Once Through Steam Generators

Design, Operation, and Maintenance Considerations

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Presentation Overview

• OTSG vs HRSG Comparisons
• Design Considerations
  – Material Selection
  – Mechanical Design for Thermal Cycling
• Operational Considerations
  – Water Treatment
  – Operation & Control
• Questions
Heat Recovery OTSG for Power Generation

Direct Fired OTSG for Enhanced Oil Recovery
Purpose of the heat recovery
OTSG
OTSG vs HRSG

LM6000 Installation – overall size comparison
HRSG vs OTSG

Drum-Type HRSG
Fixed Sections

OTSG Type HRSG
Non Fixed Section

GT EXHAUST GAS

SUPERHEATER

EVAPORATOR

ECONOMIZER

STACK EXHAUST

BLOWDOWN

Feedwater In

ECONOMIZER

EVAPORATOR

SUPERHEATER

Superheated Steam Out
“Drumless” Design

- All tubes thin-walled → low thermal mass → fast cycling
- Compact lightweight pressure bundle
- Simple once through steam path
- Zero Blowdown (no blowdown treatment)
Design Considerations - Metallurgy

- Incoloy 800/825 tubing designed to mitigate the following failure modes:
  - Dew point corrosion (water/acid)
    - Allows cold feedwater 60°F (17°C)
  - Flow assisted corrosion
  - Thermal shock
  - Creep/fatigue failures
  - Cycling/daily start – stop

  Thin wall tubes & mechanical design

- 409SS & 316SS Liners
- CS, 409SS, & 316SS brazed fins
- Allows **dry running** capability up to 1100°F (593°C)
Advanced Metallurgy – Fin Materials

Design Limits
CS < 454 °C
409SS < 593 °C
316SS < 871 °C

Corrosive duty must be considered as well.
Main Internal Components for Cycling Applications

- Flex Tubes
- LP Feedwater Header
- HP Feedwater Header
- LP Steam Header
- Jumper Tubes
- HP Steam Header
- U-Bends
- V-Seals
- Acoustic Baffles
- Tube Sheets
- Finned Tubes
- Top Support Beams
Bundle Growth – Thermal Cycling

Blue – hot/expanded condition
Black hidden – Cold condition

Note the tubesheet movement, tube growth, and flex tubes.
OTSG and Plant Feedwater Treatment

- No blowdown so water quality critical

- Requires demineralized and polished feedwater.
  - Cation Conductivity Limit: 0.25 μS/cm

- IST recommends stainless FW piping from polisher to OTSG (particularly for cycling plants)

- Eliminates:
  - Tube scaling
  - Deposition and carry over
  - Active chemical treatment
## OTSG Feedwater Specification

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Target Value</th>
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<tbody>
<tr>
<td>Water Cation Conductivity (μS/cm)</td>
<td>&lt;0.25</td>
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<tr>
<td>pH (stainless piping)</td>
<td>8 to 8.5</td>
<td>9.3 to 9.6</td>
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<tr>
<td>(CS piping)</td>
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<tr>
<td>Dissolved Oxygen (ppb) (stainless piping)</td>
<td>&lt;300</td>
<td>&lt;7</td>
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<tr>
<td>(CS piping)</td>
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<tr>
<td>Sodium (ppb)</td>
<td>&lt;6</td>
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</tr>
<tr>
<td>Chloride (ppb)</td>
<td>&lt;6</td>
<td></td>
</tr>
<tr>
<td>Sulfate (ppb)</td>
<td>&lt;6</td>
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<thead>
<tr>
<th>Parameter</th>
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<tbody>
<tr>
<td>Iron (ppb)</td>
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<tr>
<td>Copper (ppb)</td>
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<tr>
<td>Total Organic Carbon (ppb)</td>
<td>&lt;100</td>
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<tr>
<td>Hardness (ppb)</td>
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Note: Typically, the water quality required in gas turbine injection applications is more stringent than the OTSG FW spec.
Typical Condensate Handling Diagram

- LP Steam Turbine
- To Pressurized D.A.
- Make Up Water
- Condenser Hot Well
- Condenser
- Condensate Pumps
- Vacuum Deareator
- Chemical Injection:
  - Hydrazine
  - Ammonia
- Condensate Polisher
- Analyzers:
  - Conductivity
  - pH
  - Oxygen
  - Silica
- Vacuum Pumps
- Optional Pressurized D.A.
- Condensate Buffer Tank
- Feedwater Pumps
Condensate Polishing Options

• Mixed bed polisher
  – Contains both acid and caustic resins within the vessel.

• Precoat (Powdex®) Polisher
  – Ideal where polishing and filtration are required due to suspended solids in the condensate. Filter elements are pre-coated with ion exchange resin.
Pre-coat Polisher Technology

- Less sensitive to hot condensate
- No need for acid or caustic storage on site
- Simple regeneration procedure
Benefits of Clean Water

- Eliminates need for blowdown and its treatment (3% energy savings)
- Extended boiler life (10 - 15%)
- Reduced maintenance and downtime
- Eliminates tube scaling
- Minimize need for active chemical treatment
- Minimizes chemical costs

Clean water benefits the entire plant
Simplified Control System

- Patented control system maintains constant temperature (and/or pressure) by regulating feedwater flow
- Feedforward control loop signals changes in gas turbine output
- Feedback control loop adjusts final trim of feedwater valve
- Pressure is controlled by plant downstream equipment such as pressure regulating valve or steam turbine
- All I/Os monitored by plant DCS
OTSG Start-Up Curve

(Start Permissive approx 12 min from GT ignition without SCR/CO)
Questions?