**Excellent corrosion resistance**
The outer stainless layer Sandvik 310 (25Cr-20Ni) shows excellent corrosion resistance to various salts at metal temperatures up to 550°C (1022°F).

The inner component T22 (2/4Cr-1Mo) superheater tube, acting as load carrier, eliminates the risk for stress corrosion cracking from the steam side that may otherwise occur on solid stainless tube.

**Sandvik composite tube offer the following advantages:**
- Lower thermal expansion reduces system stresses
- Higher thermal conductivity lowers operating metal temperature, i.e. reduces corrosion
- Elimination of the risk of SCC, pitting and crevice corrosion at the water/steam side provides safer systems
- Joint welding of composite tubes with carbon-to-carbon or low alloy-to-low alloy welds means: proven reliability for long-term service, good structural stability, wider tolerances for achieving precise welds, elimination of high-alloyed joints
- Easier bending – the inner carbon steel or low alloy layer supports the outer stainless layer during bending.

**The established solution to fireside corrosion**

Composite tubes are since many years the established solution to fireside corrosion in Black Liquor Recovery Boilers (BLRB). The first installation from 1972 is still working and since then, the water walls of more than 300 boilers have been fitted with these tubes.

Closing of the pulp mill system places a great corrosion burden on the superheaters in BLRBs. Accumulated salts, some of which come from seawater floated logs, others from carbonates, chlorides and sulphates in the pulp chemicals, evaporate in the boiler and settle out on the superheater tubes. The deposits formed cause a corrosive environment, which corrodes the standard low alloy steels. Higher superheater temperatures often used today increase the risk of melting these deposits, leading to even greater metal loss and coincident risk of tube failure. Therefore, more corrosion resistant tubes are required.

To fight superheater corrosion Sandvik 310/T22 composite superheater tube was developed. For more corrosive conditions Sandvik has developed a more resistant composite tube product than 310/T22, namely Sandvik Sanicro 28 over inner layer T22 or T91.

**Good fabricability**
The metallurgical bond between the components assures the integrity of the tube during bending. Butt-welding to adjacent low alloy steel is done without difficulty. Similarly, Sandvik 310/T22 can easily be expanded or swaged to fit other tube sizes in an existing superheater.

**Plant experiences**
The first Sandvik 310/T22 installation was made in 1984 and the service experience in the same boiler is more than 10 years. Sandvik 310/T22 has been used successfully in a number of pulp mills. One case relates to a major Brazilian plant that experienced severe corrosion to the ordinary T11 superheater tubes, requiring regular re-tubing at high costs. Another case refers to a bark-fired boiler in Sweden, where T22 only lasted 1–2 years.

See also separate reference list.
Bending
Sandvik 310/T22 composite tubes can be cold or hot bent by the same methods as those used for single component tubes of T22. It is possible to hot bend to hairpins without losing the bond between the components. The hot bending should be performed preferably in the range of 850-1000°C (1562-1832°F) followed by tempering at 700-750°C (1292-1382°F) for 0.5-2h. An alternative is to hot bend in the range of 850-900°C (1562-1652°F) followed by both normalization annealing at 900-960°C (1652-1760°F) for 5-15min. and tempering at 700-750°C (1292-1382°F) for 0.5-2h.

Grades

Outside component
Sandvik 3RE28 (AISI 310, SS 2361, W.-Nr. 1.4845, EN 1.4845)

Inside component
Sandvik HT8 (ASME SA-213, SS 2218, W.-Nr. 1.7380, 10CrMo9-10, EN 1.7380)

Chemical compositions (nominal), %

<table>
<thead>
<tr>
<th></th>
<th>C</th>
<th>Si</th>
<th>Mn</th>
<th>Cr</th>
<th>Ni</th>
<th>Mo</th>
</tr>
</thead>
<tbody>
<tr>
<td>3RE28</td>
<td>≤0.08</td>
<td>0.4</td>
<td>1.8</td>
<td>25.5</td>
<td>21</td>
<td>–</td>
</tr>
<tr>
<td>HT8</td>
<td>0.10</td>
<td>0.3</td>
<td>0.5</td>
<td>2.3</td>
<td>–</td>
<td>1.0</td>
</tr>
</tbody>
</table>

Specifications
Sandvik tube specification 7-1-1169.
PED 97/23/EC
EN 10216-2, EN 12952-2 Annex C
ASME Section I and Section II, VD-TÜV Werkstoffblatt 541 03 2001

Dimensions, standard sizes in stock

<table>
<thead>
<tr>
<th>Outside diameter</th>
<th>Total minimum wall thickness</th>
<th>Thickness of stainless component</th>
<th>Minimum thickness of carbon steel component</th>
</tr>
</thead>
<tbody>
<tr>
<td>mm</td>
<td>mm</td>
<td>mm</td>
<td>mm</td>
</tr>
<tr>
<td>50.8</td>
<td>5.08</td>
<td>1.42</td>
<td>3.66</td>
</tr>
<tr>
<td>63.5</td>
<td>6.53</td>
<td>1.82</td>
<td>4.71</td>
</tr>
</tbody>
</table>

*) Other sizes can be produced upon request

Tolerances
Permissible variations in O.D. and wall thickness
Outside diameter  ± 0.5% but min.
                    ± 0.30 mm (+/- 0.012”)
Total wall thickness
<50.8 mm (2”)         +22%/-0
≥50.8 mm (2”)         +15%/-0

The thickness of the stainless steel component is checked by testing the entire length of each tube.

Bending
Sandvik 310/T22 composite tubes can be cold or hot bent by the same methods as those used for single component tubes of T22. It is possible to hot bend to hairpins without loosing the bond between the components. The hot bending should be performed preferably in the range of 850-1000°C (1562-1832°F) followed by tempering at 700-750°C (1292-1382°F) for 0.5-2h. An alternative is to hot bend in the range of 850-900°C (1562-1652°F) followed by both normalization annealing at 900-960°C (1652-1760°F) for 5-15min. and tempering at 700-750°C (1292-1382°F) for 0.5-2h.
Welding

Butt-welding

Sandvik 310/T22 composite tubes are commonly butt-welded to similar tubes or to ordinary T22 tubes. Welding of the composite tubes must be done with some care, since the melting point of the bonding zone is lower than the melting point of the stainless steel. If the bonding zone is exposed to too high heat flux, a local melting may occur. This is why the 310 layer is peeled back 5 mm during edge preparation.

In order to obtain the optimum corrosion resistance and mechanical properties of the welded joints the following edge preparation (Fig. 2) and welding sequence (Fig. 3) are recommended.

Figure 2. Edge preparation of a 310/T22 to T22 joint. The 310 layer should be peeled back approx. 5 mm and finished with a smooth chamfer to avoid notch effects.

Figure 3. Welding sequence.

Filler metals and welding methods

<table>
<thead>
<tr>
<th>Pass (Ref. to figure 3)</th>
<th>Welding method</th>
<th>Filler metals (Standardization)</th>
<th>Preheating temperature (^{1}) (\degree C) (\degree F)</th>
<th>Max heat input (^{2}) (kJ/mm) (kJ/in)</th>
<th>Max interpass temperature (\degree C) (\degree F)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Root run A</td>
<td>TIG/MIG</td>
<td>AWS 5.28 (ER90SB3)</td>
<td>200-300 (392-572)</td>
<td>2.5 (63)</td>
<td>250 (482)</td>
</tr>
<tr>
<td></td>
<td>MMA</td>
<td>SFA A 5.5 E9018-BSL</td>
<td>200-300 (392-572)</td>
<td>2.5 (63)</td>
<td>250 (482)</td>
</tr>
<tr>
<td>Filler run B</td>
<td>TIG/MIG</td>
<td>AWS 5.28 (ER90SB3)</td>
<td>200-300 (392-572)</td>
<td>2.5 (63)</td>
<td>250 (482)</td>
</tr>
<tr>
<td></td>
<td>MMA</td>
<td>SFA A 5.5 E9018-BSL</td>
<td>200-300 (392-572)</td>
<td>2.5 (63)</td>
<td>250 (482)</td>
</tr>
<tr>
<td>Top run C</td>
<td>TIG/MIG</td>
<td>Sandvik 25.20.L (Q-5.9”310L&quot;)</td>
<td>1.5 (38)</td>
<td>1.5 (38)</td>
<td>100 (212)</td>
</tr>
<tr>
<td></td>
<td>MMA</td>
<td>Sandvik 25.20.B(SFA 5.4 E310-15)</td>
<td>1.5 (38)</td>
<td>1.5 (38)</td>
<td>100 (212)</td>
</tr>
</tbody>
</table>

\(^{1}\) When TIG/MIG welding is used a lower preheating temperature may be applied provided it is proved to be satisfactory by procedure tests.

\(^{2}\) A higher max. heat input may be applied if the stainless peel off is increased.

If post weld heat treatment (PWHT) is considered necessary, the properties of both components must be considered. PWHT 700\(\degree C\)/30 min. (1292\(\degree F\)) followed by cooling in air is recommended.

Longitudinal welding

Superheater tubes are sometimes fixed to each other by welding. Sandvik 310/T22 tubes can be longitudinally welded to adjacent T22 tubes. The difference in thermal expansion is marginal, and will not affect the integrity of the joint. It is recommended to perform such welds by using MMA and an austenitic filler, type Sandvik 25.20.B (SFA 5.4 E310-15) or Sandvik Sanicro 71 (AWS A5.14-ER NiCrFe-3). If the metal temperature could exceed 600\(\degree C\) (1112\(\degree F\)) temporarily, Sanicro 72/71 is not advisable since sulphidation might become a problem.
**Thermal expansion/conductivity**

The values given below for composite tubes have been calculated on a typical 310 thickness of approx. 25% of total wall thickness (Fig. 4 and 5).

**Pressure ratings**

The design pressures pertinent to the stocked tube sizes, calculated according to ASME, are shown in Fig. 6.

**Quality Assurance**

Sandvik Materials Technology has Quality Management Systems approved by internationally recognized organizations. We hold for example: the ASME Quality System Certificate as a Materials Organization; approval to ISO 9001, QS-9000 and PED 97/23/EC, as well as approvals from LRQA, JIS, TÜV and others as a materials manufacturer.

**Environment**

Environmental awareness is an integral part of our business and is at the forefront of all activities within our operation. We hold approval to ISO 14001.

**Further information**

www.smt.sandvik.com/composite

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Recommendations are for guidance only, and the suitability of a material for a specific application can be confirmed only when we know the actual service conditions. Continuous development may necessitate changes in technical data without notice.