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Once Through Steam Generators

Design, Operation, and Maintenance Considerations

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Innovative Steam Technologies (IST)

McIlvaine Company Hot Topic Hour
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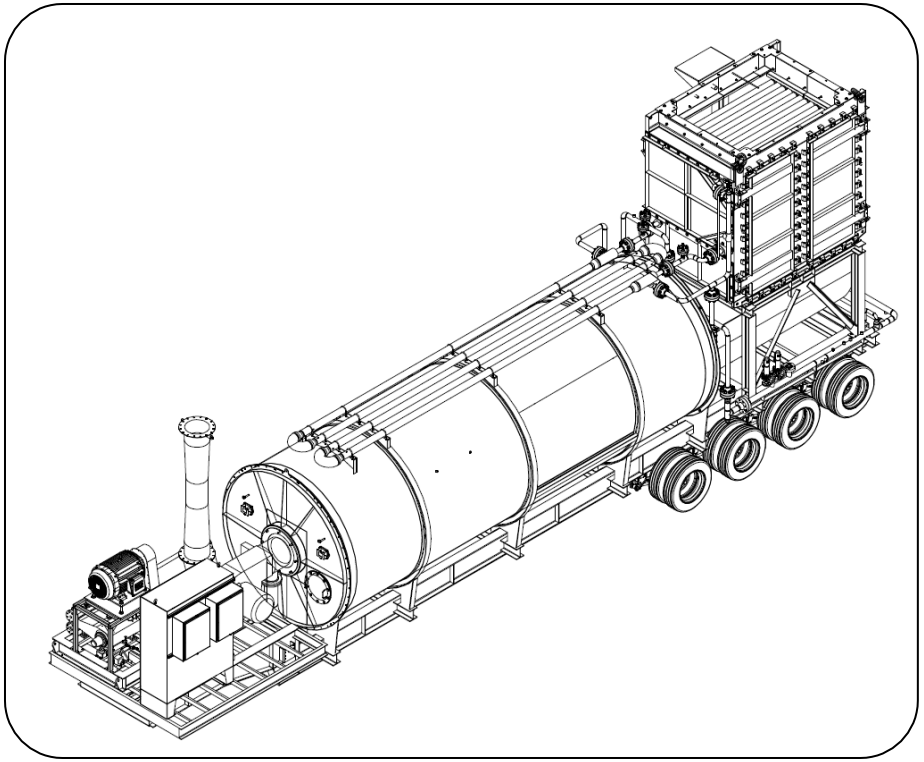
Presentation Overview

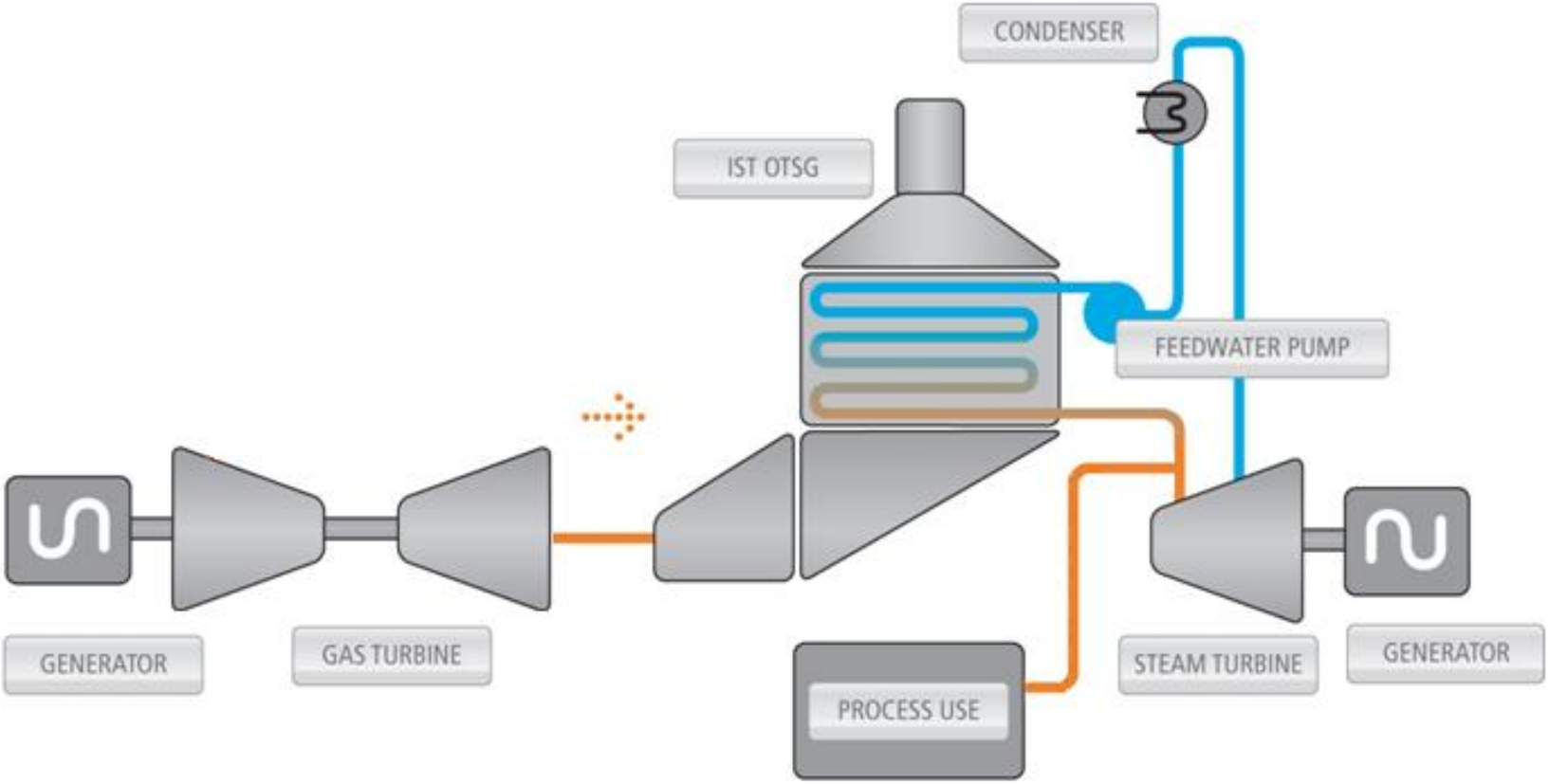
- *OTSG vs HRSG Comparisons*
- *Design Considerations*
  - *Material Selection*
  - *Mechanical Design for Thermal Cycling*
- *Operational Considerations*
  - *Water Treatment*
  - *Operation & Control*
- *Questions*

Heat Recovery OTSG for Power Generation

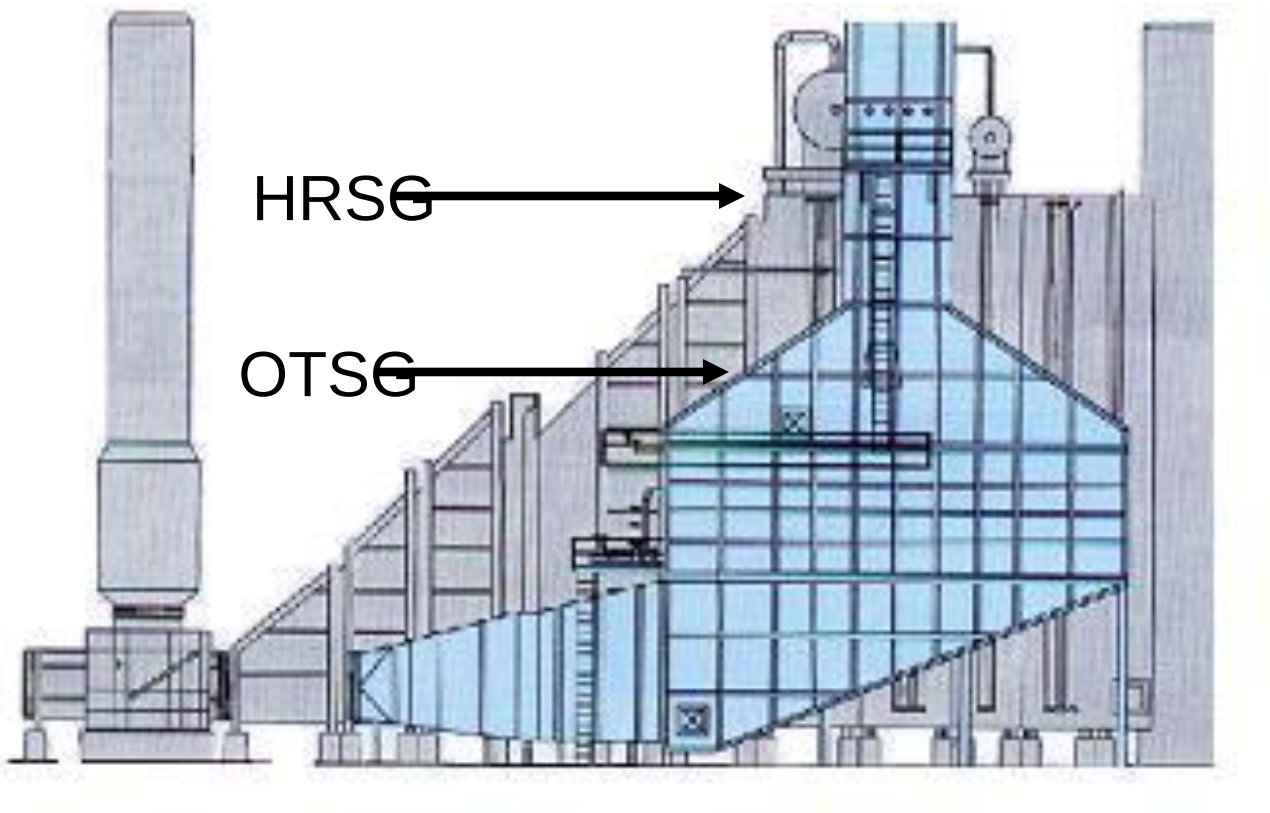
Direct Fired OTSG for Enhanced Oil Recovery



Purpose of the heat recovery OTSG



OTSG vs HRSG

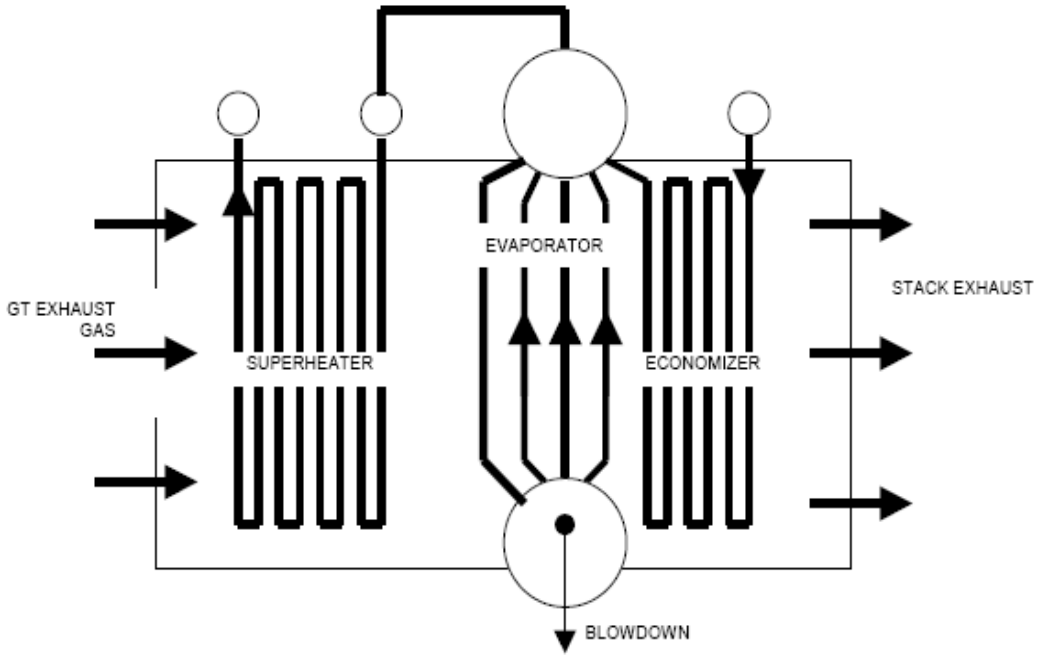


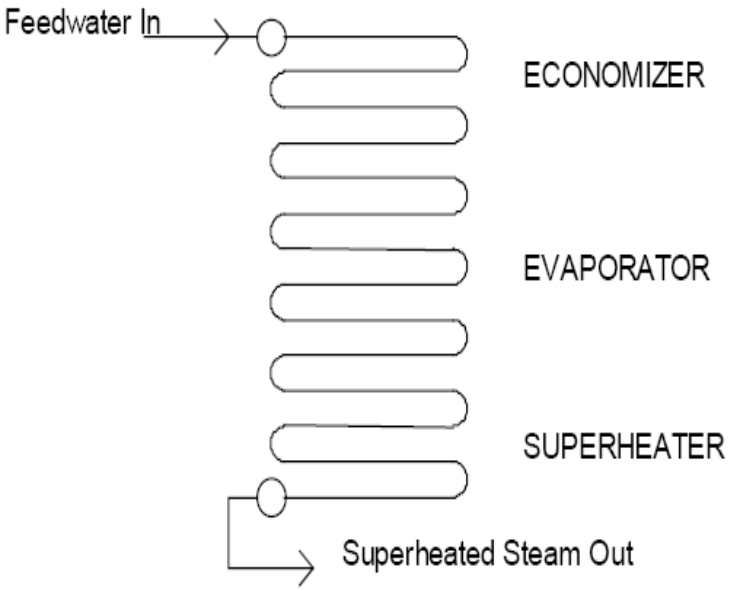
LM6000 Installation – overall size comparison

HRSG vs OTSG

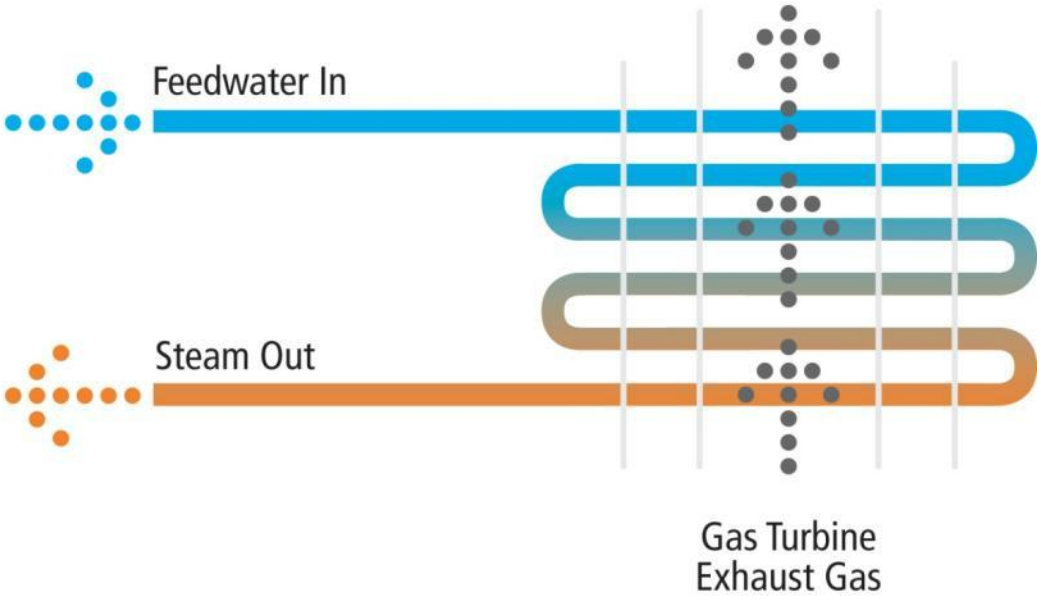
Drum-Type HRSG
Fixed Sections

OTSG Type HRSG
Non Fixed Section





“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

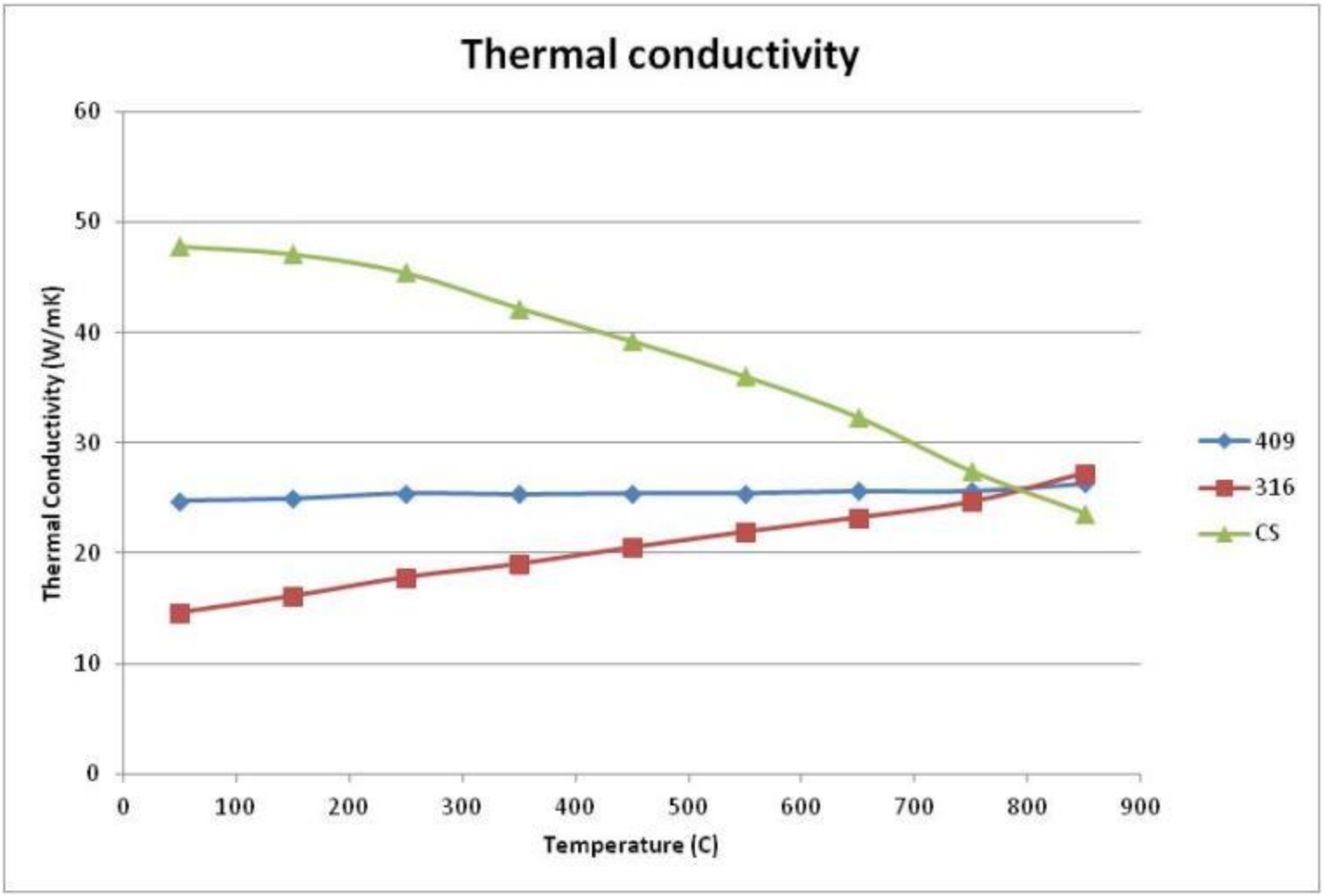
  } Thin wall tubes & mechanical design

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

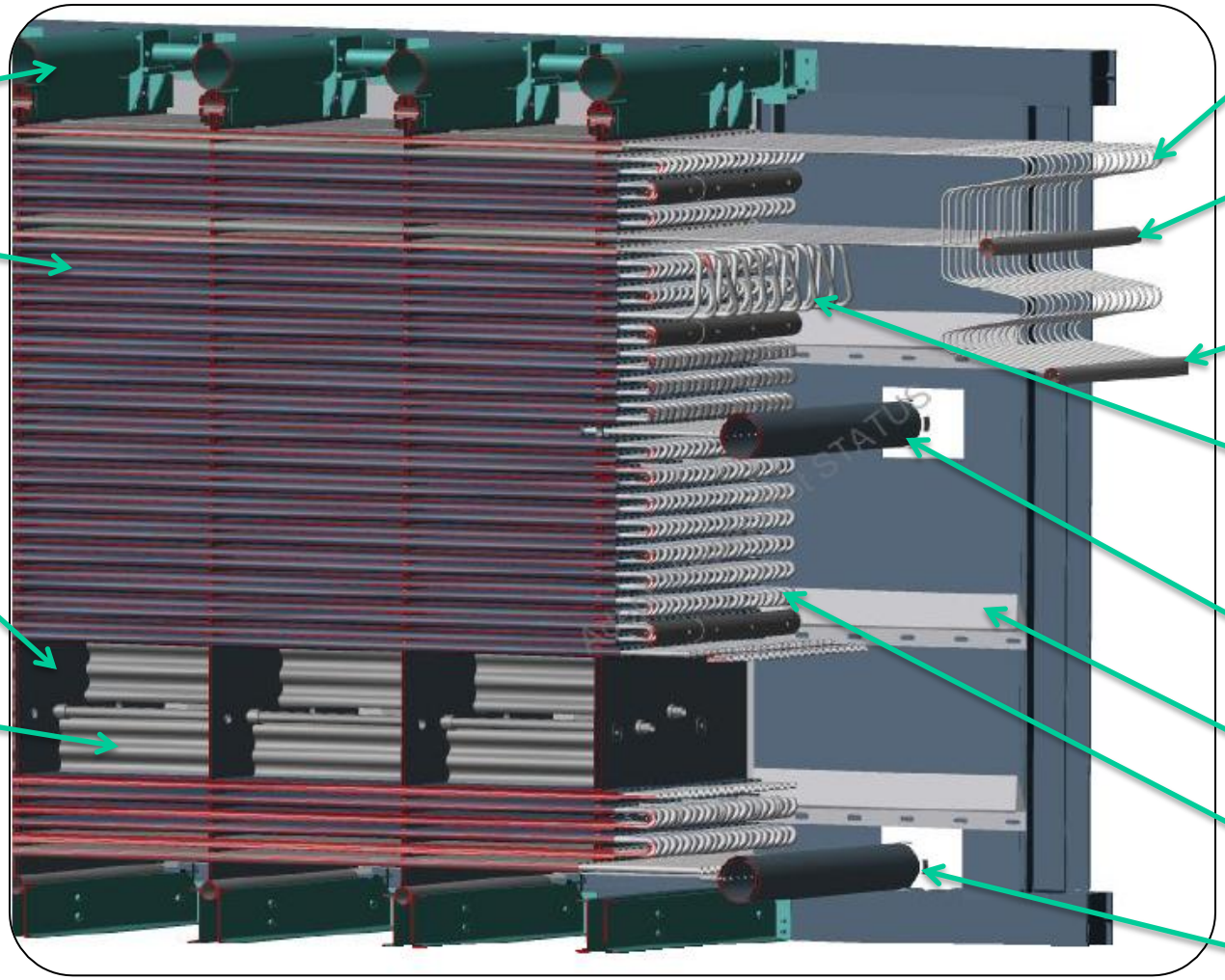
Advanced Metallurgy – Fin Materials

<u>Design Limits</u>
CS < 454 C
409SS < 593 C
316SS < 871 C

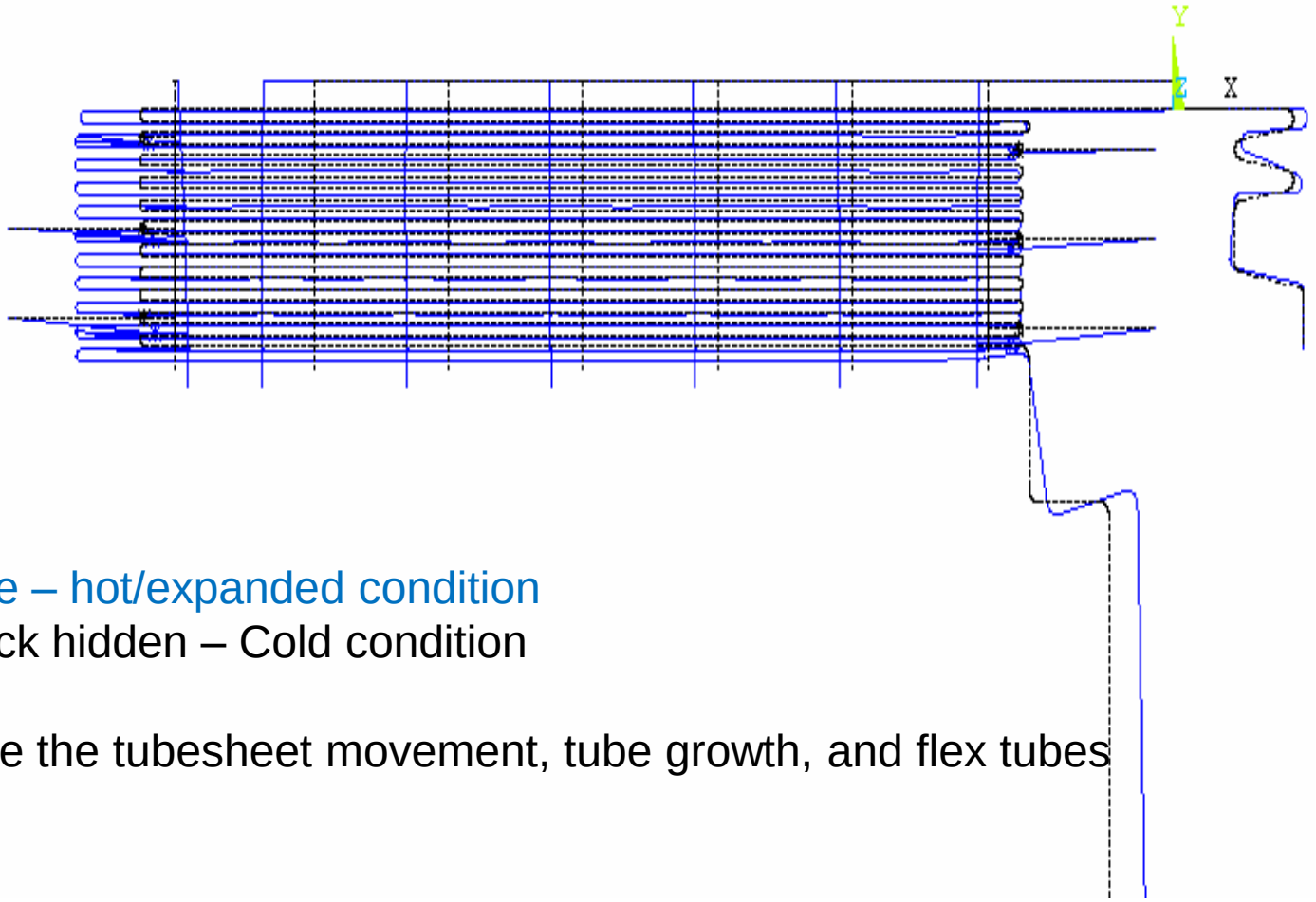
Corrosive duty must be considered as well



Main Internal Components for Cycling Applications



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

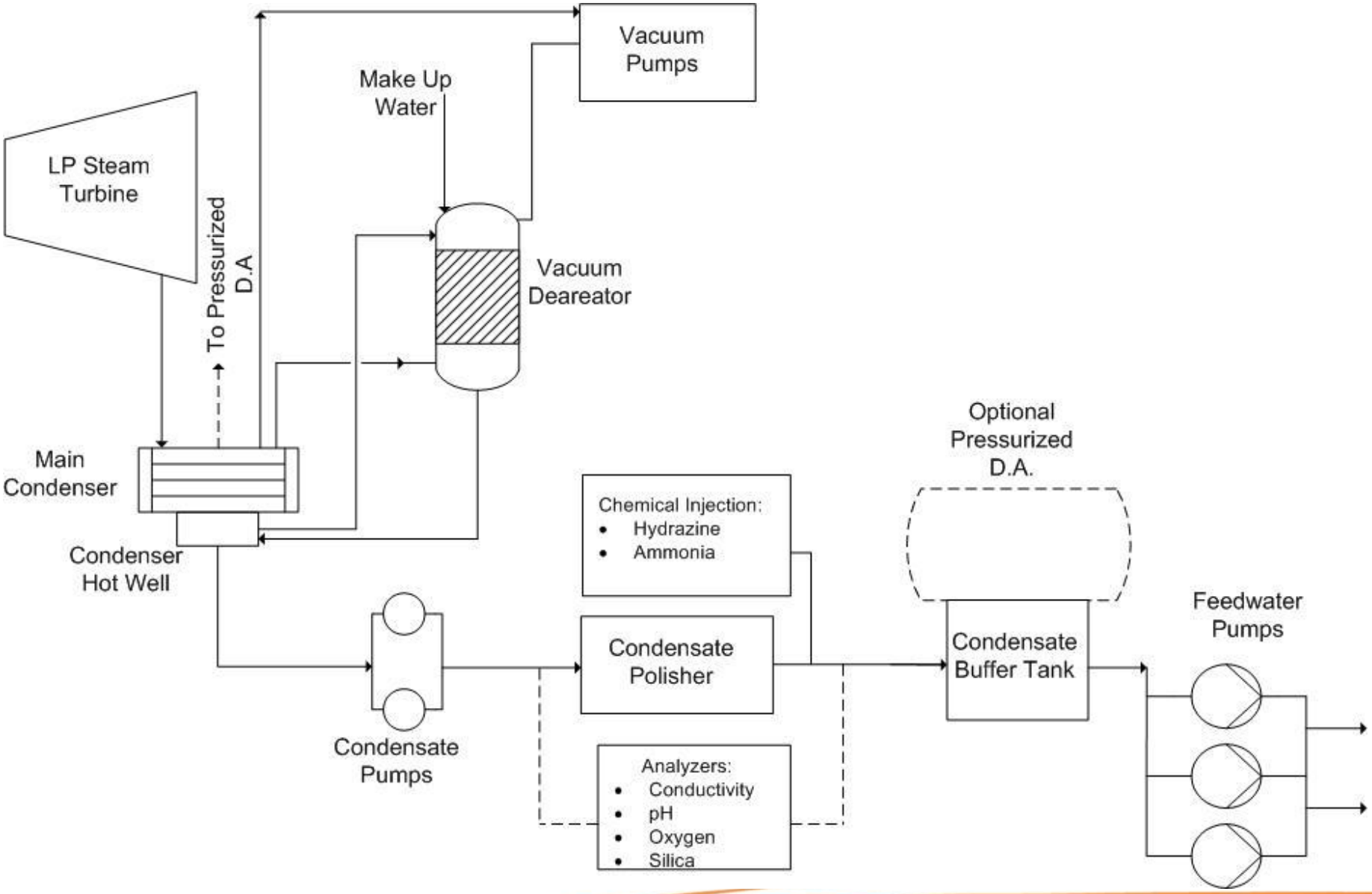
OTSG Feedwater Specification

Parameter	Target Value
Water Cation Conductivity (µS/cm)	<0.25
pH (stainless piping) (CS piping)	8 to 8.5 9.3 to 9.6
Dissolved Oxygen (ppb) (stainless piping) (CS piping)	<300 <7
Sodium (ppb)	<6
Chloride (ppb)	<6
Sulfate (ppb)	<6

Parameter	Target Value
Iron (ppb)	<10
Copper (ppb)	<2
Total Organic Carbon (ppb)	<100
Hardness (ppb)	<1

Note: Typically, the water quality required in gas turbine injection applications is more stringent than the OTSG FW spec.

Typical Condensate Handling Diagram

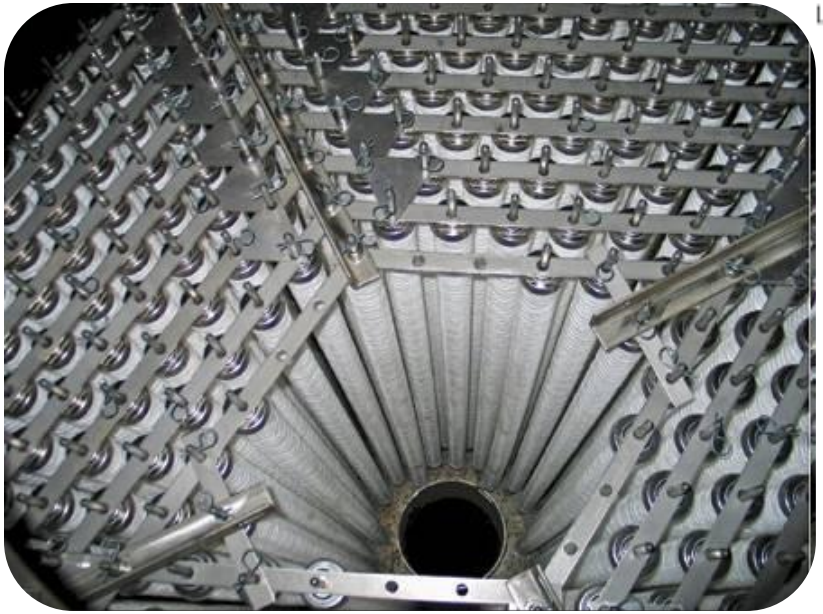


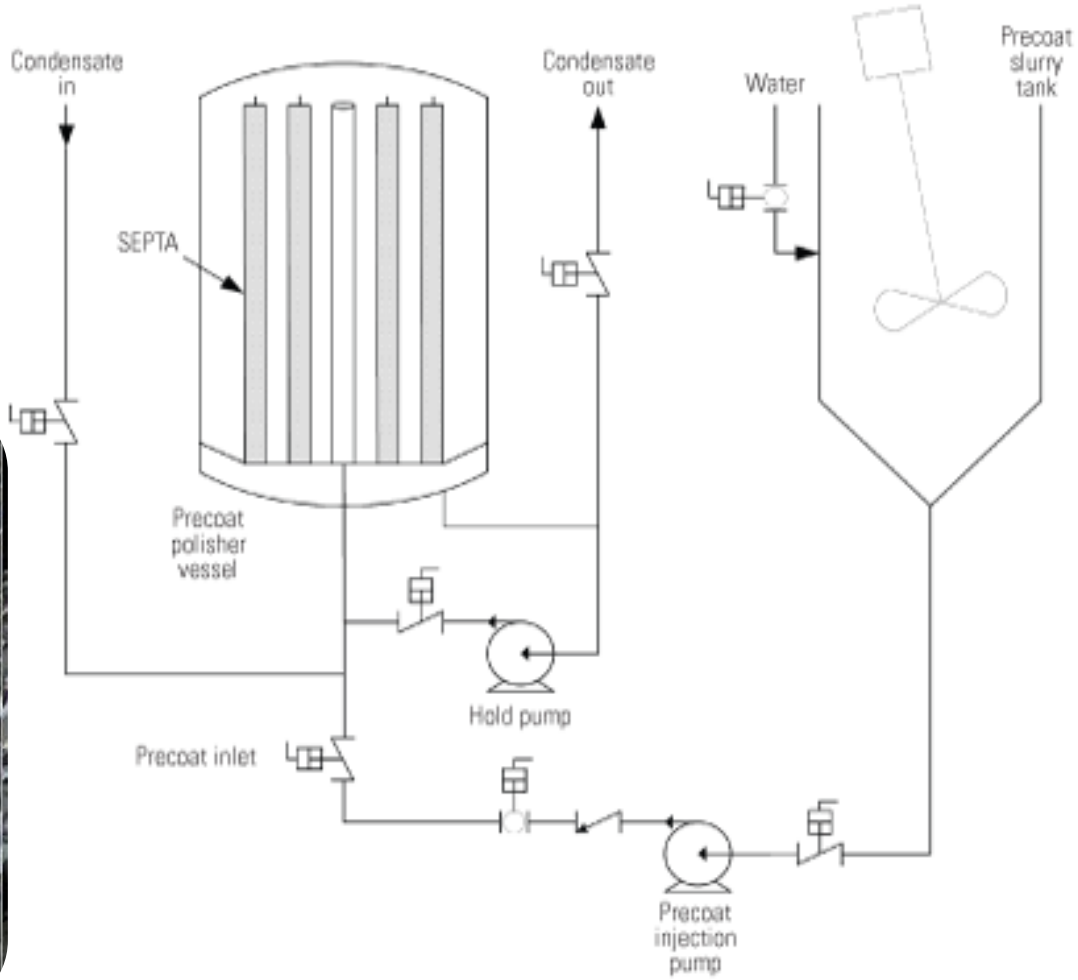
Condensate Polishing Options

- 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



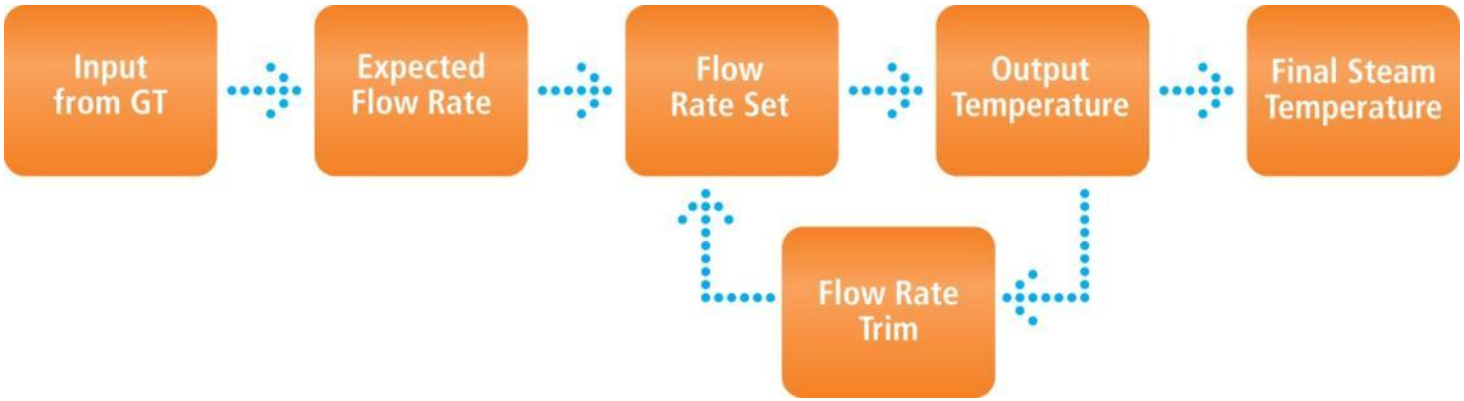


Benefits of Clean Water

- 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

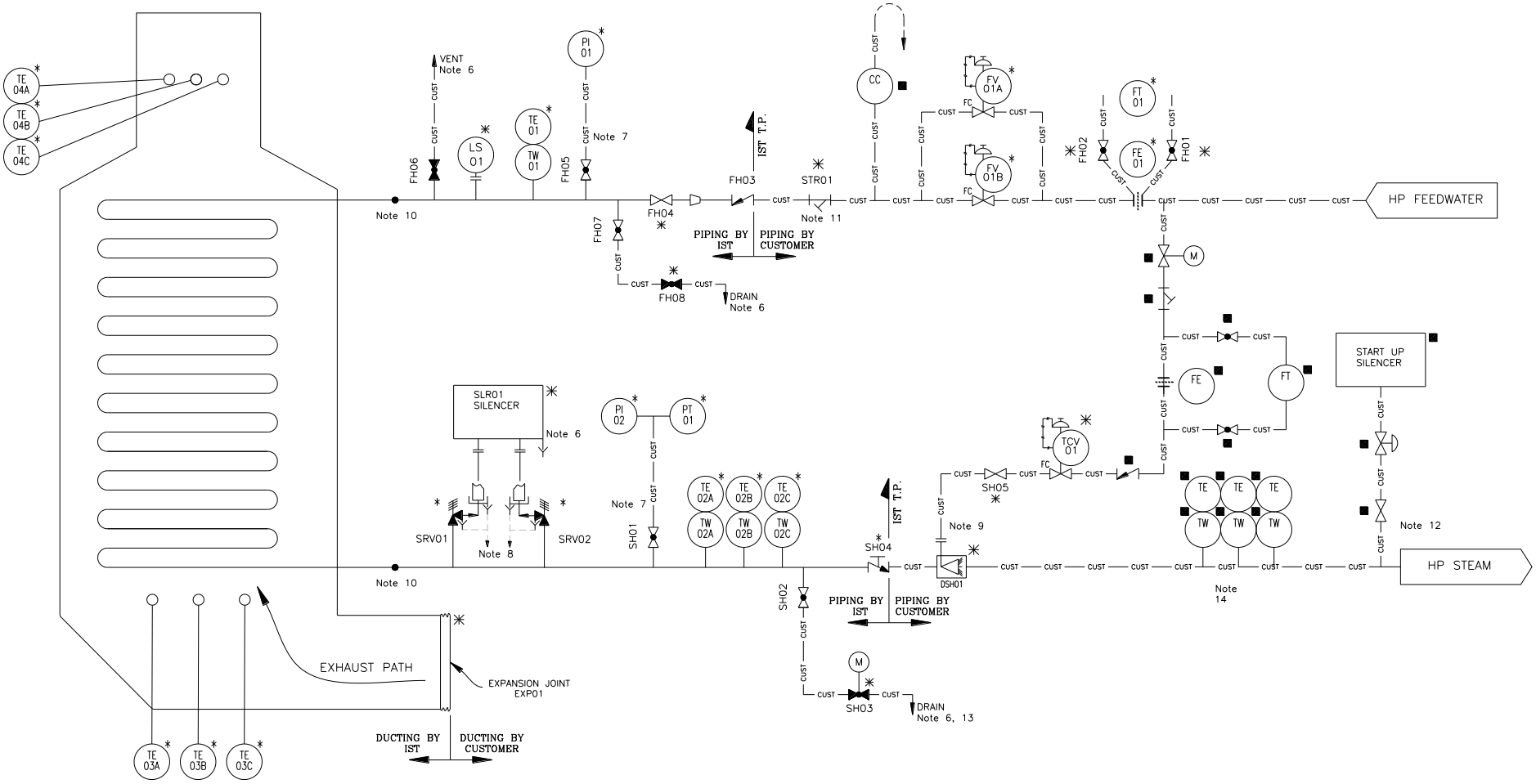
Clean water benefits the entire plant

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

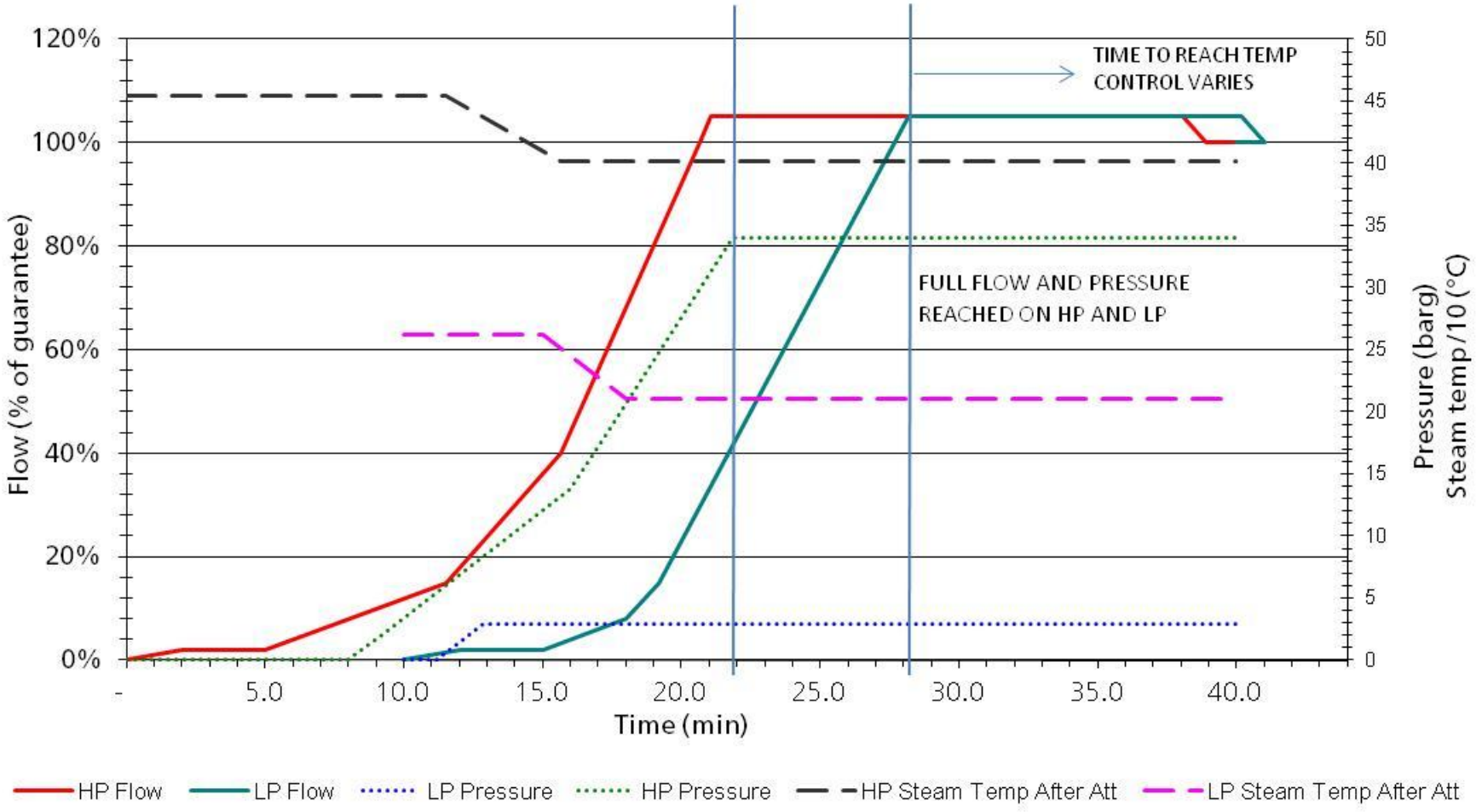
Typical OTSG P&ID



LM6000 (Typical)

OTSG Start-Up Curve

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



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Questions?