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Troubleshooting Steam Surface Condensers

HTS Forum

12 September 2012

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Steam Condenser Troubleshooting

- What is a steam surface condenser?
- Troubleshooting tools
- Is there a problem?
- Fault diagnosis
- Locating air leaks
- Condenser monitoring

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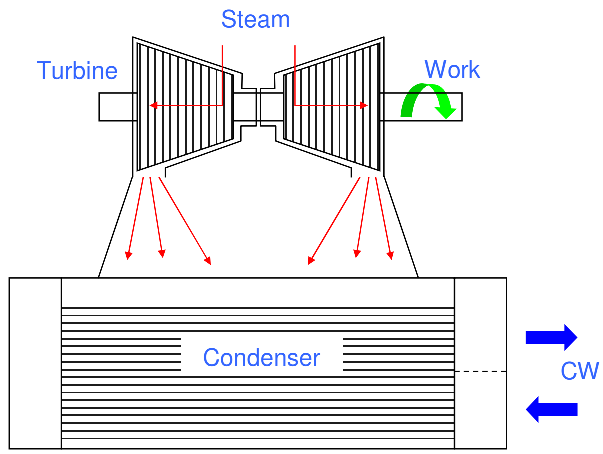
What is a Surface Condenser?



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What Does it Do?

- Condenses the exhaust steam
  - → Rejects the latent heat at the lowest practical temperature
    - → Condenses under vacuum
- By creating vacuum, the condenser increases the efficiency of the turbine
- The condenser also performs some other important functions

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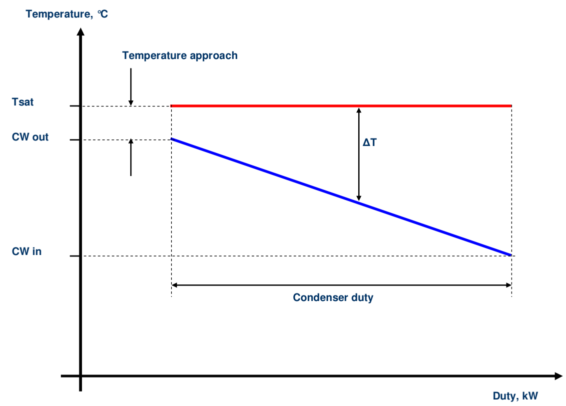
Condenser Temperature Profile



$Q = U\,A\,\Delta T$, if U and A are large, ΔT can be small → vacuum

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Typical Condensers

Round condenser
(up to about 3m diameter)

Rectangular condenser
(for larger units)

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Condenser Vacuum Pumps

- Condensers are provided with vacuum pumps/ejectors
- The condenser creates the vacuum, NOT the vacuum pump
- Vacuum pumps are there to extract air and pump it up to atmospheric pressure
- A startup ejector (“hogger”) is provided to create a rough vacuum in order to start the turbine

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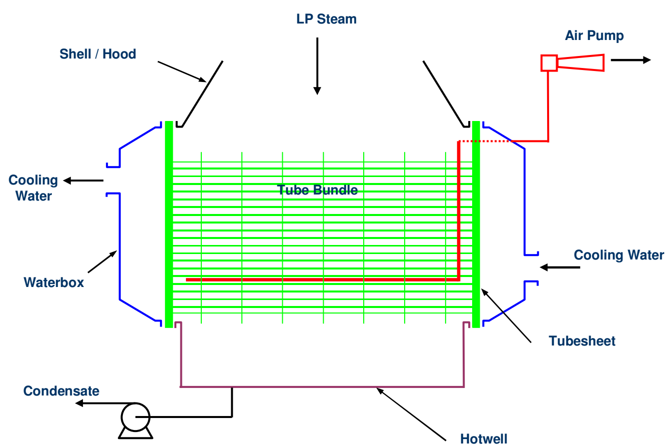
Condenser Venting



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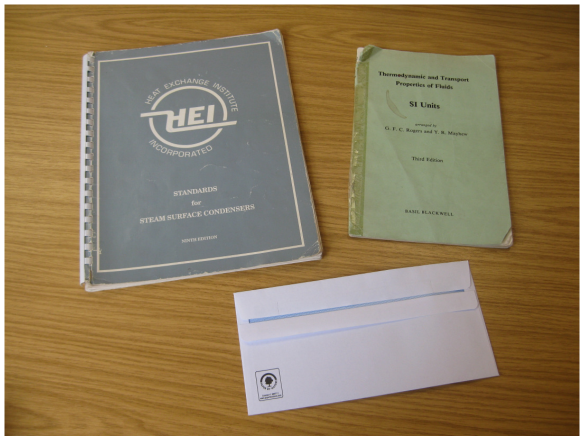
Troubleshooting Tools



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Is There a Problem?

- Plant operator is typically concerned about turbine exhaust pressure
- First task is to establish whether the exhaust pressure is higher than expected
- Two issues:
  - The plant measurement may not be accurate
  - The turbine exhaust pressure will naturally vary with plant load and CW temperature

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Case Study

6 x 660MW generating units, turbine exhaust pressure (kPa) by unit:

1	2	3	4	5	6
6.85	7.01	3.23	6.98	6.89	6.81

CW temperature = 25°C

Comments?

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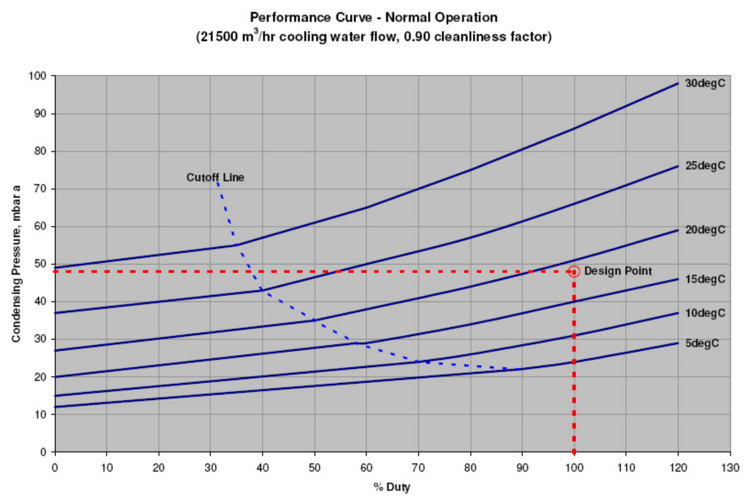
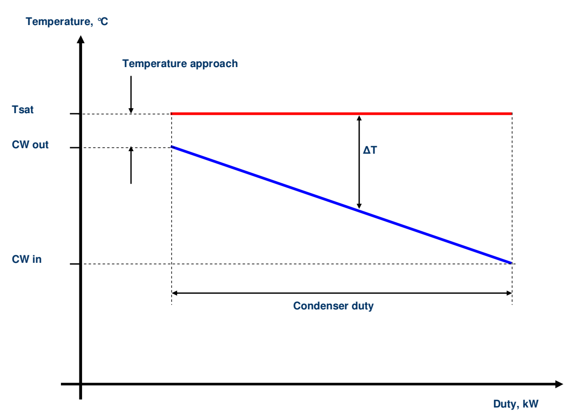
Condenser Performance Curve



Identifying Faults

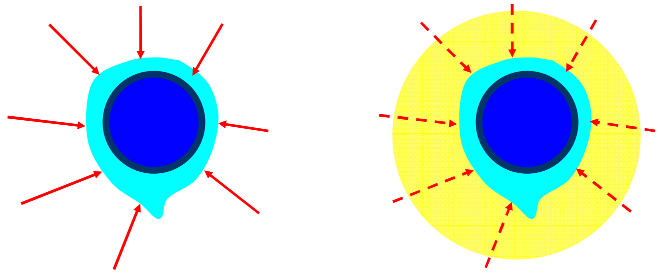
- Three most common causes of condenser performance problems:
  - Air accumulation in condenser
  - Cooling water fouling
  - Reduced cooling water flow
- Unfortunately, all have the same effect on condenser performance:
  - Increase in turbine exhaust pressure

Condenser Temperature Profile



What is the response to the three most common faults?

Effect of Air in Steam Space



- No air
- Steam condenses easily
- Minimal sub-cooling

- Air "blanket"
- Steam must diffuse
- Sub-cooling

The presence of air reduces the heat transfer rate

Fault Diagnosis

- To differentiate between the various causes of high turbine exhaust pressure, examine temperatures, not pressure:
  - CW flow reduction is indicated by increase in CW temperature rise
  - Fouling is indicated by increase in temperature approach (T_{sat} – CW_{out})
  - Air accumulation is indicated by increase in temperature approach *and* increased ΔT between T_{sat} and condensate temperature

Confirming and Fixing Faults

- Reduction in cooling water flow is caused by fouling or a pump fault
- Fouling can be confirmed by inspection (most condensers have divided waterboxes)
- Air accumulation is a more complex issue
- For air to accumulate:
  - Vent rate too low (vacuum pump fault)
  - Ingress rate too high (air leak)

Vacuum Pump Faults

- Generally rare, although original specification may be deficient
- For LRVPs check seal water temperature
- For steam ejectors check motive steam pressure (too high or too low)
- Detailed troubleshooting outside scope of this presentation

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Air Leaks

- Some in-leakage is expected (hence the vacuum pump)
- Vacuum pump is usually over-specified (especially if to HEI Standard)
- Once excess capacity is used, any additional in-leakage will cause turbine exhaust pressure to rise
- Vacuum boundary must be maintained

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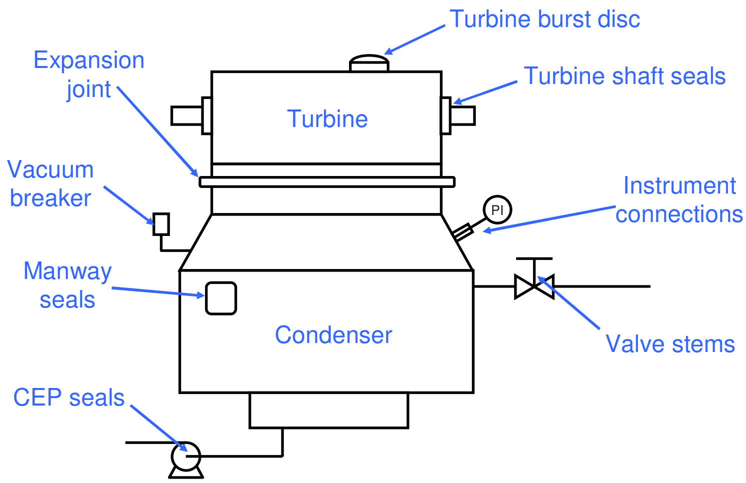
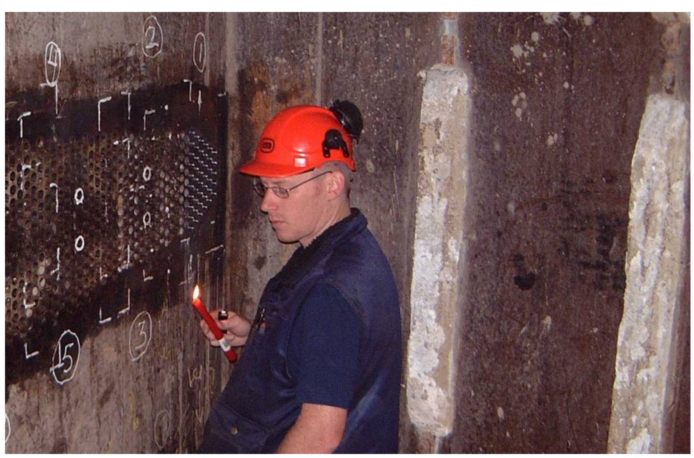
Air Leakage Points



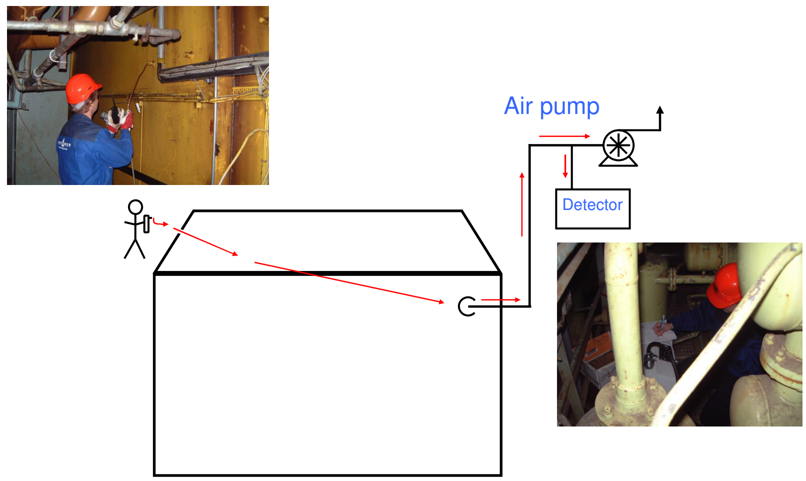
Air Leak Detection Methods

- Many methods exist
- Online methods:
  - Feathers / Smoke / Candles
  - Ultrasonics
  - Helium testing
  - Halogen testing
- Offline method – water fill test
- Online testing with tracer gases is the most successful approach

Traditional Methods?



Tracer Gas Testing



Tracer Gas Testing - Tips

- Always check the detector is working before you start
- Avoid false indications:
  - Helium: work from top to bottom
  - Halogen: work from bottom to top
  - Time the response
- Consider testing under low load conditions:
  - The vacuum boundary is more extensive at low loads

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Case Study

- 200MW electrical generation unit in Ireland
- High turbine exhaust pressure on startup after outage, close to turbine trip point
- Outage scope had included:
  - Condenser cleaning
  - LP turbine rotor removal
- Heat balance indicates full CW flow
- Hotwell temperature inconclusive

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Case Study - Actions

- Evidence suggests air leak
- High probability of leak at turbine shaft seals
- Helium testing ordered to confirm diagnosis:
  - Warranty issue
  - Shutdown required to repair
  - Which shaft seal is leaking?
  - Other leaks?

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Case Study - Results

- Leakage at both turbine shaft seals confirmed
- Additional leakage also found at:
  - Turbine bursting disc
  - Cracked weld on pipe
  - Plugged connection on condenser shell
- Resolution of non-shaft leaks moved turbine pressure away from trip point without shutdown

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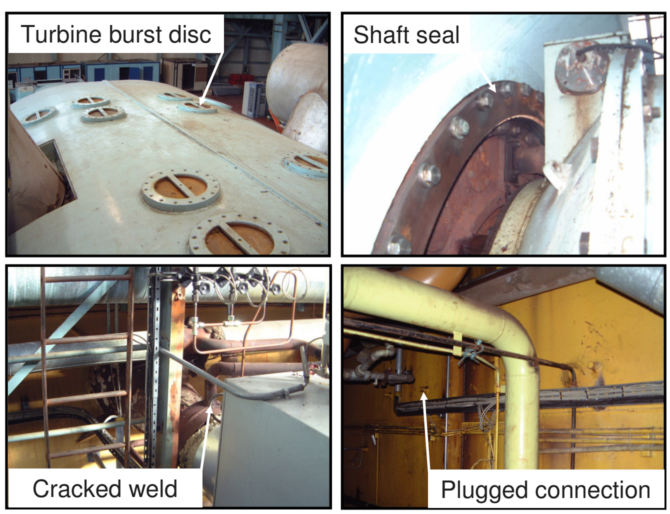
Leak Locations



Condenser Monitoring

- Critical situations can be avoided by regular monitoring
- Monitoring pressure not very useful
- Monitor key temperature differences:
  - (CW_{out} – CW_{in})
  - (T_{sat} – CW_{out})
  - (T_{sat} – $T_{hotwell}$)
- Perform vacuum decay testing
  - Isolate vacuum pump and measure rate of pressure increase