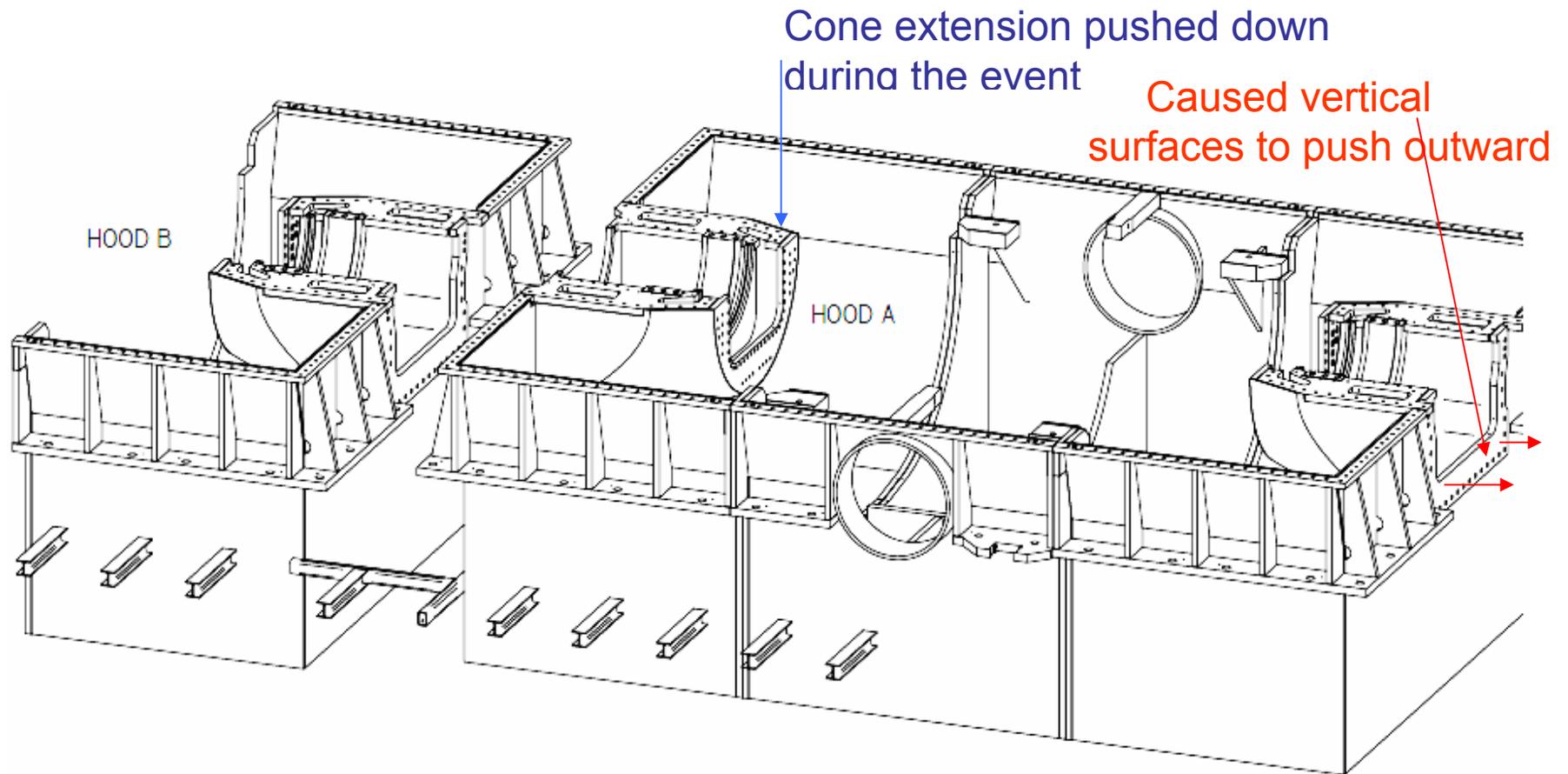
Repairs Complete



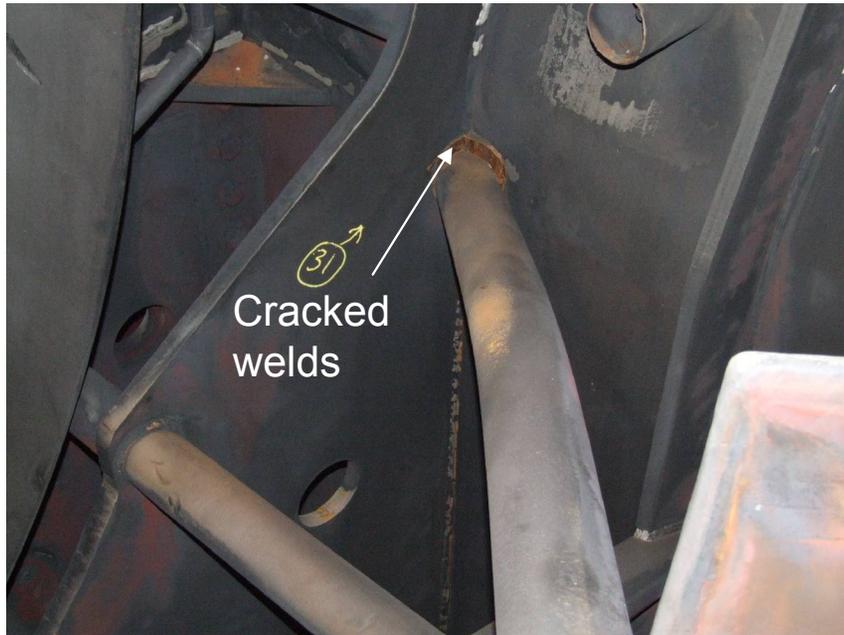
- HP & LP turbine rotors repaired
- HP turbine inlet and outlet piping reconnected to turbine shell
- LP exhaust hood upper and lower seating surface repairs complete**
- Generator rotor installed
- Exciter installed
- HP turbine - front and mid-standards complete
- LP turbines - Repaired sole plates, concrete and foundation bolts
- Repaired foundation plates and ready to grout
- Support Systems being operated and flushed

** See next 5 slides for a description of the significance of the lower exhaust hood repair effort

Lower Exhaust Hood (LEH)



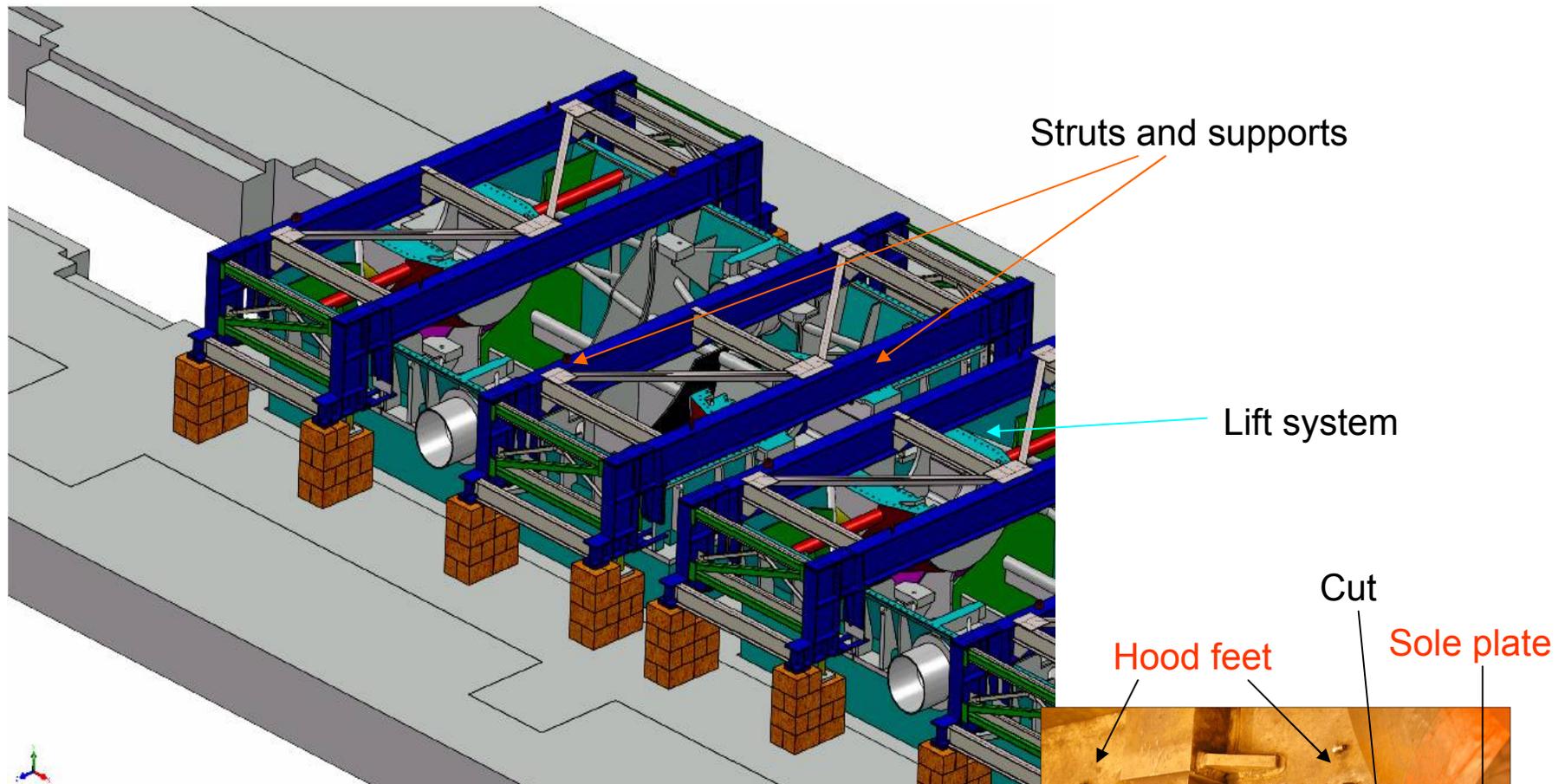
Initial Inspection of LEHs



Initial damage assessment:

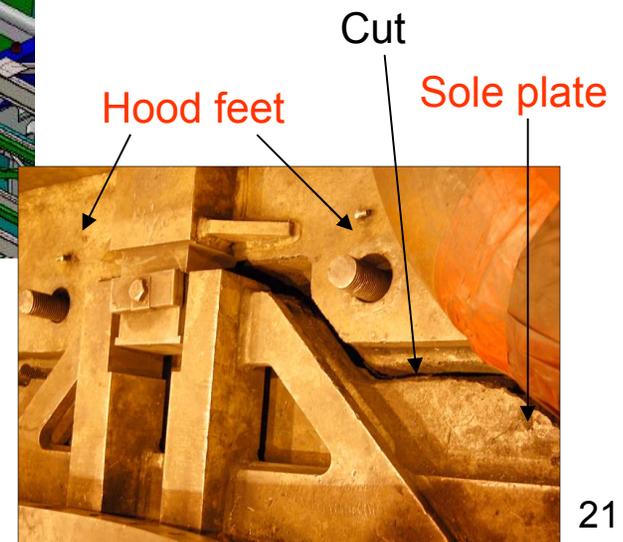
- Structural supports and struts damaged
 - Grout cracking and foundation bolts damaged
 - Cone extension have moved
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- LEHs required extensive repairs and are now complete

Lifting LEH's



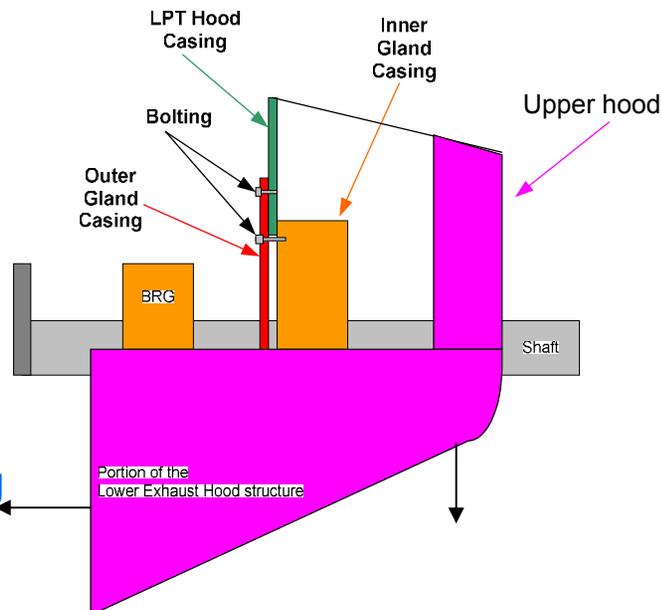
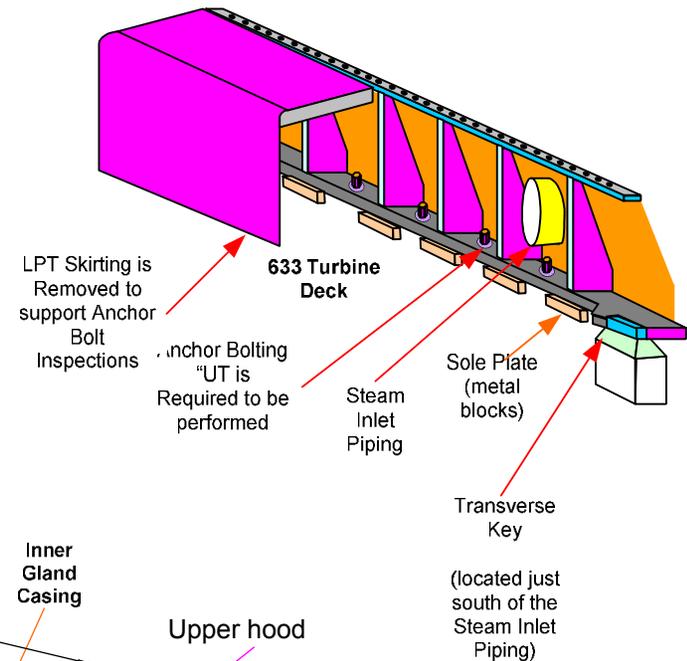
Issue on first lift attempt:

- Sole plates between hoods were welded, due to event, to bottom of LEH feet. Had to be cut without effecting hood supports.



Inspection after Lift

- Sole plates welded to bottom of LEH feet causing damage to feet, requires machining
- Cone extensions have pushed vertical wall on north and south ends
- Large number of welds inside the cones had to be repair and stressed relieved.



Scope expansion:

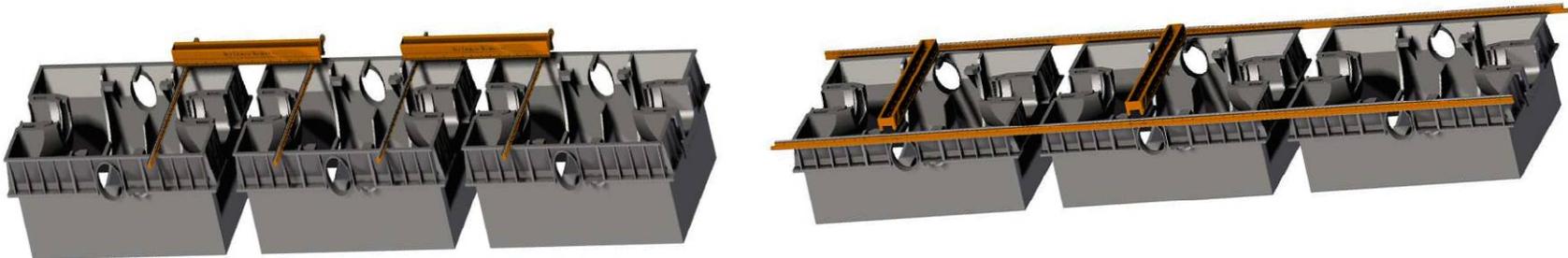
- 1) Number of welds
- 2) Lift hoods additional 2' for machining
- 3) Machining feet and verticals

Major challenges:

- 1) Hood movement during repairs
- 2) Access to welds

Repairs after LEH's Set

- 100% NDE on welds revealed more repair than expected.
- Weld build-up on horizontal cone section and bolt holes.
- Machining on horizontal cones
- Installation of strut modification
- Weld buildup and machining on horizontal surfaces for UEH and LEH fit.
- Lower exhaust hood alignment to centerline
- Weld buildup for boring operations



Challenges:

Never been done

Volume of welding in small area

Stress relieve of cones during welding and hood movement due to welding

Current Repair Status

Repairs Remaining



- Lower inner casing installation
- Main turbine lube oil system cleanup
- Main generator seal oil system cleanup
- Main condenser eddy current testing, repair and cleanup
- Cleanup of all secondary system heat exchangers
- Replace and setup turbine digital control system and Turbine supervisory instruments

Rotor Support Testing

- Rotor is supported by foundation, bearings, and oil film
- Testing will verify that adequate support exists
- Shaker testing allows for selective identification of natural resonances
- Concrete foundation adequacy has been verified by initial testing
- Bearing cone testing is in progress
- Total shaft support testing will follow later in the testing program

Restart Readiness Validation, Testing & Start-up



- Validation
 - Recertification Report
 - Independent assessment by MPR Associates
 - System Affirmations
- Testing
 - Baffle plate bump test
 - Rotor support bump and shaker testing
 - Laser alignment checks of rotor bearings
 - Support system performance monitoring
- Start-up
 - 3 hour ramp from 10% to 29% power (400 minute minimum heat soak)
 - 10 hour ramp from 29% to 68% power (200 minute minimum heat soak)
 - 8 hour ramp from 68% to 100% power
 - Online torsional monitoring and shaft vibration monitoring

Closing Remarks and Questions



- Overall
 - Major physical event to the Cook plant
 - Major emotional event to Cook employees and stakeholders
 - Repair effort is unprecedented in nuclear industry (biggest insurance claim ever)
- The Cook team's immediate and long term response to the event were recognized by the industry as very good
- Unit 2 has continued to safely operate
- Nuclear safety culture has remained strong (October 2009 USA Assessment)
- The Cook team is a stronger, smarter, more agile team as a result of the event.
- **Questions?**