2507

High Strength Duplex Welded Stainless Tubular Products

Characteristics

Grade 2507 is a Molybdenum and Nitrogen alloyed Super-Duplex stainless steel with corrosion resistance in-line with the 6 Mo grades (e.g. 254 SMO®), and with a yield strength more than double that of austenitic stainless steels. It is also the strongest Duplex in welded tubular products.

Characteristic properties:
• High mechanical strength
• Good weldability
• Good corrosion resistance
• High resistance to Stress Corrosion Cracking (SCC)
• Good machinability
• Very good wear and abrasive resistance
• Low thermal expansion
• Good fatigue properties
• Temperature range -40°C to 250°C

Dimensions

2507 is considered a stock standard material for OSTP in selected production standards and dimension ranges.

Tubes, Pipes and Butt Weld Fittings
• OD: 21.3–1219.0 mm
• WT: 1.5–25.4 mm
• Lengths: up to 12 m

Tubes below 21.3 mm OD and tubes with wall thickness below 1.5 mm or length over 12 m on special request.

Standard Stock Dimension Range
• ANSI NPS 6–12” Sch 10S, ASTM A928 Class 3
• Fittings according to ASTM A815

Executions

Tubes, Pipes and Butt Weld Fittings
• Welded with- or without filler metal
• Unannealed, pickled
• Solution annealed and pickled
• With – or Without BCW (Bead Cold Work)
• Tubes Only
• Bevelled ends according to standards

Corrosion resistance

Grade 2507 possesses excellent resistance to general corrosion, SCC, pitting corrosion and high resistance to crevice corrosion. It has similar resistance to sea water as the 6 Mo grades, and has hence been widely used in sea water RO desalination. See Outokumpu Corrosion Handbook for more information.

Microstructure / Ferrite content

The balanced chemical composition of 2507 results in a microstructure containing approximately equal amount of ferrite and austenite in the microstructure after annealing in a temperature about 1050–1125°C. By determining the ferrite content in the weld, it is ensured that the welding and/or annealing has been done properly. The general opinion is that a too high ferrite content, i.e. >70% decreases the toughness and pitting resistance, and a too low ferrite content, i.e. <25% decreases the SCC-resistance.

Weld factor

<table>
<thead>
<tr>
<th>Type of weld process and NDT</th>
<th>EN 10217-7 / EN 10253-4</th>
<th>EN 10296-2 / EN 10253-3</th>
<th>A 789</th>
<th>A 790</th>
<th>A 928</th>
</tr>
</thead>
<tbody>
<tr>
<td>EFW, 100% ET</td>
<td>1.0</td>
<td>-</td>
<td>0.8</td>
<td>0.8</td>
<td>0.8</td>
</tr>
<tr>
<td>EFW, 100% RT</td>
<td>1.0</td>
<td>-</td>
<td>1.0</td>
<td>1.0</td>
<td>1.0</td>
</tr>
<tr>
<td>EFW, spot RT</td>
<td>-</td>
<td>0.85</td>
<td>0.85</td>
<td>0.85</td>
<td>0.85</td>
</tr>
<tr>
<td>EFW, double butt</td>
<td>-</td>
<td>0.7</td>
<td>0.85</td>
<td>0.85</td>
<td>0.85</td>
</tr>
<tr>
<td>EFW, single butt</td>
<td>-</td>
<td>0.7</td>
<td>0.8</td>
<td>0.8</td>
<td>-</td>
</tr>
</tbody>
</table>

EFW = Electric Fusion Welded
ET = Eddy Current Test
RT = Radiographic Test

The joint coefficient (z used in EN standards) or joint quality factor (Ej, used in ASME standards) is used for calculation of the wall thickness for welded tubes.

The type of welding process, amount and type of NDT decide the factor.

Chemical composition, % (Typical values)

<table>
<thead>
<tr>
<th>Outokumpu</th>
<th>EN</th>
<th>ASME/UNS</th>
<th>C</th>
<th>Cr</th>
<th>Ni</th>
<th>Mo</th>
<th>N</th>
<th>Others</th>
<th>PRE*</th>
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<tbody>
<tr>
<td>4307</td>
<td>1.4307</td>
<td>304L</td>
<td>0.02</td>
<td>18.1</td>
<td>8.1</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>18</td>
</tr>
<tr>
<td>4404</td>
<td>1.4404</td>
<td>316L</td>
<td>0.02</td>
<td>17.2</td>
<td>10.1</td>
<td>2.1</td>
<td>-</td>
<td>-</td>
<td>24</td>
</tr>
<tr>
<td>LDX 2101*</td>
<td>1.4162</td>
<td>S32101</td>
<td>0.03</td>
<td>21.5</td>
<td>1.5</td>
<td>0.3</td>
<td>0.22</td>
<td>5Mn</td>
<td>26</td>
</tr>
<tr>
<td>2304</td>
<td>1.4362</td>
<td>S32304</td>
<td>0.02</td>
<td>23</td>
<td>4.8</td>
<td>0.3</td>
<td>0.10</td>
<td>-</td>
<td>26</td>
</tr>
<tr>
<td>LDX 2404*</td>
<td>1.4662</td>
<td>S82441</td>
<td>0.02</td>
<td>24</td>
<td>3.6</td>
<td>1.6</td>
<td>0.27</td>
<td>3Mn</td>
<td>33</td>
</tr>
<tr>
<td>2205</td>
<td>1.4462</td>
<td>S32205**</td>
<td>0.02</td>
<td>22</td>
<td>5.7</td>
<td>3.1</td>
<td>0.17</td>
<td>-</td>
<td>35</td>
</tr>
<tr>
<td>2507</td>
<td>1.4410</td>
<td>S32750</td>
<td>0.02</td>
<td>25</td>
<td>7</td>
<td>4</td>
<td>0.27</td>
<td>-</td>
<td>41</td>
</tr>
</tbody>
</table>

* PRE = % Cr + 3.3% Mo + 16% N (The formula is used as a ranking tool to estimate pitting corrosion resistance in the material).
** Also available as S31803.

Product standards

Europe
• EN 10217-7: Welded steel tubes for pressure purposes
  – Technical delivery conditions
Part 7: Stainless steel tubes
• EN 10296-2: Welded circular steel tubes for mechanical and general engineering purposes
  – Technical delivery conditions
Part 2: Stainless steel
• EN 10253-3: Butt-welding pipe fittings
  Part 3: Wrought austenitic and austenitic-ferritic (Duplex) stainless steels without specific inspection requirements
• EN 10253-4: Butt-welding pipe fittings
  Part 4: Wrought austenitic and austenitic-ferritic (Duplex) stainless steels with specific inspection requirements

USA
• ASTM A 789: Seamless and Welded Ferritic/Austenitic Stainless Steel Tubing for General Service
• ASTM A 790: Seamless and Welded Ferritic/Austenitic Stainless Steel Pipes
• ASTM A 528: Seamless and Welded Ferritic/Austenitic Stainless Steel Pipe electric fusion welded with addition of filler metal
• ASTM A 815: Wrought Ferritic, Ferritic/Austenitic, and Martensitic Stainless Steel Piping Fittings

Pressure vessel requirements

Europe
The Pressure Equipment Directive PED regulates the use of welded SS pipe in most European countries. OSTP fulfills the Directive, and is an approved manufacturer of welded Duplex stainless steel tubes and fittings.

Outside Europe
Pressure vessel regulations are authorized to ASME. ASME Section II, Part D Table 2A, shows design values for tube and pipe. ASME B31.1 Power Piping and ASME B31.3 Process Piping state design for approved pipe material.

Norway
NORSOK is a Norwegian standard that regulates the use of materials in some offshore applications. OSTP is an approved manufacturer of Duplex UNS S32750 pipe and butt weld fittings based on NORSOK requirements.
Fabrication

Welding
Common welding methods for tubular products are:
- MMA, MIGW (Shielded Metal Arc Welding)
- TIG, GTAW (Gas Tungsten Arc Welding)
- MIG, MAG, GMAW (Gas Metal Arc Welding)
- FCAW (Flux-Cored Arc Welding)
- PAW (Plasma Arc Welding)
- SAW (Submerged Arc Welding)

The general recommendation for shielding and plasma gas is pure Argon (TIG/PAW). An addition of 1–2% nitrogen/purging gas the general recommendation is Formier improve the corrosion resistance in the weld. As backing gas is pure Argon (TIG/PAW). An addition of 1–2% nitrogen enhances the corrosion resistance of the weld. When material thickness requires more than one run, the interpass temperature has to be below 100°C. General filler recommendation for dual or multiple runs and interpass temperature will form within 1–2 minutes.

Heat treatment
Normal annealing temperature is 1050–1125°C followed by rapid cooling to at least 700°C. At temperatures between 800–950°C, intermetallic phases that impair the properties will form in 1–2 minutes.

Cold forming
The allowable design values are more than twice than for standard austenitic steels. This means that the possibility of designing thinner walls can save costs. Please use our Pressure Calculation Tool on www.ostp.biz, to discover the weight saving possibilities and other benefits of Outokumpu Duplex Stainless Steel.

General filler recommendation for Duplex stainless steels

<table>
<thead>
<tr>
<th>Outokumpu</th>
<th>EN</th>
<th>ASTM/UNS</th>
<th>Covered electrodes</th>
<th>Welding consumables</th>
<th>Wires</th>
</tr>
</thead>
<tbody>
<tr>
<td>LDX 2101**</td>
<td>1.4162</td>
<td>S32101</td>
<td>23 7 NL or 22 9 3 NL</td>
<td>ISO 14343</td>
<td>ISO 14172</td>
</tr>
<tr>
<td>LDX 2404**</td>
<td>1.4662</td>
<td>S82441</td>
<td>22 9 3 NL</td>
<td>22 9 3 NL</td>
<td>22 9 3 NL</td>
</tr>
<tr>
<td>LDX 2101*</td>
<td>1.4462</td>
<td>52205/S31803</td>
<td>22 9 3 NL</td>
<td>22 9 3 NL</td>
<td>22 9 3 NL</td>
</tr>
<tr>
<td>LDX 2404*</td>
<td>1.4410</td>
<td>S32750</td>
<td>25 9 4 NL</td>
<td>25 9 4 NL</td>
<td>25 9 4 NL</td>
</tr>
</tbody>
</table>

Applications
- Chloride containing environments
- Heat exchanger tubes
- Pipe systems within:
  - Hydrometallurgy
  - Chemical and Petrochemical
  - Desalination
  - Oil & Gas

Design
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Mechanical properties (At room temperature)

<table>
<thead>
<tr>
<th>Outokumpu</th>
<th>Min values acc. to EN 10028-7:2007</th>
<th>Min values according to ASTM A240-10</th>
</tr>
</thead>
<tbody>
<tr>
<td>P</td>
<td>H</td>
<td>C</td>
</tr>
<tr>
<td>4307</td>
<td>200</td>
<td>200</td>
</tr>
<tr>
<td>4404</td>
<td>220</td>
<td>220</td>
</tr>
<tr>
<td>LDX 2101*</td>
<td>450*</td>
<td>465*</td>
</tr>
<tr>
<td>LDX 2404*</td>
<td>480**</td>
<td>550**</td>
</tr>
<tr>
<td>2205</td>
<td>445/460</td>
<td>445/460</td>
</tr>
<tr>
<td>LDX 2404**</td>
<td>515/530</td>
<td>515/530</td>
</tr>
</tbody>
</table>

Physical properties

<table>
<thead>
<tr>
<th>Outokumpu</th>
<th>Density, g/cm³</th>
<th>Modulus of elasticity, GPa</th>
<th>Poisson’s ratio</th>
<th>Average linear expansion at RT - 100°C x10⁻⁶/°C</th>
</tr>
</thead>
<tbody>
<tr>
<td>P</td>
<td>H</td>
<td>C</td>
<td>P</td>
<td>H</td>
</tr>
<tr>
<td>4307</td>
<td>7.9</td>
<td>200</td>
<td>0.3</td>
<td>16.0</td>
</tr>
<tr>
<td>4404</td>
<td>8.0</td>
<td>200</td>
<td>0.3</td>
<td>13.0</td>
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<tr>
<td>LDX 2101*</td>
<td>7.8</td>
<td>200</td>
<td>0.3</td>
<td>13.0</td>
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<tr>
<td>LDX 2404**</td>
<td>7.7</td>
<td>205</td>
<td>0.3</td>
<td>10.0</td>
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<tr>
<td>2205</td>
<td>7.8</td>
<td>200</td>
<td>0.3</td>
<td>13.0</td>
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<tr>
<td>2507</td>
<td>7.8</td>
<td>200</td>
<td>0.3</td>
<td>13.0</td>
</tr>
</tbody>
</table>

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OSTP is a joint-venture between Tubinox and Outokumpu Group. OSTP manufactures the broadest range of stainless steel tubular products: