Section I: Boiler Safety Valve Sizing & Selection

[Diagram of boiler system with numbered parts and arrows indicating flow directions]

- 1: Furnace
- 2: Drum
- 3: Superheater Outlet
- 4: Turbine
- 5: Condenser
- 6: Condensate Pump
- 7: Boiler Feed Water Pump
- 8: Cold Reheat Inlet
- 9: Hot Reheat Outlet

23 and 24 January 2007
Total Relieving Capacity of all Code valves must be equal to or greater than the maximum continuous rating of the boiler (Drum & SHO) or reheater (RHO & RHI).
Steam Drum Valves must relieve a minimum of 75% of boiler capacity.
Basic Section I Sizing Rules

- Low set drum valve set at design pressure
- Other valves shall have staggered settings
- Not permitted to rise more than 6% above MAWP, taking into account 3% accumulation

All valves open/full flowing: 106%

Low Set Drum Valve open/full flowing (High Set Drum Valve set pressure): 103%

Design Pressure (MAWP) (Low Set Drum Valve set pressure): 100%
Sizing

• Basic Section I Sizing Rules
  • Superheater outlet safety valve must be set to insure opening prior to drum safeties
Data Needed to Properly Select Boiler Safety Valve Set

- Total Boiler Capacity
- Maximum Allowable Working Pressure (MAWP)
- Drum Operating pressure
- Superheater Operating Pressure
- Superheater Operating Temperature

For Units with Reheaters:

- Capacity
- MAWP
- Inlet Operating Pressure
- Inlet Temperature
- Outlet Operating Pressure
- Outlet Operating Temperature
Sizing

• To determine SHO Safety Valve Set Pressure, the pressure drop through the superheater must be considered:
  • To determine the pressure drop:
    • Drum Operating Pressure
    • Less SHO operating pressure

\[ \text{Superheater Pressure Drop} = \text{Drum Operating Pressure} - \text{Less SHO operating pressure} \]
Sizing

• Superheater SV Set Pressure is then determined by:
  • Design Pressure
  • Less SHO pressure drop
  • Less 20 PSIG safety factor*

= Superheater Set Pressure
## Application: Recommended Valve Selection

<table>
<thead>
<tr>
<th>System</th>
<th>15-600 (psig)</th>
<th>601-2000 (psig)</th>
<th>2001-3000 (psig)</th>
</tr>
</thead>
<tbody>
<tr>
<td>DRUM</td>
<td>HSJ/HL</td>
<td>HCI</td>
<td>HE</td>
</tr>
<tr>
<td>SUPERHEAT OUTLET</td>
<td>HSJ/HL</td>
<td>HCI</td>
<td>HCI</td>
</tr>
<tr>
<td>REHEATER OUTLET</td>
<td>HSJ/HL</td>
<td>HCI</td>
<td>HCI</td>
</tr>
<tr>
<td>REHEATER INLET</td>
<td>HSJ/HL</td>
<td>HCI</td>
<td>HCI</td>
</tr>
</tbody>
</table>

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Boiler Specifications

Total steam generation: 813,036 lbs/hr
Design Pressure: 2190 psig
Drum Operating Pressure: 2018 psig
SHO Operating Pressure: 1948 psig
SHO Design Temp: 1064°F
SHO Operating Temp: 1054°F
ASME Code Requirements

- Drum valves must relieve a minimum of 75% of total required relieving capacity.
- Two drum valves typically required.
Drum Safety Valves Capacity

• To determine minimum flow through all drum valves:
  \[ 813,036 \text{ lbs/hr} \times 0.75 = 609,777 \text{ lbs/hr} \]

• Approximate flow through each valve:
  \[ 609,777 \div 2 = 304,888.5 \text{ lbs/hr (per valve)} \]
Drum Safety Valves Set Pressures

- To determine drum valve set pressures:
  - Low set valve = 2190 psig (design pressure)
  - High set valve = 2254 psig (design pressure x 1.03)
Valve Capacity

• Saturated steam capacities (Catalog CROMC-0295):
  Smallest valve to flow approximately 304,888 lbs/hr – K2 orifice
• Low set drum K2 orifice-
  2190 psig @ sat steam  274,145 lbs/hr
• High set drum M orifice-
  2254 psig @ sat steam  401,428 lbs/hr

• Total through both valves:  675,573 lbs/hr
SHO Valve Capacity

• The balance of the total required capacity must pass through the superheater outlet safety valve (typically between 15% - 25% of total capacity).
SHO Valve Capacity

• Minimum SH Outlet Valve flow for this example:

  Total required capacity: 813,036 lbs/hr
  Less total drum valve capacity: 675,573 lbs/hr
  Minimum SH capacity: 137,463 lbs/hr
SHO Valve Set Pressure

• To determine Superheater Outlet Valve Set Pressure, the pressure drop through the superheater must be considered:

To determine the pressure drop:

Drum operating pressure:  2018 psig
Less SH outlet operating pressure:  - 1948 psig

Superheater pressure drop:  70 psig

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SHO Valve Set Pressure

- Set Pressure is then determined by:
  - Design pressure: 2190 psig
  - Less SH outlet pressure drop: -70 psig
  - Less safety factor*: -20 psig

  SHO valve set pressure: 2100 psig

* Safety factor provided by Crosby Engineering to ensure SHO safety valve opens first.
Valve Capacity

- Saturated Steam Capacities (Catalog CROMC-0295):
  Smallest valve to flow a minimum of 137,463 lbs/hr – K2 orifice
  SHO Safety Valve -
  2100 psig @ 1054°F*: 192,014 lbs/hr

* At set pressure, SHO operating temperature is above sat steam temperature, therefore K2 saturated capacity is multiplied by correction factor (Ksh) is 0.736.
## Boiler Set Safety Valve selection

<table>
<thead>
<tr>
<th>Location</th>
<th>Valve Size</th>
<th>Valve Model</th>
<th>Set Pressure (PSIG)</th>
<th>Temp (F)</th>
<th>Capacity (Lbs/Hr)</th>
<th>% of Total Capacity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low Set Drum Safety Valve</td>
<td>2-1/2 K2 6</td>
<td>HE-86</td>
<td>2190 PSIG</td>
<td>Sat. Steam</td>
<td>274,145 Lbs/Hr</td>
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<tr>
<td>High Set Drum Safety Valve</td>
<td>3 M 6</td>
<td>HE-86</td>
<td>2254 PSIG</td>
<td>Sat. Steam</td>
<td>401,428 Lbs/Hr</td>
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<tr>
<td>Total Flow thru Drum SV’s</td>
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<td></td>
<td></td>
<td></td>
<td>675,573 Lbs/Hr</td>
<td>83.1%</td>
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<tr>
<td>SHO Outlet Safety Valve</td>
<td>2-1/2 K2 6</td>
<td>HCI-99</td>
<td>2100 PSIG</td>
<td>1054F</td>
<td>192,014 Lbs/Hr</td>
<td>23.6%</td>
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<tr>
<td>Total Flow thru all SV’s</td>
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<td></td>
<td></td>
<td></td>
<td>867,587 Lbs/Hr</td>
<td>106.7% of MCR</td>
</tr>
</tbody>
</table>
Safety Valve Sizing & Selection

- Boiler Set Sizing Program
  - Available September 2007
    - Datasheets / Calculation Sheets
    - Marketing-linked catalog pdf’s
    - Reaction Forces
    - Noise Calculations