Duplex stainless steel for storage tanks
Why use Duplex stainless steels for storage tanks?

Thanks to superior strength compared to standard stainless steels, Duplex lets you reduce material weight – and cut costs!

The Duplex grades of today offer high corrosion resistance, which means low maintenance costs and no need for coating.

Duplex stainless steels combine many of the outstanding properties of ferritic and austenitic steels. Thanks to high levels of chromium and nitrogen, and frequently molybdenum, these steels offer good resistance to local and uniform corrosion. Furthermore, their low nickel content implies a stable price, which, combined with high strength, makes Duplex a cost-efficient alternative to lower strength stainless as well as coated carbon steels. The Duplex microstructure also contributes to high resistance to stress corrosion cracking, which can be an important issue in storage tanks. For typical chemical composition and mechanical properties, see Tables 1 to 3.

Characteristic properties
- High strength
- Excellent corrosion resistance
- High resistance to stress corrosion cracking
- High erosion resistance
- Low thermal expansion
- High fatigue resistance
- Good weldability
- High energy absorption
- Good weight and cost saving potential

Weight saving with Duplex stainless steel

Figure 1 illustrates how the high strength of Duplex steels reduces the thickness of sheet and plate used in the walls of storage tanks. In this case, the minimum thickness permitted at the top is 6 mm.

To further illustrate what can be gained by using Duplex stainless steel, minimum required wall thickness versus height is plotted in Figures 3 and 4.

Life Cycle Cost

When investing in a new storage tank park, taking into account the Life Cycle Cost (LCC) is just as important as the initial costs for materials and construction.

By doing so, you’ll often find that using Duplex stainless steel is a very cost competitive alternative. For example, stainless steel doesn’t require regular repainting to maintain its function, the general need for maintenance is much reduced, and the overall life-length of tanks made with Duplex stainless steel is simply outstanding.
Benefits of using 2-meter wide and tailor-made plate

Outokumpu supplies sheet and plate from 2-meter wide coils as well as tailor-made plate up to 3.2 meters in width. This enables cost-effective designs where welding is kept to a minimum and assembly is simplified, see Figure 2. Less welding and fewer weld joints reduce the risk of damage and thus lower the costs for repair.

Conventional standards used in the design of storage tanks

Two standardisation documents, EN 14015 and API 650, are frequently used when designing storage tanks. Information in these documents can serve to estimate the minimum cylindrical wall thickness in a storage tank. Allowable design stresses for Duplex stainless steels as well as for austenitic ones are included in both standards. Figures 3 and 4 show calculation estimates made for tanks with a diameter of 15 meters using the EN 14015 and API 650 standards respectively.

Note that these estimates only serve to illustrate the differences between austenitic and Duplex steels. Since the stability of the tank is not considered in these calculations, the values given in the diagrams cannot be used as default values.

<table>
<thead>
<tr>
<th>Grade</th>
<th>ASTM</th>
<th>Outokumpu</th>
<th>EN</th>
<th>ASTM</th>
<th>API 650</th>
<th>EN 14015</th>
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</thead>
<tbody>
<tr>
<td>1.4301</td>
<td>304</td>
<td>4301</td>
<td>210, 520</td>
<td>205, 515</td>
<td>154</td>
<td>139</td>
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<tr>
<td>1.4404</td>
<td>316L</td>
<td>4404</td>
<td>220, 520</td>
<td>170, 486</td>
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<td>145</td>
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<tr>
<td>1.4162</td>
<td>S32101</td>
<td>LDX2101 (®)</td>
<td>450*, 650*</td>
<td>450*, 650*</td>
<td>260</td>
<td>260</td>
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<tr>
<td>1.4362</td>
<td>S32304</td>
<td>2304</td>
<td>400, 630</td>
<td>400, 600</td>
<td>240</td>
<td>260</td>
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<tr>
<td>1.4462</td>
<td>S32205, S31803</td>
<td>2205</td>
<td>460, 640</td>
<td>450, 655</td>
<td>262</td>
<td>260</td>
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<tr>
<td>1.4410</td>
<td>S32750</td>
<td>SAF 2507 (®)</td>
<td>530, 730</td>
<td>550, 795</td>
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<td>260</td>
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</tbody>
</table>

Table 1: Allowable design stress at room temperature

Duplex steels are marked in blue.

![Figure 2. Fewer joints simplify the design and reduce construction time](image)

![Figure 3: Required wall thickness at different tank heights according to European standard EN 14015](image)

![Figure 4: Required wall thickness at different tank heights according to American standard API 650](image)
The right grade for your application

From the new and very successful LDX 2101 to Superduplex SAF 2507 with its exceptional corrosion resistance, we have a Duplex stainless steel grade that matches the requirements for your industrial storage tanks.

LDX 2101®
(EN 1.4162, UNS S32101) is the latest addition to the Duplex stainless steel family. LDX 2101 is suitable for moderately corrosive environments and offers the same or better corrosion resistance than 4301/304. LDX 2101 has been used for tanks containing:
- palm oil
- wine
- marble slurry
- white liquor
- potable and sewage water
- ethanol
- fruit juice
- biodiesel

2304
(EN 1.4362, UNS S32304) offers slightly better corrosion properties than LDX 2101 and can be compared to grades such as 4401/316 and 4404/316L. 2304 has been used in tanks containing:
- white liquor
- marble slurry
- pulp suspension
- hot water
- pure acetic acid
- wine

2205
(EN 1.4462, UNS S32205) was the first commercially successful Duplex and has been used for more than 20 years in storage tanks. The resistance of 2205 to pitting and crevice corrosion is superior to that of LDX 2101 and 2304. This Duplex grade is ideal for storing corrosive chemicals and can be compared to austenitic grades such as 904L. 2205 has been used in tanks containing:
- phosphoric acid
- pulp suspension
- hot water

SAF 2507®
(EN 1.4410, UNS S32750) is a Superduplex grade with very high corrosion resistance. It can be compared to high alloy 6 Mo austenitic grades such as 254 SMO. SAF 2507 has been used in process plants in the hydrometallurgy industry for tanks containing aggressive chemicals.
Table 2: Chemical composition of normal stainless steel grades compared with Outokumpu Duplex stainless steel. Duplex steels are marked in blue.

<table>
<thead>
<tr>
<th>Steel grades</th>
<th>Typical chemical composition (weight-%)</th>
</tr>
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<tbody>
<tr>
<td>EN</td>
<td>ASTM</td>
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<tr>
<td>1.4301</td>
<td>304</td>
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<tr>
<td>1.4404</td>
<td>316L</td>
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<tr>
<td>1.4162</td>
<td>S32101</td>
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<td>1.4362</td>
<td>S32304</td>
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<td>S32205/S31803</td>
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<tr>
<td>1.4410</td>
<td>S32750</td>
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Table 3: Minimum values for the mechanical properties of the steel grades. Duplex steels are marked in blue.

<table>
<thead>
<tr>
<th>Mechanical properties, minimum values</th>
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<tbody>
<tr>
<td>Grade</td>
</tr>
<tr>
<td>1.4301</td>
</tr>
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<tr>
<td>1.4462</td>
</tr>
<tr>
<td>1.4410</td>
</tr>
</tbody>
</table>

* Corresponds to ASTM A240 (LDX 2101 is not yet listed in EN 10088)

Duplex stainless steel is ideal for the clean and hygienic handling of foodstuffs like honey.
Case projects

**Emypro, Spain**
Location: Tarragona, Spain  
Height: 25 meters  
Diameter: 22 meters  
Thickness: 6.5–12 mm  
Engineering: Emypro  
Owner: Terquimsa, Terminales Quimicos SA, Spain  
Content: Pure acetic acid  
Material: 2304  
Delivered plate width: 2 meters  
Completed: 2005

(Courtesy of Emypro)

**Midsunds Bruk AS, Norway**
Location: Elnesvågen, Norway  
Height: 22.8 meters  
Diameter: 15.25 meters  
Thickness: 5–13 mm  
Engineering: Midsunds Bruk AS  
Owner: Hustadmarmor AS, Norway  
Content: Marble slurry  
Material: LDX 2101  
Delivered plate width: 2–2.5 meters  
Completed: 2005

(Courtesy of Midsunds Bruk)

**Emypro, Spain**
Location: Barcelona, Spain  
Height: 25 meters  
Diameter: 19 meters  
Thickness: 5–13.5 mm  
Engineering: Emypro  
Owner: Relisa SA, Spain  
Content: Honey, edible oils  
Material: LDX 2101  
Delivered plate width: 2.5 meters  
Completed: 2006

(Courtesy of Emypro)
Metal Alimentaria SL, Spain
Location: Ávila, Spain
Thickness: 4–5 mm
Engineering: Metal Alimentaria SL
Owner: Harinera vilafraquina SA, Spain
Content: Wheat flour
Material: LDX 2101, 304
Delivered plate width: 1.5 meters
Completion: 2007

Oostwouder, the Netherlands
Location: Amsterdam, the Netherlands
Height: 20 meters
Diameter: 11.5 meters
Thickness: 3–8 mm
Engineering: Oostwouder Tank- & Silobouw BV
Owner: Noba Vetveredeling BV, the Netherlands
Content: Biodiesel, edible oils
Material: LDX 2101, 2304
Delivered plate width: 1.5–2 meters
Completion: Main assembly 2007, final completion 2008
Outokumpu is an international stainless steel company. Our vision is to be the undisputed number one in stainless, with success based on operational excellence. Customers in a wide range of industries use our stainless steels and services worldwide. We are dedicated to helping our customers gain competitive advantage.

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