Best Practice in Boiler Water Treatment

Boiler Water Treatment Part 2 – Internal Treatment

Objectives of Internal Water Treatment

1 – To control the level of total dissolved solids (TDS) within the boiler

As water is boiled within the boiler and steam is produced, then the solids remain in the water and concentrate. Thus, over time the level of total dissolved solids (TDS) increases. Further evaporation causes these dissolved solids to come out of solution, and to produce suspended solids (sludge). As the dissolved solids increase there is a risk of ‘carry over’ of boiler water into the steam. It is therefore extremely important to control the level of Total Dissolved Solids. This is achieved by either continuous or intermittent blow down. Manual bottom blow down through the main bottom blow down valve should still be carried out at regular intervals to remove sludge.
How to calculate the required blowdown rate of a boiler

Blowdown rate = \( \frac{F 	imes S}{B - F} \)

Where:
- \( F \) = Feed tank TDS in ppm
- \( S \) = Actual boiler steam production in kg/hr
- \( B \) = Maximum TDS allowed in the boiler in ppm

For example:

To keep a steam boiler producing 4000 kg/hr of steam below 3500 ppm TDS when fed from a feed tank having a TDS of 80ppm, it will need to blowdown at least;

\[
\begin{align*}
F &= 80 \text{ ppm} \\
S &= 4000 \text{ kg/hr} \\
B &= 3500 \text{ ppm}
\end{align*}
\]

\[
\frac{80 \times 4000}{3500 - 80} = 93.6 \text{ kg/hr}
\]

Typical permissible levels of boiler water TDS

<table>
<thead>
<tr>
<th>Type of Boiler</th>
<th>TDS level in parts per million (ppm)</th>
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</thead>
<tbody>
<tr>
<td>Water tube – High Pressure</td>
<td>1,000</td>
</tr>
<tr>
<td>Vertical shell</td>
<td>2,500</td>
</tr>
<tr>
<td>Modern packaged 3 pass</td>
<td>3,000</td>
</tr>
<tr>
<td>Older economic 2 pass</td>
<td>4,500</td>
</tr>
<tr>
<td>Water tube – Low Pressure</td>
<td>5,000</td>
</tr>
<tr>
<td>Lancashire</td>
<td>10,000</td>
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</tbody>
</table>

2 – To prevent corrosion

This is achieved by keeping a controlled level of alkalinity in the boiler at all times, and by removing oxygen by de-aeration in the boiler feed tank. In most cases an oxygen scavenger will also be used. The most common types of oxygen scavenger are sodium sulphite and sodium bisulphite, other organic chemicals may also be used.
3 – To control deposition

Any deposits in the boiler can only come from the feed water. Control of the deposits is of high importance to maintain the efficiency of the heat exchange surfaces within the boiler. The heat conductivity of scale is about 100th of that of steel. Temperature increases in furnace tubes could eventually lead to tubes becoming deformed or distorted. The two main methods of deposition control are by either carbonate or phosphate control.

Methods of Chemical Dosing

The method for dosing the treatment chemicals will depend on the function of the chemicals, the quality of the feed water and the individual boiler.

Pumps used for dosing should be of sufficient capacity, be able to supply against the line pressure, and be resistant to the chemicals employed.

Water quality for on-site mixing of chemicals should be base exchanged softened as a minimum, and warmed to remove as much oxygen as possible.

Chemical dosing should be continuous and proportional to the feed water flow rate.
Types of Chemicals Used in Boiler Water Treatment

**Oxygen Scavengers**

These should always be dosed continuously. The point of injection should give sufficient time for the reaction to take place, if a de-aerator is fitted, then the outlet of the de-aerator is a suitable point. If no de-aerator is fitted, then a point close to the bottom of the feed tank would be suitable. **Do not** mix sodium sulphite or sodium bisulphite with other chemicals. **Always** use stainless steel or plastic dosing lines and stainless steel injection quills.

**Neutralising Amines**

Neutralising amines are used to prevent condensate corrosion by reacting with any carbon dioxide in the steam, and preventing the formation of carbonic acid. They should only be dosed at the storage side of a de-aerator, the suction side of the boiler feed pump, or into the boiler feed tank, if it is well covered.

**Phosphates**

Phosphates are used to reduce the level of scale deposition within the boiler. Phosphates can be dosed continuously or intermittently. Where an economiser or feed water pre-heater is used they should be dosed directly into the boiler shell, this is to prevent deposition on (and therefore overheating of) the heat transfer surfaces.

**Sludge Conditioners**

These chemicals are used to keep any precipitated salts in a mobile condition within the boiler shell, so that they can be removed by blowdown. These chemicals can normally be mixed with other chemicals, **but not** with sulphite/bisulphite, and generally do not require a separate dosing pump. They should be dosed continuously into a convenient point in the feed system.
Alkalinity Builders

These chemicals are used to raise the pH of the water within the boiler. In some circumstances the natural alkalinity of the feed water will be adequate to keep a high enough level of pH within the boiler. Generally these products should be dosed into the boiler feed tank, especially if sodium bisulphite is used, as this is acidic.

Generally it is desirable to have a slightly high pH for boiler feed water. Ideally the feed water should be in the range of pH 8.5 – 9.5. This ensures that free carbon dioxide within the system becomes ‘fixed’. If copper fed lines or heaters are used, restrict the feed water pH to a maximum of 9.2.

![Effect of Boiler pH Level on Corrosion](image)
General Guidance

- Wherever possible oxygen should be reduced as far as possible by pre-heating the feed water, before adding an oxygen scavenger.
- Feed water temperature should be above 70°C before the use of sulphite is considered.
- Dose oxygen scavenger into the feed tank to minimise pitting corrosion, and ensure that the tank is well vented to atmosphere, unless a de-aerator is fitted.

![Graph: The Effect of Temperature on the Oxygen Content of Water]

Recommended characteristics for the boiler:

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<table>
<thead>
<tr>
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<tbody>
<tr>
<td><strong>pH @ 25°C:</strong></td>
<td>10.5 – 12</td>
</tr>
<tr>
<td><strong>Suspended Solids:</strong></td>
<td>≤ 200 mg/kg</td>
</tr>
<tr>
<td><strong>Dissolved Solids @ 25°C (un-neutralized):</strong></td>
<td>≤ 3500 mg/kg</td>
</tr>
<tr>
<td><strong>M-Alkalinity (Total Alkalinity) to pH 4.5:</strong></td>
<td>≤ 1000 mg/kg CaCO₃</td>
</tr>
<tr>
<td><strong>Caustic Alkalinity (O or P₂ Alkalinity):</strong></td>
<td>≥ 350 mg/kg CaCO₃ &amp; 10 - 15% of TDS</td>
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<tr>
<td><strong>Phosphate:</strong></td>
<td>30 – 60 mg/kg PO₄</td>
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<tr>
<td><strong>Oxygen Scavenger:</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Sodium Sulphite:</strong></td>
<td>30 – 70 mg/kg</td>
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<tr>
<td><strong>Tannin:</strong></td>
<td>120 – 160 mg/kg</td>
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