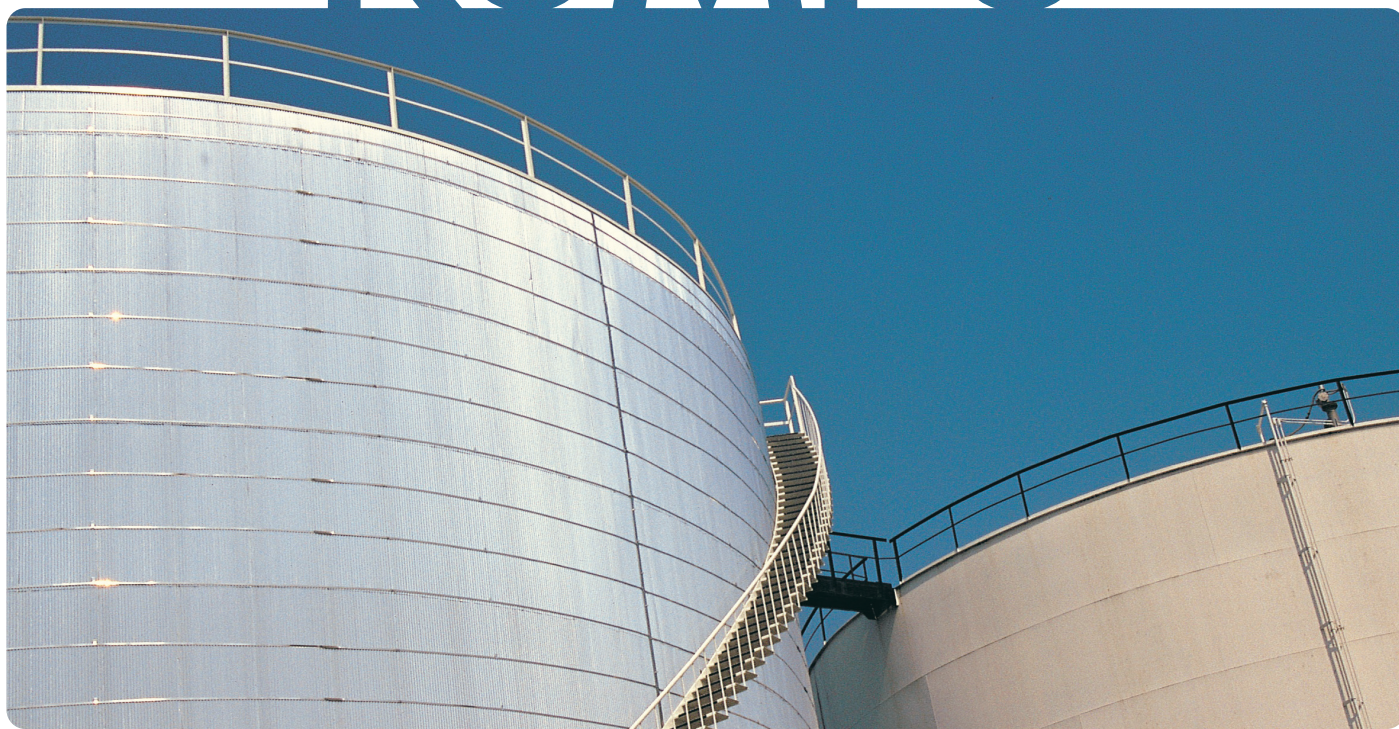


OUTO KUMPU



**Duplex stainless steel
for storage tanks**

www.outokumpu.com

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.



Storage tanks for marble slurry (Courtesy of Midsunds Bruk)

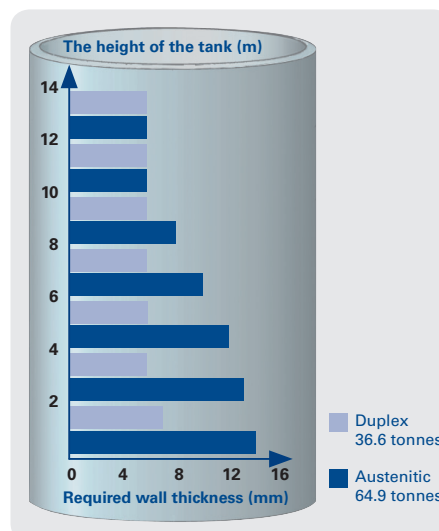


Figure 1: Potential wall thickness reduction using Duplex stainless steel compared with austenitic

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.

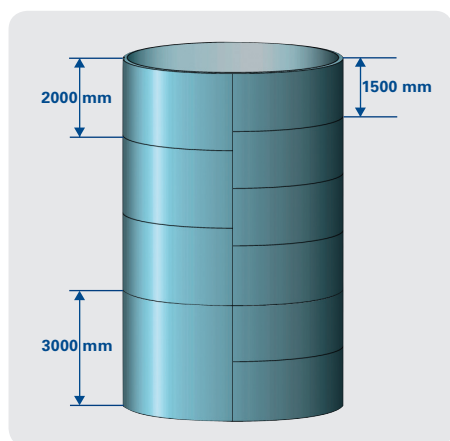


Figure 2. Fewer joints simplify the design and reduce construction time

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.

Allowable design stress at room temperature

Grade			R _{p0.2} , R _m [MPa] EN	R _{p0.2} , R _m [MPa] ASTM	S _d [MPa]	
EN	ASTM	Outokumpu			API 650	EN 14015
1.4301	304	4301	210, 520	205, 515	154	139
1.4404	316L	4404	220, 520	170, 485	145	145
1.4162	S32101	LDX2101 ^{®1)}	450*, 650*	450*, 650*	260	260
1.4362	S32304	2304	400, 630	400, 600	240	260
1.4462	S32205, S31803	2205	460, 640	450, 655	262	260
1.4410	S32750	SAF 2507 ^{®2)}	530, 730	550, 795	318	260

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

Table 1: Allowable design stress (S_d) for different steels and standards. Duplex steels are marked in blue

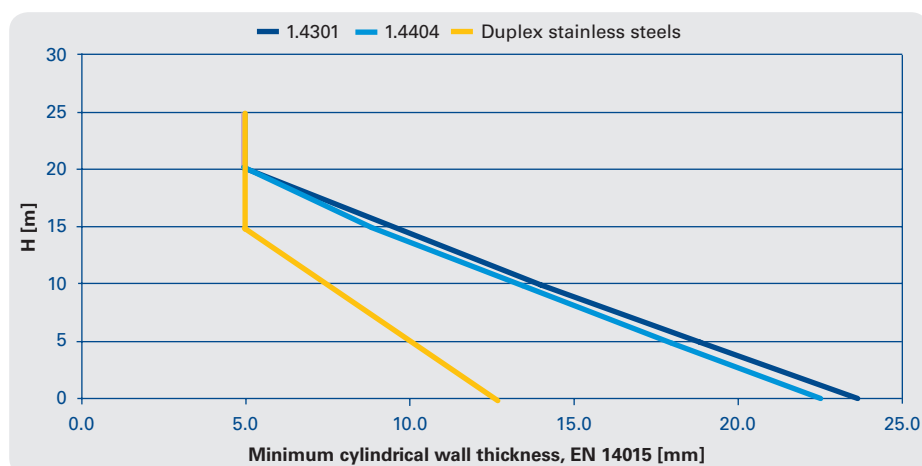


Figure 3: Required wall thickness at different tank heights according to European standard EN 14015

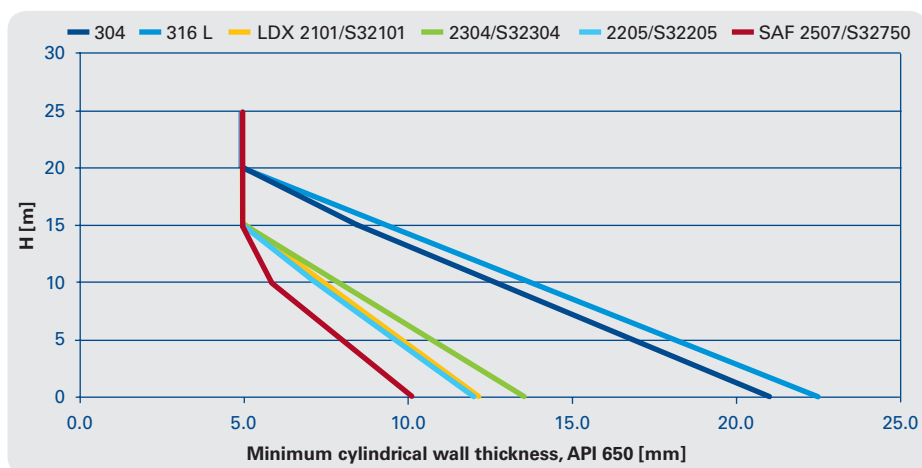


Figure 4: Required wall thickness at different tank heights according to American standard API 650

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.

Steel grades

Typical chemical composition (weight-%)

EN	ASTM	Outokumpu	Cr	Ni	Mo	N	C	Others
1.4301	304	4301	18.1	8.3	–	–	0.04	–
1.4404	316L	4404	17.2	10.2	2.1	–	0.02	–
1.4162	S32101	LDX 2101 ^{®1)}	21.5	1.5	0.3	0.22	0.03	5Mn
1.4362	S32304	2304	23	4.8	0.3	0.10	0.02	–
1.4462	S32205/S31803	2205	22	5.7	3.1	0.17	0.02	–
1.4410	S32750	SAF 2507 ^{®2)}	25	7	4	0.27	0.02	–

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PRE = % Cr + 3.3 x % Mo + 16 x % N.

Table 2: Chemical composition of normal stainless steel grades compared with Outokumpu Duplex stainless steel. Duplex steels are marked in blue

Mechanical properties, minimum values

Grade		Proof strength	Tensile strength	Elongation	Yield strength	Tensile strength	Elongation
EN	ASTM	R _{p0.2} [MPa]	R _m [MPa]	A ₅ %	0.2% [MPa]	[MPa]	In 2" %
1.4301	304	210	520	45	205	515	40
1.4404	316L	220	520	45	170	485	40
1.4162	S32101	450*	650*	30*	450	650	30
1.4362	S32304	400	630	25	400	600	25
1.4462	S32205	460	640	25	450	655	25
1.4410	S32750	530	730	20	550	795	15

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

Table 3 : Minimum values for the mechanical properties of the steel grades. Duplex steels are marked in blue



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



Case projects



(Courtesy of Emypro)

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 Midsunds Bruk)

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 Emypro)

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 Metal Alimentaria SL)

Metal Alimentaria SL, Spain

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



(Courtesy of Oostwouder)

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

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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.

**OUTO
KUMPU**

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