S1000 R
Surface Condensers
Standard Xchange Surface Condenser

History

• Ross offers 1\textsuperscript{st} all welded surface condenser in 1929.

• American Standard introduces pre-engineered S1000R in 1954.

• ITT Standard develops standard configuration capability for HVAC market in 2002.
Typical Steam Turbine Surface Condenser Application
First Function of Surface Condenser

• Create Vacuum

- Turbine exhaust pushes against atmospheric pressure without vacuum wasting energy.

- Creating vacuum at turbine exhaust reduces back pressure allowing more energy converted to power.

- The vacuum provides a greater pressure differential across the turbine hence more HP at same steam flow rate.
How is vacuum created.

- **Steam condensing to water**

  - Condensing steam into water greatly reduces occupied volume.

  - For ex. One pound of steam at atmospheric pressure and 212°F occupies 26 cu.ft. Cool the steam to 70°F condenses the steam to water and occupies 1/60th of a cubic foot.

  - For a fixed shape (Surface Condenser) the collapsing volume from steam to condensate creates a vacuum.
Steam Flow in Surface Condenser

• **Impingement**
  - Steam at high velocity carrying moisture particles is erosive.
  - Impingement plates direct impact of particles on tube surfaces reducing erosion.

• **Distribution**
  - Bundle design to facilitate proper steam flow to tube surfaces.
  - Controls steam flow to appropriate steam bundle velocities.
Condensate management

- Steam condensate return to boiler. Saves energy and money.

- Condensate collected in shell side hot well and provides NPSH available for pumping.

- Effective flow and removal of condensate required to maintain effective condensing surface area.
Liquid Level Control  For Surface Condenser

Condensate Control System

- Controls condensate level in hot well to provide adequate NPSH(a)

- Overboard and recirculation valves allows for continuous running of condensate pump with changing steam flow rates.
Surface Condenser Condensate Pumps

Condensate designed for vacuum service.

- Design hot well for positive gravity head of condensate NPSH(a) available and eliminate swirling.

- Design pump to minimize NPSH(r) required and air infiltration.

\[ NPSH_A = \left( \frac{p_i}{\rho g} + \frac{V_i^2}{2g} \right) - \frac{p_v}{\rho g} \]
Air Leakage and Removal

Air reduces vacuum

- Atmospheric pressure of 14.7 psia forces air into system under vacuum.

- Turbine packing.

- Piping gaskets and valves.

- Air in surface condenser blocks steam from tubes reducing condensation and loss of vacuum.

- Condenser needs air removal design features and vacuum pump.
Atmospheric Relief of Surface Condenser

Shell side designed for minimal positive pressure.

- Atmospheric relief valve opens with slight positive pressure.

- Protects condenser from over pressurization.

- Reseats itself.

- Water Sealed.
S1000 Surface Condenser Package

Benefits

- Eliminates costly field fabrication and assembly
- Pre-mounted accessories less likely to be lost.
- Designed by experienced mfg.
- Accessories properly installed.
Surface Condenser Interaction with Turbine

Economics Life Cycle Costing

- Balance performance of turbine with surface condenser.

- Optimize turbine discharge pressure with vacuum in surface condenser.

- Provides lowest combined first purchase and operating cost.
Thank you!