

Duplex and high-strength stainless steels

Outokumpu Forta range

outokumpu
high performance stainless steel



outokumpu.com/forta



We believe in a world that lasts forever

Outokumpu is a global leader in the advanced materials business, creating stainless steels that are efficient, long lasting, and recyclable. A strong customer focus, sustainability, and technical excellence are at the heart of everything we do.

As an open and approachable company, our customers rely on our advice to help them select products that will deliver the best long-term performance for their needs.

With over a century of innovation behind us and some of the best minds in the business, we continue to develop pioneering materials to meet the demands of tomorrow.

The durability of stainless steel means that it is not only the best, but also the most economically sustainable choice for a wide range of applications. All of our products are made from an average of 85% recycled material and are fully recyclable at the end of their lifecycles.

Together with our customers and partners, we are building a world that lasts forever.

Stay up to date on our latest innovations, follow market trends, and get inspired by success stories – subscribe to our magazines and newsletters
outokumpu.com/newsletter

The inside view

Duplex and other high strength stainless steels that enable thinner structures and weight reduction (yield strength $R_{p0.2} > 400$ MPa. PRE 16 to 43).

Outokumpu has been producing austenitic stainless steel for over a century, duplex stainless steel for 80 years, and working with the automotive industry for 50 years. This legacy of innovation and consistent quality means that we have the right product for every application.

By grouping our products into ranges based on performance rather than stainless steel family, we aim to make choosing the best product for your application easier. The Forta range contains the following products:

- Duplex products for high strength, corrosion resistance, and enhanced resistance to stress corrosion cracking
- H-series austenitic products for high strength and high ductility
- Temper rolled products for high strength and high hardness

Unlike carbon steels, Forta range duplex products with their superior corrosion resistance do not need to be coated making them a more cost effective long-term choice. Since duplex products are also high strength, thinner gauges can potentially be used which saves on material costs. The thermal expansion of duplex is similar to carbon

steels making it possible to combine the two in one and the same application. The weldability of duplex steels is good provided the suggested welding procedures are followed.

Forta H400 has been used in the automotive industry for structural parts for over 10 years. Forta H400 allows to create lighter and stronger parts while improving passenger safety. We also manufacture Forta H500 product with further increased yield strength. Forta H-series products are available in an industry-leading range of thicknesses and widths. We offer our customers support on welding, forming, painting, corrosion and simulation. Please contact our technical experts. Their light weight potential and easy recyclability make Forta H steels an interesting alternative to carbon steels and aluminium in automotive applications.

Temper rolled products are standard stainless steels like Core 304L/4307 and Supra 316L/4404 treated for higher strength and hardness, and commonly used in tanks, bus chassis, and railcars. In comparison to carbon steels they do not have to be coated to improve corrosion resistance.

Contact us by [outokumpu.com/contacts](https://www.outokumpu.com/contacts) to find out which product is right for your next project.



When you need stainless steel for high temperature applications (above 250 °C/ 480 °F), austenitic products from the Core, Supra, or Ultra ranges are preferred. For temperatures above 550 °C/1020 °F, check the Therna range.

Forta range applications

Duplex applications

- Pressure piping systems for seawater, chemicals, and oil and gas handling
- Pressure vessels like digesters, evaporators, fermenters, autoclaves, water heaters and road tankers
- Storage tanks for pulp, chemicals, biofuels, beverages, grains and ore slurry
- Structural components for bridges, offshore platforms, sluice and flood gates, steel frameworks and rebar for concrete structures
- Blast and fire walls on offshore platforms
- Cargo tanks in chemical tankers
- Evaporators in desalination plants
- Heat exchangers in petrochemical plants
- Suction roll shells in paper machines
- Flue-gas cleaning equipment
- Rotors, impellers and shafts
- Vehicle and chassis components
- Flanges and valves

H-series applications

- Automotive applications including structural safety parts, chassis parts and complex-forming parts
- Railroad cars, trucks, buses and agricultural vehicles

Temper rolled applications

- Tanks and containers
- Bus chassis and railroad car components
- Shielding rings for beer kegs

Contact us at outokumpu.com/contacts to find out which of our products is right for your next project.



If you need stainless steel for very low temperature environments (-40°C/-40°F or below), austenitic stainless steels would mostly be the more accurate choice.



Choosing the right product

Duplex products

Outokumpu name	Typical applications	Product forms
<p>Forta DX 2205</p> <p>The most popular duplex product on the market. Offers very good resistance to uniform and localized corrosion and stress corrosion cracking in combination with high mechanical strength.</p>	<ul style="list-style-type: none"> • Cargo tanks in chemical tankers • Pulp and paper industry applications such as digesters and process tanks • Oil and gas industry applications such as flanges, valves, tubes, and pipes • Structural components in bridges 	C, H, P, B, R, S, T
<p>Forta LDX 2101</p> <p>A lean-alloyed duplex product with good resistance to localized and uniform corrosion, as well as stress corrosion cracking, making it a good substitute for coated carbon steel. Also offers high mechanical strength and good machinability.</p>	<ul style="list-style-type: none"> • Storage tanks • Household heaters • Structural components for floodgates and bridges or rebar for concrete structures • Pulp and paper industry applications • Flanges and valves 	C, H, P, B, R, S, T
<p>Forta DX 2304</p> <p>A duplex product with a leaner alloying composition than Forta DX 2205. It has good resistance to localized and uniform corrosion, as well as stress corrosion cracking, combined with high mechanical strength.</p>	<ul style="list-style-type: none"> • Offshore topside applications • Storage tanks • Rebar • Flanges and valves 	C, H, P, B, R, S, T

Product forms



C
Cold rolled coil and sheet



H
Hot rolled coil and sheet



P
Quarto plate



B
Bar



R
Wire rod



S
Semifinished (bloom, billet, ingot & slab)



T
Pipe

Outokumpu name	Typical applications	Product forms
<p>Forta EDX 2304 An enhanced version of Forta DX 2304 with better corrosion resistance and higher mechanical strength.</p>	<ul style="list-style-type: none"> • Offshore topside structural components • Tank applications • Flanges and valves 	C, H, P, B, R, S
<p>Forta LDX 2404 A low-nickel, high-nitrogen duplex product with higher mechanical strength than Forta DX 2205. Offers very good resistance to localized and uniform corrosion, as well as stress corrosion cracking.</p>	<ul style="list-style-type: none"> • Storage tanks • Structural components for flood and sluice gates • Mining industry applications such as dewatering equipment • Flanges and valves 	C, H, P, B, R, S, T
<p>Forta SDX 100 A super duplex with higher corrosion resistance and mechanical strength than Forta DX 2205. Often used in extremely corrosive environments such as desalination, chemical, or offshore subsea applications.</p>	<ul style="list-style-type: none"> • Industrial piping • Scrubbers • Tubes for oil and gas applications • Deep-sea pipelines • Flanges and valves 	P, B, R, S
<p>Forta SDX 2507 A super duplex product with higher corrosion resistance and mechanical strength than Forta DX 2205. Often used in extremely corrosive environments such as desalination, chemical, or offshore subsea applications.</p>	<ul style="list-style-type: none"> • Desalination plants • Industrial piping • Scrubbers • Tubes for oil and gas applications • Deep-sea pipelines • Flanges and valves 	C, H, P, B, R, S, T
<p>Forta FDX 25 A duplex stainless steel with improved formability and good resistance to uniform and localized corrosion, as well as stress corrosion cracking. It has high mechanical strength and excellent forming properties and is used in applications where the use of standard duplex is restricted due to its formability limitations.</p>	<ul style="list-style-type: none"> • Plate heat exchangers • Deep drawing applications for thin material such as beer kegs • Pump components 	C, H
<p>Forta FDX 27 A duplex product with improved formability and better corrosion resistance than Forta FDX 25. It has high strength and excellent forming properties and is used in applications where the use of standard duplex is restricted due to its formability limitations.</p>	<ul style="list-style-type: none"> • Plate heat exchangers • Deep drawing applications for corrosive environments • Pump components 	C, H

H-series products

Outokumpu name	Typical applications	Product forms
<p>Forta H400 Forta H400 has higher strength than standard Core 304/4301 and a lower nickel content, making it a cost-effective and lightweight austenitic product for the automotive industry. It has been used in automotive applications for over 10 years.</p>	<ul style="list-style-type: none"> • Cross members • Strut domes • Bumpers 	C, H
<p>Forta H500 Forta H500 has a higher yield strength than Forta H400, making it a cost-effective and lightweight austenitic stainless steel for the automotive industry and other transport or construction applications.</p>	<ul style="list-style-type: none"> • Structural components for transport applications • Tube and profile applications 	C, H
<p>Forta H800 and Forta H1000 Forta H800 and Forta H1000 are temper rolled variants with a higher yield strength than Forta H500, which creates further possibilities for lightweighting in the automotive industry and other transport or construction applications.</p>	<ul style="list-style-type: none"> • Structural components for transport applications • Tube and profile applications 	C, H

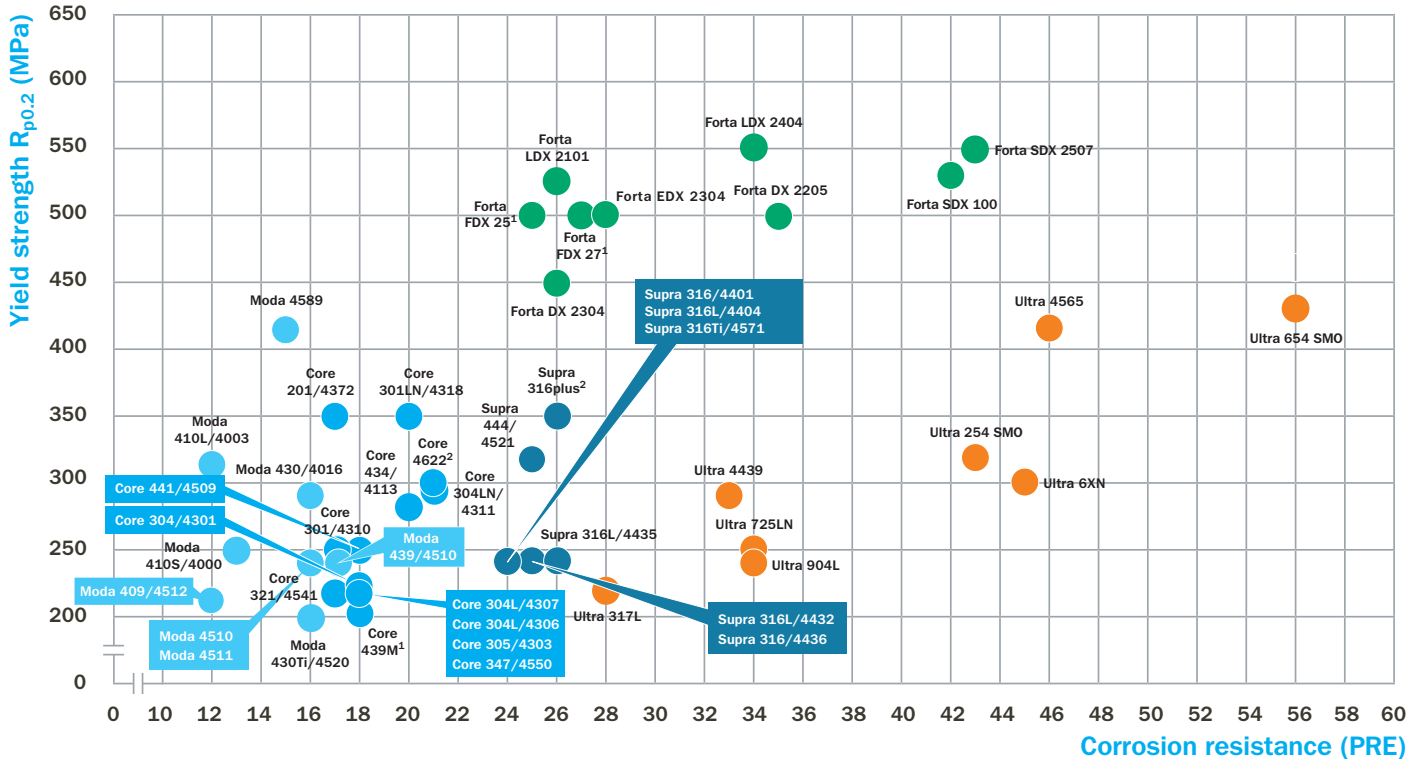
Temper rolled products

Outokumpu name	Typical applications	Product forms
<p>Forta 430/4016 A classic 16% chromium ferritic stainless steel used in mildly corrosive environments.</p>	<ul style="list-style-type: none"> • Automotive components • Structural applications • Tanks 	C
<p>Forta 301LN/4318 A low-carbon, nitrogen alloyed alternative to Forta 301/4310.</p>	<ul style="list-style-type: none"> • Vehicle chassis • Profiles 	C
<p>Forta 301/4310 A lower chromium and nickel alternative to Forta 304/4301 with high work hardening capacity.</p>	<ul style="list-style-type: none"> • Automotive components • Cable connectors • Springs • Window frames • Commercial appliances 	C

Outokumpu name	Typical applications	Product forms
<p>Forta 304/4301 Forta 304/4301 is a classic 18% chromium, 8% nickel austenitic stainless steel. It's an all-purpose product with good corrosion resistance and is suitable for a wide variety of applications.</p>	<ul style="list-style-type: none"> • Beer kegs • Cutlery • Automotive components • Tanks and vessels • Furniture • Structural applications 	C
<p>Forta 304L/4307 Forta 304L/4307 is a low-carbon alternative to Forta 304/4301 and is suitable for a wide variety of applications.</p>	<ul style="list-style-type: none"> • Beer kegs • Cutlery • Automotive components • Tanks and vessels • Furniture • Structural applications 	C
<p>Forta 316/4401 A normal-carbon alternative to Forta 316L/4404 that is widely used for various applications.</p>	<ul style="list-style-type: none"> • Automotive components • Tanks and vessels 	C
<p>Forta 316L/4404 Forta 316L/4404 is a low-carbon alternative to Forta 316/4401 and is used in various aggressive environments.</p>	<ul style="list-style-type: none"> • Chemical tanks and tubing • Pulp and paper process equipment 	C
<p>Forta 316plus Forta 316plus is a cost-efficient, 21Cr lower-nickel/molybdenum alternative to traditional molybdenum austenitics like Forta 316L/4404.</p>	<ul style="list-style-type: none"> • Automotive components • Tanks and vessels 	C
<p>Forta 316Ti/4571 A titanium-stabilized, molybdenum-alloyed austenitic alternative to Forta 316L/4404 – mainly used in Germany.</p>	<ul style="list-style-type: none"> • Heating technology • Profiles 	C

Product performance comparison

Strength vs. corrosion resistance



- Moda – Mildly corrosive environments
- Core – Corrosive environments
- Supra – Highly corrosive environments
- Forta – Duplex and other high strength (PRE 16 to 43)
- Ultra – Extremely corrosive environments (PRE > 27)

PRE calculation = $\%Cr + 3.3 \times \%Mo + 16 \times \%N$

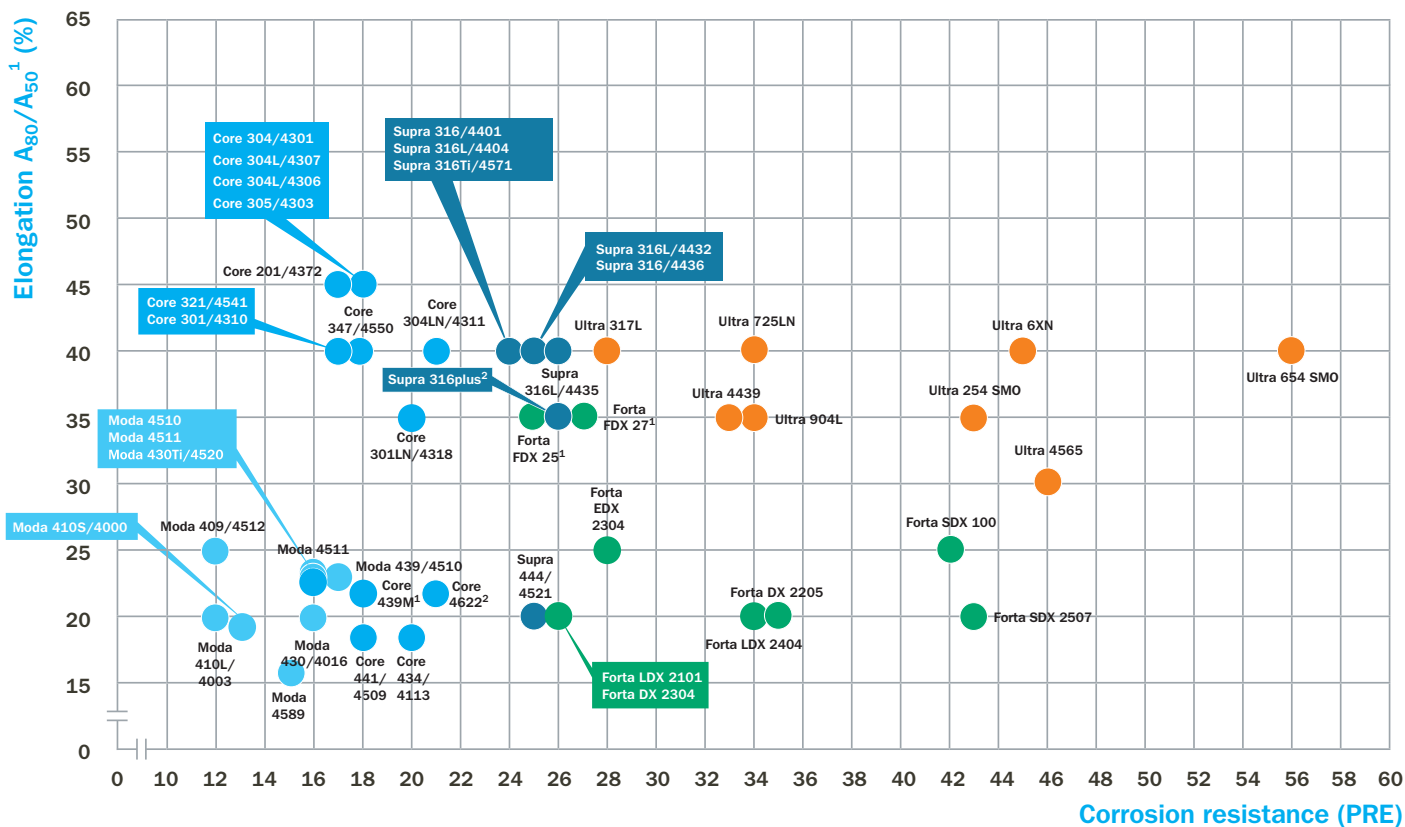
Note: PRE values shown are Outokumpu typical values. Yield strength ($R_{p0.2}$) according to EN 10088-2 minimum values for cold rolled strip. Yield strength for temper rolled products ranges from 500-2000 MPa.

¹⁾ According to ASTM A240.

²⁾ According to EN 10028-7.

For more values by product, please see steelfinder.outokumpu.com

Elongation vs. corrosion resistance




Learn more at outokumpu.com/forta

Product properties

Forta range

Duplex and other high strength
(Yield strength $R_{p0.2} > 400$ MPa. PRE 16 to 43)

Steel designations				Performance				Typical chemical composition, % by mass					
Outokumpu name	EN	ASTM Type	UNS	PRE	A_{80}/A_{50}^4 %	$R_{p0.2}$ MPa	Grade family	C	Cr	Ni	Mo	N	Others
Duplex, high strength, high corrosion resistance and enhanced resistance to stress corrosion cracking													
Forta DX 2205	1.4462	–	S32205	35	20	500	D	0.02	22.4	5.7	3.1	0.17	–
Forta LDX 2101	1.4162	–	S32101	26	20	530	D	0.03	21.5	1.5	0.3	0.22	5Mn Cu
Forta DX 2304	1.4362	–	S32304	26	20	450	D	0.02	23.0	4.8	0.3	0.10	Cu
Forta EDX 2304	1.4362	–	S32304	28	25 ¹⁾	500 ¹⁾	D	0.02	23.8	4.3	0.5	0.18	Cu
Forta LDX 2404	1.4662	–	S82441	34	20	550	D	0.02	24.0	3.6	1.6	0.27	3Mn Cu
Forta SDX 100	1.4501	–	S32760	42	25 ²⁾	530 ²⁾	D	0.02	25.4	6.9	3.8	0.27	W Cu
Forta SDX 2507	1.4410	–	S32750	43	20	550	D	0.02	25.0	7.0	4.0	0.27	–
Forta FDX 25	1.4635 ³⁾	–	S82012	25	35 ⁴⁾	500 ⁴⁾	D	≤0.05	19.0–20.5	0.8–1.5	0.1–0.6	0.16–0.26	2–4Mn
Forta FDX 27	1.4637 ³⁾	–	S82031	27	35 ⁴⁾	500 ⁴⁾	D	≤0.04	19.0–22.0	2.0–4.0	0.6–1.4	0.14–0.24	≤2.5Mn
High strength and high ductility													
Forta H400	1.4376	–	–	–	40	400	A	0.04	17.5	4.0	–	0.20	6.8Mn
Forta H500	–	–	–	–	40 ⁵⁾	500 ⁵⁾	A	–	–	–	–	–	–
Forta H800	–	–	–	–	30 ⁶⁾	800 ⁶⁾	A	–	–	–	–	–	–
Forta H1000	–	–	–	–	13 ⁶⁾	1000 ⁶⁾	A	–	–	–	–	–	–
High strength and high hardness (temper rolled)⁷⁾													
Forta 430/4016	1.4016	430	S43000	16	–	350–700	F	0.05	16.2	–	–	–	–
Forta 301LN/4318	1.4318	301LN	S30153	20	–	500–900	A	0.02	17.7	6.5	–	0.14	–
Forta 301/4310	1.4310	301	S30100	17	–	500–1300	A	0.10	17.0	7.0	–	–	–
Forta 304/4301	1.4301	304	S30400	18	–	350–1300	A	0.04	18.1	8.1	–	–	–
Forta 304L/4307	1.4307	304L	S30403	18	–	350–1300	A	0.02	18.1	8.1	–	–	–
Forta 316/4401	1.4401	316	S31600	24	–	350–700	A	0.04	17.2	10.1	2.1	–	–
Forta 316L/4404	1.4404	316L	S31603	24	–	350–700	A	0.02	17.2	10.1	2.1	–	–
Forta 316plus	1.4420	–	S31655	25	–	500–700 ⁶⁾	A	0.02	20.3	8.6	0.7	0.19	–
Forta 316Ti/4571	1.4571	316Ti	S32100	24	–	350–700	A	0.04	16.8	10.9	2.1	–	Ti

¹⁾ Outokumpu MDS-D35 for EDX 2304. ²⁾ Min. values for plate acc. to EN 10088-2. ³⁾ Designation included in Stahl-Eisen-Liste. ⁴⁾ Min. values acc. to ASTM A240, for strip $t \leq 5$ mm. ⁵⁾ Values acc. to Stahl-Eisen-Liste. ⁶⁾ Outokumpu tested values.

⁷⁾ Products with higher strength available on request.

Note: PRE values and chemical composition figures shown are Outokumpu typical values. Yield strength ($R_{p0.2}$) and elongation (A_{80}) are based on EN 10088-2 minimum values for cold rolled strip unless marked otherwise.

For more values by product, please see steelfinder.outokumpu.com

Duplex less expensive than coated carbon steel

Tank fabricator Ellimetal in the Netherlands was considering coated carbon steel for a storage tank. By switching to Forta LDX 2101 they saved 3% on initial costs. As Forta LDX 2101 does not need to be coated the customer also saves on long-term maintenance.

Initial cost calculation for coated carbon steel tank:

Carbon steel:	73%
External coating:	6%
Internal coating:	21%
Total:	100%

Cost of tank in Forta LDX 2101

Total: 97% of coated carbon steel cost

“ The customer saved 3% initially by using Forta LDX 2101 instead of coated carbon steel.



Looking for expert help to choose the best product for your next project?
Contact us at outokumpu.com/contacts



Old bridge stressed by salt

Allt Chonoglais bridge
Scotland

Customer need

Identified as too weak to meet modern traffic needs on the A82 trunk road, the entire bridge needed replacement with a stronger structure. Instead of extending the bridge's life through interval construction work, the aim was to find a solution through a lifecycle approach that would extend the bridge's lifespan with as low maintenance as possible.

Our solution

After discussions with Outokumpu, the customer selected Forta DX 2304 rebar due to its competitive cost and exceptional chloride resistance.

The new structure meets the needs of modern-day traffic while retaining attractive features of the original bridge, including the locally sourced granite.

“ The concrete structure incorporates stainless steel rebar in areas exposed to de-icing salts during the winter months. This includes the bridge deck, abutments, wing walls and bearing plinths.

Stephen Jones

Rebar Commercial Manager and head of Long Products Research and Development, Outokumpu



FISIA chooses duplex

Desalination FISIA

Customer need

Desalination can make fresh water increasingly available where it is most needed. However, the process faces challenges: high demands on materials and high costs, which can discourage investment in new plants.

Our solution

The benefits of building the chambers out of solid duplex stainless steel are improved corrosion resistance and strength compared to austenitic stainless steel. Duplex chambers can be built with thinner plates, resulting in less material, less need for welding, and easier handling.

“ Outokumpu’s business development went further to make full use of the Outokumpu range of duplex stainless steels. The availability of Forta LDX 2101 duplex made solid duplex chambers increasingly attractive to FISIA.

Duplex for Europe's longest pedestrian and cycling bridge

756-meter bridge
Sölvesborg, Sweden

Customer need

To design and construct Europe's longest pedestrian and cycling bridge with an attractive design, low maintenance cost and minimum environmental impact on nearby bird conservation area.

Our solution

The arches built from Outokumpu duplex stainless steel mean approximately a 500 000 euro calculative saving in maintenance and repainting costs. The benefits of avoided painting and sand blasting are significant also from the environmental perspective.



We can avoid repainting costs associated with the bridge arches and rails every 15th year.

Ronny Södergren

Stål & Rörmontage AB





Green, lean and long lasting

Waterfront Building
Stockholm, Sweden

Customer need

To build a spectacular façade from a highly sustainable, durable and aesthetically pleasing material that can endure the environmental stresses such as the vibrations from the wind.

Our solution

Consultations with Outokumpu experts in architectural applications to identify just the right grade – Forta DX 2205 duplex. And just the right surface finish with desired levels of reflection - the 2E finish. Complementing indoors with the grade 1.4301 and a fingerprint-resistant finish. Outokumpu's material and expertise provide a rich design and sustainable platform for 3000 seats, 418 hotel rooms and 24.000 square meters of office space.



A lot of work were put in for finding the exact material for this complex structure. With the help of Outokumpu, we got the support we needed to realize our vision.

Stefano Mangili

White Arkitekter of Stockholm



Oculus soars above the Big Apple's transit hub

Oculus
New York, USA

Customer need

The interior space is framed by soaring, gently curved white ribs and streams of light. In creating the structure, contractor Cimolai SPA needed material that prevents excessive length expansion and tension.

Our solution

Lean duplex stainless steel from Outokumpu, offering an exceptional combination of strength and corrosion resistance. Produced at Outokumpu's Degerfors mill, which specializes in tailor-made, heavy plate products, lean duplex plate presents a technically sound, cost-efficient solution. In the Oculus, Forta LDX 2101 duplex plate strips welded between the structure's carbon steel components act as a thermal barrier. In the process, the Oculus gains strength, durability, corrosion resistance and low life-cycle costs.

“ Twice as strong as austenitic grades, Outokumpu Forta LDX 2101 duplex stainless steel is a perfect fit for a demanding project like the Oculus.

Forta LDX 2101
Forta DX 2304



Forta breakthrough in wine storage tanks

Sparkling Wine Case
Garcia Carrión, Spain

Customer need

The traditional stainless combination 304 and 316L presented a challenge: soaring nickel prices put the price of new tanks very high.

Our solution

Outokumpu's Spanish sales and technical team explained how Forta LDX 2101 and Forta DX 2304 could provide a solution: the low nickel content of these grades would bring major cost savings while providing equal or better corrosion resistance than 304 and 316L. Additional savings would come from the high strength of Forta duplex grades, which allows for thinner gauges.

“ Additional savings would come from the high strength of all duplex grades, which allows for thinner gauges. As a result, Martinez Sole could use thinner, either hot or cold rolled coil instead of thicker hot rolled material.



Forta 316plus in transport containers

The Langh Group needed a wear and corrosion-resistant steel for transport containers for ships, trucks, and trains.

The properties of temper rolled Outokumpu Forta 316plus allow for thinner wall thickness – meaning a lower overall container weight – while enabling transportation of aggressive and sharp bulk materials.

Developed by Outokumpu, Forta 316plus is a unique product that provides a competitive alternative to Supra 316L/4404. Forta 316plus contains less nickel and molybdenum and has higher strength than Supra 316L/4404, even in the annealed condition, due to higher nitrogen alloying.



I was excited to find out about 316plus as it offered better material performance than 316L, but the price was lower.

Markku Yli-Kahri
Langh Group



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Courtesy of Porsche AG.

Forta H400 in the Porsche Panamera

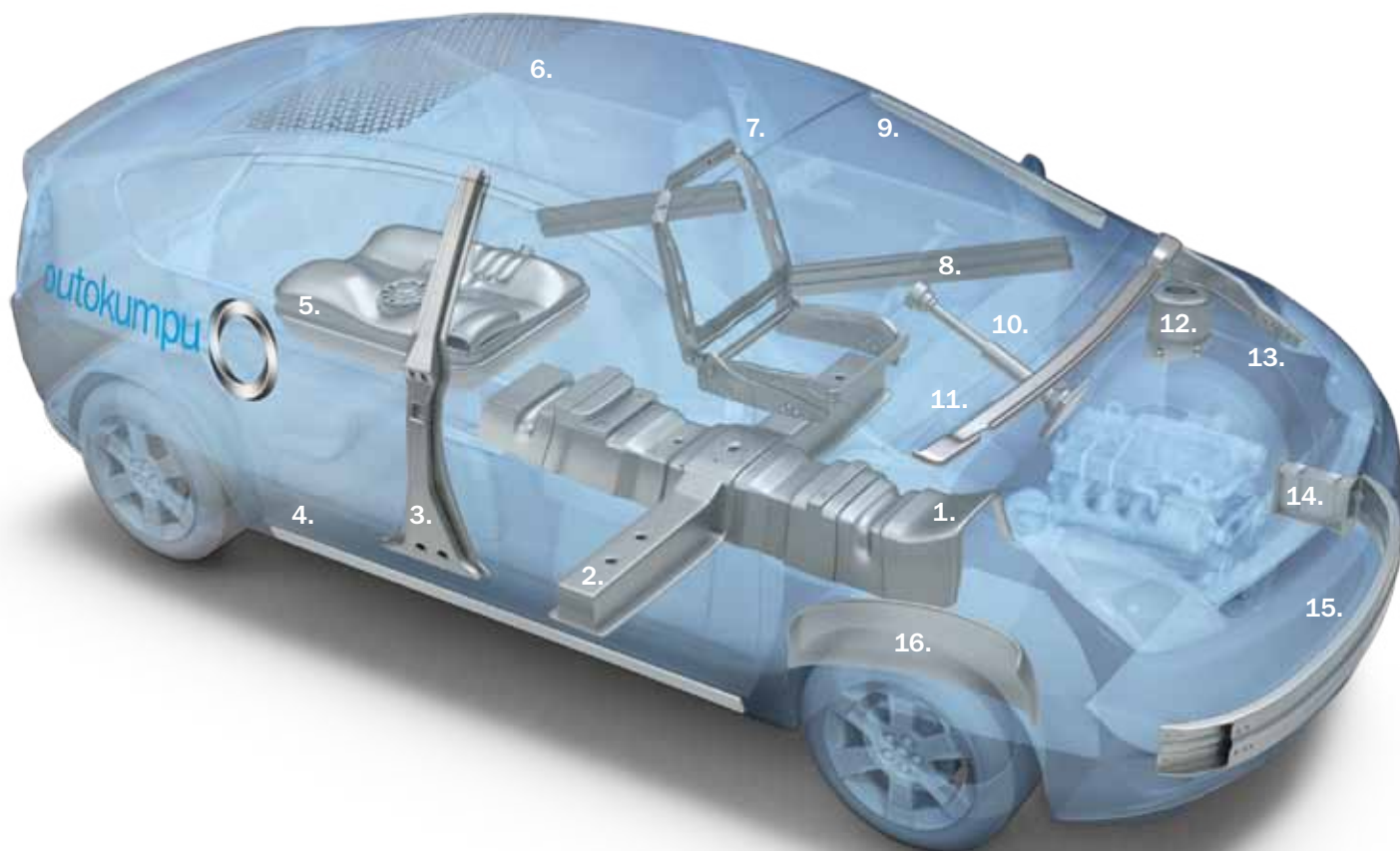
Porsche used Forta H400 hydroformed tube to create a dashboard cowl in the Porsche Panamera. Forta H400 was selected due to its excellent crash properties.

Outokumpu Forta range H-series products help automotive manufacturers to create structural parts that are both lightweight and feature good crash behavior. Forta H-series products have all the advantages of steels with an austenitic microstructure – good weldability and formability – without the cost-intensive and volatile alloying element nickel.

Forta H400 has been used in the automotive industry for over 10 years in structural parts like B pillars, cross members, channels, and bumpers. Our Forta H500, Forta H800, and Forta H1000 stainless steels build on this successful history while offering even better yield strength.



Dashboard cowl
Hydroformed/complex
Outstanding crash absorption



Forta H-Series potential in automotive design

- | | |
|---------------------------|-----------------------|
| 1. Channel | 9. A-Pillar |
| 2. Seat cross member | 10. Steering column |
| 3. B-Pillar | 11. Dashboard cowl |
| 4. Rocker rail | 12. Strut dome |
| 5. Hybrid tank | 13. Longitudinal beam |
| 6. Stainless steel fabric | 14. Crashbox |
| 7. Seat structures | 15. Bumper |
| 8. Door shock absorber | 16. Wheel house |



For support to successfully use our Forta H-series products for automotive application please contact us by outokumpu.com/contacts

Working towards forever.

We work with our customers and partners to create long lasting solutions for the tools of modern life and the world's most critical problems: clean energy, clean water, and efficient infrastructure. Because we believe in a world that lasts forever.

outokumpu classic			outokumpu pro						
Moda Mildly corrosive environments	Core Corrosive environments	Supra Highly corrosive environments	Forta Duplex & other high strength	Ultra Extremely corrosive environments	Dura High hardness	Therma High service temperatures	Prodec Improved machinability	Deco Special surfaces	

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