904L High Performance Austenitic Welded Stainless Tubular Products

Characteristics
Grade 904L is a Molybdenum and Copper alloyed Cr-Ni austenitic stainless steel with low Carbon content. The high performance austenitic stainless steels such as 904L have a fully austenitic micro-structure in the quench annealed condition.

Characteristic properties:
- Very good resistance to uniform corrosion
- Good to exceptionally good resistance to pitting and crevice corrosion
- Very good resistance to stress corrosion cracking
- Very good formability

Dimensions
Tubular products in grade 904L are not stock standard, but can be generally manufactured in most common standard sizes within OSTP’s product range and to client tailored needs by agreement.

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.

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 904L has a high corrosion resistance to a wide range of corrosive environments. A PRE of 35 indicates that the steel grade has good resistance to warm sea water and other high chloride environments. High nickel content results in a much better resistance to stress corrosion cracking than the standard austenitic grades. Copper enhances the corrosion resistance in certain acids, particularly in the very aggressive “mid concentration” range. In most environments 904L has a corrosion performance intermediate between the standard austenitic grade 316L and the very highly alloyed 6 Mo and similar “super austenitic” grades. See Outokumpu Corrosion Handbook for more information.

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 269: Seamless and Welded Austenitic Stainless Steel Tubing for General Service
- ASTM A 312: Seamless, Welded, and Heavily Cold Worked Austenitic Stainless Steel Pipes
- ASTM A 358: Electric-Fusion-Welded Austenitic Cr-Ni Stainless Steel Pipe for High-Temperature Service and General Applications
- ASTM A 774: As-welded wrought austenitic stainless steel fittings for general corrosive service at low and moderate temperatures
- ASTM A 403: Wrought austenitic stainless steel piping fittings

Pressure vessel requirements
Europe
The Pressure Equipment Directive (PED) regulates the use of stainless steel pipe and fittings in most European countries. OSTP fulfils the Directive, and is an approved manufacturer of welded stainless tubular products.

Outside Europe
Pressure vessel regulations are authorized to ASME. ASME Section VIII, Division 1, Table UHA-23, shows design values for tube and pipe manufactured and tested according to ASME SA-249 and SA-312 respectively. ASME B31.1 Power Piping and ASME B31.3 Process Piping prescribes design and design stress values for approved pipe materials.

Fabrication
Welding
Common welding methods for tubular products are:
- MMA, SMAW (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 shielded and plasma gas is pure Argon (TIG/PAW). Additions of 2–3% hydrogen H₂ and 2–3% nitrogen N₂ will improve the penetration and corrosion resistance. As backing/ purging gas the general recommendation is pure Argon or Former gas (90% N₂ and 10% H₂). When material thickness requires more than one run, the interpass temperature has to be below 100°C. General filler recommendation for steel grade 904L can be found in the table below. Welding without filler metal not followed by post heat treatment will reduce the corrosion resistance and is therefore not recommended. See Outokumpu Welding Handbook for more information.

Cold forming
Excellent cold forming properties. The same properties as for other standard austenitic stainless steels.

Hot forming
Grade 904L is slightly harder at higher temperatures than austenitic standard grades. Hot forming temperature range is 1150 - 850°C. If the hot forming is discontinued at a temperature above 1000°C and the material is quenched directly thereafter the material may be used without subsequent heat treatment. It is important that the entire workpiece has been quenched from temperatures above 100°C. In the case of partial heating or partial cooling below 1100°C or if the cooling has been too slow, hot working should always be followed by solution annealing and quenching.

Heat treatment
The normal solution annealing temperature is 1050–1140°C followed by rapid cooling to at least 700°C. At temperatures between 800–900°C, inter metallic phases that impair the properties will form within a few minutes.

Applications
- Process equipment in chemical industry
- Bleaching equipment in the pulp and paper industry
- Flue-gas cleaning
- Desalination
- Seawater handling
- Heat exchangers

Design
The allowable design values are similar to those for standard austenitic steels. Please use our Pressure Calculation Tool on www.ostp.biz for design purposes.
General filler recommendation for high performance austenitic stainless steels

<table>
<thead>
<tr>
<th>Outokumpu</th>
<th>EN</th>
<th>ASTM / UNS</th>
<th>Welding consumables</th>
<th>Wires</th>
<th>Coverage electrodes</th>
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<tbody>
<tr>
<td>904L</td>
<td>1.4539</td>
<td>N08904</td>
<td>20 25 5 Cu L</td>
<td>Ni Cr 21 Mo Fe Nb / Ni Cr 25 Mo 16R or P54* Ni Cr 22 Mo 9 Nb</td>
<td></td>
</tr>
<tr>
<td>254 SMO*</td>
<td>1.4547</td>
<td>S31254</td>
<td></td>
<td>Ni Cr 21 Mo Fe Nb / Ni Cr 25 Mo 16R or P54* Ni Cr 22 Mo 9 Nb</td>
<td></td>
</tr>
<tr>
<td>4565</td>
<td>1.4565</td>
<td>S34565</td>
<td></td>
<td>Ni Cr 21 Mo Fe Nb / Ni Cr 25 Mo 16R or P54* Ni Cr 22 Mo 9 Nb</td>
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</table>

* Avesta Welding designation

Weld factor

<table>
<thead>
<tr>
<th>Type of weld process and NDT</th>
<th>EN 13480-3</th>
<th>ASME B31</th>
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<tbody>
<tr>
<td>EFW, 100% ET</td>
<td>1.0</td>
<td>A 269</td>
</tr>
<tr>
<td>EFW, 100% RT</td>
<td>1.0</td>
<td>A 312 / A 774</td>
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<tr>
<td>EFW, spot RT</td>
<td>0.85</td>
<td>A 358 / A 403</td>
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<tr>
<td>EFW, double butt</td>
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</tr>
<tr>
<td>EFW, single butt</td>
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</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>ASTM / UNS</th>
<th>Cr</th>
<th>Ni</th>
<th>Mo</th>
<th>N</th>
<th>PRE*</th>
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<tr>
<td>4307</td>
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<td>18.1</td>
<td>8.3</td>
<td>-</td>
<td>-</td>
<td>18</td>
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<tr>
<td>4404</td>
<td>1.4404</td>
<td>316L</td>
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<td>10.1</td>
<td>2.1</td>
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<td>316L</td>
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<td>17</td>
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</table>

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

Mechanical properties (At room temperature)

<table>
<thead>
<tr>
<th>Outokumpu</th>
<th>EN</th>
<th>ASTM / UNS</th>
<th>Rm, MPa</th>
<th>A5, %</th>
<th>Rp0.2, MPa</th>
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<td>170</td>
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<tr>
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<td>316L</td>
<td>220</td>
<td>40</td>
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<td>4432</td>
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<td>316L</td>
<td>220</td>
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<td>35</td>
<td>220</td>
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<tr>
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<td>420*</td>
<td>35</td>
<td>415</td>
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</table>

* Min values according to EN 10088-4:2009
P = Hot rolled plate  H = Hot rolled strip  C = Cold rolled coil and strip

Physical properties

<table>
<thead>
<tr>
<th>Outokumpu</th>
<th>EN</th>
<th>ASTM / UNS</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>
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<tr>
<td>4307</td>
<td>1.4307</td>
<td>304L</td>
<td>18.1</td>
<td>200</td>
<td>0.3</td>
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<td>200</td>
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- PROCESS PIPES
  - Jakobstad, Finland
  - Riyadh, Saudi Arabia
- HEAVY WALL PIPES
  - Starfors, Sweden
- BUTT WELDED FITTINGS
  - Örnsköldsvik, Sweden
  - Jakobstad, Finland
- PROCESS EQUIPMENT
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