Steam Leakage
Quantification and Cost

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Steam leaks have a negative affect on steam plant operations.

- Energy losses
- Increase in Emissions
- Loss of reliability
- Production issues
- Safety

ENERGY LOSSES

- Energy losses can be as high as 19% (or even higher in a few cases) of the total steam energy production cost.
- $ 1,000,000.00 fuel cost for the boiler operation (yearly)
- $ 190,000.00 energy loss
STEAM LEAKAGE CORRECTION

- Has the greatest payback of all items in the steam system. Most leaks can be corrected without capital cost.
  - Great than:
    - Steam traps repair or replacement
      - Steam trap failure will typically only lose the latent energy – sensible energy is typically still recovered.
    - Insulation
    - Etc.

STEAM VS. COMPRESSED AIR

- Steam leak = $3,591.00
  - 100 psig
  - 1/8"
  - $10.00 per thousand lbs.
- Compressed air = $2,095.00
  - 100 psig
  - 1/8"
  - $0.05 per Kwh

ESTIMATING STEAM LEAKAGE

- Size of the leak diameter
  - Equation are based on a perfect orifice
- Steam pressure (P1)
- Downstream will always be atmospheric or zero (P2)
BASICS

\[ P_1 = ? \]

\[ P_2 = 0 \]

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BASICS OF LEAKAGE

- Leak will not be a perfect orifice
- A constant has to be used in the equation to compensate for this factor

\[ P_1 = ? \]

\[ P_2 = 0 \]

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BASICS

\[ P_1 = ? \]

\[ P_2 = 0 \]
Test results indicate not a significant difference between the plume when varying the orifice size. Pressure varying has a significant difference.

- Plume length is (highly) depended on pressure
- Volume is depended on orifice diameter and pressure

### 1/8" STEAM LEAKAGE

<table>
<thead>
<tr>
<th>Pressure</th>
<th>Steam Loss (pph)</th>
<th>Cost / Hour</th>
<th>Days / Year</th>
<th>Cost / Year</th>
</tr>
</thead>
<tbody>
<tr>
<td>250</td>
<td>94.6</td>
<td>0.95</td>
<td>365.00</td>
<td>$8,289.48</td>
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<tr>
<td>100</td>
<td>41.0</td>
<td>0.41</td>
<td>365.00</td>
<td>$3,591.93</td>
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<tr>
<td>70</td>
<td>30.3</td>
<td>0.30</td>
<td>365.00</td>
<td>$2,652.42</td>
</tr>
<tr>
<td>40</td>
<td>19.6</td>
<td>0.20</td>
<td>365.00</td>
<td>$1,712.91</td>
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<tr>
<td>30</td>
<td>16.0</td>
<td>0.16</td>
<td>365.00</td>
<td>$1,399.74</td>
</tr>
<tr>
<td>15</td>
<td>10.6</td>
<td>0.11</td>
<td>365.00</td>
<td>$929.99</td>
</tr>
<tr>
<td>5</td>
<td>7.0</td>
<td>0.07</td>
<td>365.00</td>
<td>$616.82</td>
</tr>
</tbody>
</table>
### 3/8" STEAM LEAK

<table>
<thead>
<tr>
<th>Pressure</th>
<th>Steam Loss (pph)</th>
<th>Cost / Hour</th>
<th>Days / Year</th>
<th>Cost / Year</th>
</tr>
</thead>
<tbody>
<tr>
<td>300</td>
<td>311.7</td>
<td>8.52</td>
<td>365.00</td>
<td>$74,605.36</td>
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<tr>
<td>100</td>
<td>169.0</td>
<td>3.69</td>
<td>365.00</td>
<td>$32,327.41</td>
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<td>70</td>
<td>222.5</td>
<td>2.73</td>
<td>365.00</td>
<td>$25,871.82</td>
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<tr>
<td>40</td>
<td>176.0</td>
<td>1.76</td>
<td>365.00</td>
<td>$15,416.23</td>
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<tr>
<td>15</td>
<td>143.8</td>
<td>1.44</td>
<td>365.00</td>
<td>$12,597.70</td>
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<tr>
<td>5</td>
<td>63.4</td>
<td>0.65</td>
<td>365.00</td>
<td>$5,551.38</td>
</tr>
</tbody>
</table>

### CALCULATIONS

- A variation of the Napier equation for flow through a orifice
  - Many different variations
  - Most equations are very aggressive in the flow rates
- Steam Loss = 22.88 x Pa X D^2

- 22.88 is a constant (to compensate for imperfect orifice
- Pa (pressure absolute)
- D^2 (Diameter squared)

### Distance: 6'
- Valve size: ¾"
- Valve opening: 1/3
- ¼" leak
- Pressure: 140 psig
- Cost: $14,367.00
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Distance: 14"
Valve size: ½"
Valve opening: 3/4
3/16" leak
Pressure: 150
Cost: $11,605.00

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Distance: 40"
Leak: 3/16
Pressure: 250
Cost: $18,651.00

CRACKS IN LINES

Best guess

Extremely hard to determine diameter of the orifice
WHAT CAUSES STEAM LEAKS

- Piping/tubing
  - Connections
    - Threaded connections
      - Expansion and contraction
      - CO₂ corrosion
    - Erosion
  - Steam Component Failures
    - Valves
    - Steam traps
    - Etc.

THREADED CONNECTIONS

- Expansion and contraction from steam system start up and shut downs
- CO₂ Corrosion or carbonic acid
**CO₂ CORROSION**

- Leaks will be created by corrosion

**EROSION**

- A small leak today – will be a larger leak tomorrow
- Steam will wire draw or erode the material causing a larger leak

**EMISSIONS**

<table>
<thead>
<tr>
<th>Pollutant</th>
<th>Natural Gas</th>
<th>Oil</th>
<th>Coal</th>
</tr>
</thead>
<tbody>
<tr>
<td>Carbon Dioxide</td>
<td>117,000</td>
<td>164,000</td>
<td>209,000</td>
</tr>
<tr>
<td>Carbon Monoxide</td>
<td>40</td>
<td>30</td>
<td>260</td>
</tr>
<tr>
<td>Nitrogen Oxides</td>
<td>92</td>
<td>446</td>
<td>457</td>
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<tr>
<td>Sulfur Dioxide</td>
<td>1</td>
<td>1,122</td>
<td>2,591</td>
</tr>
<tr>
<td>Particulates</td>
<td>7</td>
<td>84</td>
<td>2,744</td>
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<tr>
<td>Mercury</td>
<td>0.000</td>
<td>0.007</td>
<td>0.015</td>
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</tbody>
</table>

(Source: EPA - Natural Gas Street and Trends 1999)
RELIABILITY

- Valve selections
  - Isolation valves are purchased already have internal leakage occurring
  - Packing on standard valves

VALVE PACKING PROBLEMS

- Valve failure causes issues with productions areas
VALVE FAILURES

• Leaks will create pressure loss in the system

• Lower pressures = lower temperatures, which create problems in the tracer system

PRODUCTION ISSUES

SAFETY

• Steam will create safety issues
  - Personnel injury
    • Burns
  - Fog conditions (visibility)
  - Steam condenses to condensate – creates water in the air
  - Colder climates – the condensate will freeze and cause a hazard condition
SOLUTIONS TO PREVENT STEAM LEAKAGE

- NO. 1 CHANGE MUST OCCUR

- Product selection
- System design
- Installation design
- Operation
  - SOP’s
- Root cause analysis has to be part of the program

SOLUTIONS TO PREVENT STEAM LEAKAGE

- NO. 1 CHANGE MUST OCCUR

- Tube connectors and welded joints vs. threaded connections
- Valves that will eliminate packing leakage
- Valves that do not excessive leak internally
- Stainless steel vs. carbon steel

Tubing vs. Threaded Systems

- Tubing/tubing connectors
  - Eliminate threaded connections
  - Threads are used so the plant does not have to weld
STEAM LOSSES

- We can no longer accept steam losses
TODAY'S STEAM SYSTEM OPERATIONS

- No steam leaks
- No steam loss to atmosphere

Swagelok Energy Advisors

Mission Statement
Provide world class energy services to help Swagelok customers optimize their in-plant steam and condensate operations.

World-Class Services
- Standardized training programs
- Customized training programs
- In-plant steam system audits
- Steam and condensate system design
- Project management and consulting services
- Engineering Support Services

End