Boiler Control
Blowdown and TDS control
& Heat recovery
Two types of boiler blowdown

- **Sludge (or bottom) Blowdown**
  - Build up of sludge at bottom
  - Feed water + impurities (salts) + Chemicals + Solids

- **Salts (or TDS) Blowdown**
  - Build up of solids in the water
  - Pure Steam to Plant

Pure Steam to Plant

Salts (or TDS) Blowdown

Sludge (or bottom) Blowdown
TDS Blowdown

• **TDS (Total Dissolved Solids).**
• **TDS is the dissolved solids in boiler water exists because of the chemical treatment of the boiler.**
• **As a boiler generates steam, any impurities which are in the boiler feedwater and which do not boil off with the steam will concentrate in the boiler water.**
• **TDS may be expressed in a number of different units.**
Comparison of units used to measure TDS

<table>
<thead>
<tr>
<th>Total dissolved solids ppm</th>
<th>Conductivity (μS/cm)</th>
<th>Relative density at 15.5°C</th>
<th>Degrees Baume °Be</th>
<th>Degrees Treadwell °Tw</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Neutalised</td>
<td>Unneutralised</td>
<td></td>
<td></td>
</tr>
<tr>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1.0000</td>
<td>0.000</td>
</tr>
<tr>
<td>200</td>
<td>285</td>
<td>400</td>
<td>1.0018</td>
<td>0.026</td>
</tr>
<tr>
<td>400</td>
<td>571</td>
<td>800</td>
<td>1.0036</td>
<td>0.062</td>
</tr>
<tr>
<td>600</td>
<td>857</td>
<td>1200</td>
<td>1.0055</td>
<td>0.079</td>
</tr>
<tr>
<td>800</td>
<td>1 143</td>
<td>1 600</td>
<td>1.0073</td>
<td>0.105</td>
</tr>
<tr>
<td>1 000</td>
<td>1 429</td>
<td>2 000</td>
<td>1.0091</td>
<td>0.131</td>
</tr>
<tr>
<td>1 200</td>
<td>1 714</td>
<td>2 400</td>
<td>1.0109</td>
<td>0.157</td>
</tr>
<tr>
<td>1 400</td>
<td>2 000</td>
<td>2 800</td>
<td>1.0127</td>
<td>0.184</td>
</tr>
<tr>
<td>1 600</td>
<td>2 285</td>
<td>3 200</td>
<td>1.0145</td>
<td>0.210</td>
</tr>
<tr>
<td>1 800</td>
<td>2 571</td>
<td>3 600</td>
<td>1.0164</td>
<td>0.236</td>
</tr>
<tr>
<td>2 000</td>
<td>2 857</td>
<td>4 000</td>
<td>1.0182</td>
<td>0.262</td>
</tr>
<tr>
<td>2 200</td>
<td>3 143</td>
<td>4 400</td>
<td>1.0200</td>
<td>0.289</td>
</tr>
<tr>
<td>2 400</td>
<td>3 429</td>
<td>4 800</td>
<td>1.0218</td>
<td>0.315</td>
</tr>
<tr>
<td>2 600</td>
<td>3 714</td>
<td>5 200</td>
<td>1.0236</td>
<td>0.341</td>
</tr>
<tr>
<td>2 800</td>
<td>4 000</td>
<td>5 600</td>
<td>1.0255</td>
<td>0.367</td>
</tr>
<tr>
<td>3 000</td>
<td>4 285</td>
<td>6 000</td>
<td>1.0273</td>
<td>0.393</td>
</tr>
<tr>
<td>3 200</td>
<td>4 571</td>
<td>6 400</td>
<td>1.0291</td>
<td>0.420</td>
</tr>
<tr>
<td>3 400</td>
<td>4 857</td>
<td>6 800</td>
<td>1.0309</td>
<td>0.446</td>
</tr>
<tr>
<td>3 600</td>
<td>5 143</td>
<td>7 200</td>
<td>1.0327</td>
<td>0.472</td>
</tr>
<tr>
<td>3 800</td>
<td>5 429</td>
<td>7 600</td>
<td>1.0345</td>
<td>0.498</td>
</tr>
<tr>
<td>4 000</td>
<td>5 714</td>
<td>8 000</td>
<td>1.0364</td>
<td>0.525</td>
</tr>
<tr>
<td>4 200</td>
<td>6 000</td>
<td>8 400</td>
<td>1.0382</td>
<td>0.551</td>
</tr>
<tr>
<td>4 400</td>
<td>6 285</td>
<td>8 800</td>
<td>1.0400</td>
<td>0.577</td>
</tr>
<tr>
<td>4 600</td>
<td>6 571</td>
<td>9 200</td>
<td>1.0418</td>
<td>0.603</td>
</tr>
<tr>
<td>4 800</td>
<td>6 857</td>
<td>9 600</td>
<td>1.0436</td>
<td>0.630</td>
</tr>
<tr>
<td>5 000</td>
<td>7 143</td>
<td>10 000</td>
<td>1.0455</td>
<td>0.656</td>
</tr>
<tr>
<td>5 200</td>
<td>7 429</td>
<td>10 400</td>
<td>1.0473</td>
<td>0.682</td>
</tr>
<tr>
<td>5 400</td>
<td>7 714</td>
<td>10 800</td>
<td>1.0491</td>
<td>0.708</td>
</tr>
<tr>
<td>5 600</td>
<td>8 000</td>
<td>11 200</td>
<td>1.0509</td>
<td>0.735</td>
</tr>
<tr>
<td>5 800</td>
<td>8 285</td>
<td>11 600</td>
<td>1.0527</td>
<td>0.761</td>
</tr>
<tr>
<td>6 000</td>
<td>8 571</td>
<td>12 000</td>
<td>1.0545</td>
<td>0.787</td>
</tr>
<tr>
<td>6 200</td>
<td>8 857</td>
<td>12 400</td>
<td>1.0564</td>
<td>0.813</td>
</tr>
</tbody>
</table>
The effect of Too High TDS in the boiler

- High TDS and/or suspended solids
- Contamination of control valve
- Fouling of heat exchanger
- Blockage of steam trap
Boiler water with too low TDS

• Means Excessive blowdown and waste of energy
Deciding the required boiler water TDS

<table>
<thead>
<tr>
<th>Boiler type</th>
<th>Maximum TDS (ppm)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Lancashire</strong></td>
<td>10 000</td>
</tr>
<tr>
<td><strong>Two-pass economic</strong></td>
<td>4 500</td>
</tr>
<tr>
<td><strong>Packaged and three-pass economic</strong></td>
<td>3 000 to 3 500</td>
</tr>
<tr>
<td><strong>Low pressure water-tube</strong></td>
<td>2 000 to 3 000</td>
</tr>
<tr>
<td><strong>Medium pressure water-tube</strong></td>
<td>1 500</td>
</tr>
<tr>
<td><strong>High pressure water-tube</strong></td>
<td>1 000</td>
</tr>
</tbody>
</table>
Calculating Blowdown quantity

Let:

\[ F = \text{Feed water TDS (ppm)} \]
\[ S = \text{Steam generation rate (kg/h)} \]
\[ B = \text{Required boiler water TDS (ppm)} \]

Amount to be blowdown

\[ \frac{F \times S}{B - F} \]
Blowdown calculation - example

10,000 Kg/hr Steam to plant

Feed water with 250 ppm impurities

Maximum allowable boiler TDS = 2,500 ppm
Blowdown calculation

F = Feed water TDS (ppm) = 250 ppm
S = Steam generation rate (kg/h) = 2 500 ppm
B = Required boiler water TDS (ppm) = 10 000 kg/hr

Amount to be blowndown

\[
\frac{F \times S}{B - F} = \frac{250 \times 10 000}{2500 - 250}
\]

\[
= 1 111 \text{ kg/h or 11%}
\]
Blowdown valves

**Orifice Plate**

- Blowdown from boiler
- Orifice plate

**Continuous blowdown**

- Needle
- Valve movement to control the flowrate

**Radial Staged nozzle valve**

- Flow in
- Pressure dropped in stages
- Flow out
- Adjustment
Manual Blowdown

![Graph showing Boiler Water TDS over Time in Hours]

- **Maximum Allowable TDS**
- **Average TDS**

**X-axis:** Time in Hours

**Y-axis:** Boiler Water TDS
Automatic blowdown control system
Automatic TDS control

Boiler Water TDS

Time in Hours

Maximum Allowable TDS

Average TDS
Automatic TDS control Systems

• Maintain the boiler TDS near the maximum allowable to minimize heat losses and water treatment costs.
• Prevent to high TDS which would cause dirty steam, product contamination and blocked steam traps.
• Help to maintain a clean boiler without scale by ensuring predictable water conditions which can be correctly treated.
• Provide these advantages with the minimum of manual attention.
Sample Cooler
The effect of pH

• Acids and Alkalis have the effect of increasing the conductivity of water above that of a neutral sample.

• Boiler water is normally maintained Alkaline (pH 9-11) in order to prevent corrosion of the boiler and this has the effect of increasing the conductivity of the water.
Neutralizing the sample

Phenolphthalein added to make the sample alkaline.
• the sample turns pink.

Add acetic acid.
• The sample just turns clear at neutral pH.
Electric conductivity

The TDS in ppm is approximately:

\[(\text{conductivity in mS/cm}) \times 0.7\]

Notes:

• This relationship is only valid for a neutral sample at 25°C

• 1 degree C error in temperature = 2% error in reading – hence the reference temperature of 25°C
Manual Bottom Blowdown
Timed controlled Bottom Blowdown

Valve with pneumatic actuator

Timer
Blowdown Pit

 Blowdown from Boiler

 Overflow

 Standing Water Drain
Blowdown tank arrangement
Multi boiler blowdown
Heat recovery from TDS Blowdown
Recovering flash steam

Liquid Enthalpy at 10 bar = 782 KJ/Kg
Liquid Enthalpy at 0.5 bar = 468 KJ/Kg
Excess Enthalpy = 314 KJ/Kg

Excess energy = \( \frac{314 \text{ KJ/Kg}}{2226 \text{ KJ/Kg}} \)

2226 is the enthalpy of evaporation at 0.5 bar g

\( \frac{314 \text{ KJ/Kg}}{2226 \text{ KJ/Kg}} = 0.141 \text{Kg of flash/kg of blowdown or 14%} \)
Recovering flash steam

Amount of flash steam

= 1111 Kg/h x 14.1 %
= 157 kg/h (0.0435 kg/s)

Energy in steam

= 2 694 KJ/Kg

Total Energy in flash steam

= 0.0435 x 2 694
= 117 KW
Flash Vessel

Blowdown from boiler

Flash Steam

Contaminated water
Using the flash steam
Recovering heat from boiler blowdown

1111 Kg/h of boiler have been blown down

- 157 Kg/h has been flashed off and used to heat the feed tank contents.
- The remaining water, 1111 – 157 kg/h = 954 kg/h at 111 C is being directed to waste.

Energy recovered by cooling to 20 C

\[ = 0.265 \text{ kg/s} \times (111-20) \times 4.186 \]
\[ = 100 \text{ KW} \]
Total Energy recovered

From flash steam
• 117 KW

From water
• 100 KW

Total energy recovered:
• 117+100 KW = 217 KW

Total Energy blowdown
• 241 KW

• % energy recovered = (217/241)x 100 % = 90%