Controlling Condensate & Feedwater Dissolved Oxygen & Air Inleakage

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Air Inleakage/Oxygen Control Strategy

- **Focus #1:** Find It (Monitoring)
- **Focus #2:** Eliminate or Reduce Sources (Air & Makeup)
  - Oxygen in Air: 20.9% O₂ By Volume or 23.1% O₂ By Mass
  - CO₂ in Air: 0.04% By Volume
  - DO in Air Saturated Makeup: 8,000-14,000 ppb O₂
  - CO₂ in Air Saturated Makeup: <0.8-1.0 μS/cm Cation Conductivity
- **Chemical Removal** – Not Covered in Presentation
Steam Surface Condenser

From Turbine

Steam Flow

Demineralized Makeup
To Condensate Pumps

Condensate

Air Inleakage

N₂, O₂, CO₂, NH₃

Air Removal System
Ways to Monitor Air Intrusion

- Flow In: Air Inleakage
  - SF₆, Helium
  - Water/Steam Leaks During Operation & Shutdown

- Flow Out:
  - Air Removal Flow From Vacuum System: Total (cfm), Air (scfm),
  - Condensate CC (from CO₂) and DO (from O₂)

- What’s Left Behind: Condenser Back Pressure
Justify Finding & Fixing Air Leaks

- **Heat Rate Penalty Per Inch of Back Pressure For 520 mW Turbine (Example)**
  - 116.5 BTU/kwh
  - ~$108,180 Per Month (Based On $2.48 Per MMBTU)

- **Determining Your Penalty**
  - Calculate Base Line Heat Rate
  - Induce Air Leak Until Back Pressure Rises Or Until Chemistry Limit Is Reached
  - Recalculate Heat Rate

- **Use Heat Rate Justify Cost of Finding and Fixing Air Leaks**
Total Air Removal Rate Vs. Steam Seal Pressure (daily cycling 40-100% load)
Steam Seal Pressure &
Hotwell Cation Conductivity

Steam Seal Pressure (psig)

Hotwell Cation Conductivity, µS/cm
Top View of Steam Seal Line
Bottom View of Steam Seal Line
Perforated Slop Drain
# Dissolved Oxygen & Cation Conductivity Due to Air Leaks

<table>
<thead>
<tr>
<th>Condition</th>
<th>Air Removal Rate</th>
<th>Condenser Back Pressure Due To Air Inleakage</th>
<th>Hotwell / CPD Sample</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Hotwell Dissolved Oxygen</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Cation Conductivity</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Not Subcooled</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Subcooled</td>
</tr>
<tr>
<td>Air Inleakage Above Water Level</td>
<td>&gt;2-3 scfm/100 mW (of Design Capacity)</td>
<td>Normal to High</td>
<td>High</td>
</tr>
<tr>
<td></td>
<td>&lt;1-3 scfm/100 mW (of Design Capacity)</td>
<td>Normal</td>
<td>Normal to Moderate</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Normal to High</td>
</tr>
<tr>
<td>Air Inleakage Below Water Level</td>
<td>~0.01 scfm/Million pph of Condensate Flow</td>
<td>Unaffected</td>
<td>Unaffected</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>~10 ppb Increase</td>
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<tr>
<td></td>
<td></td>
<td></td>
<td>~10 ppb Increase</td>
</tr>
<tr>
<td>Reduced Vacuum Pump Capacity</td>
<td>Normal to Moderate</td>
<td>Possibly High</td>
<td>Normal to Moderate</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Normal to Moderate</td>
</tr>
</tbody>
</table>

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Sheppard T. Powell Associates, LLC

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Effect of Air & Cooling Water Inleakage

- Cond. Cation Conductivity μS/cm (Left Axis)
- Air Removal Rate, scfm (Right Axis)
- Sodium, ppb Na (Right Axis)
Effect of Makeup Spray Header

- 2004 Data
- 2006 Data (After Installing Spray Header In Condenser)
- 2008 Data (After Fixing Air Leaks)
Summary of Air Inleakage Tips

1. Inspect for Steam or Water Drips on Shutdown as well as during Operation
2. Use Heat Rate to Justify Air Leak Testing & Repairs
3. Raise Steam Seal Pressure to Reduce Air Leaks
4. Inspect Steam Seal Supply Lines & Slop Drains
5. Keep Air Removal Rate < 2-3 scfm/100MW
6. Eliminate Air Leaks in Flooded Areas: 0.01 scfm/million pph ~ 10 ppb O₂
7. Modify Makeup Water Distributor in Condenser