

Oil & Gas



outokumpu
high performance stainless steel



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We believe in a world that lasts forever.

The world needs and deserves innovations that pass the test of time and are able to be recycled and used again at the end of their lifecycle.

Outokumpu stainless steel is durable in the most challenging of conditions delivering ever longer project lifecycles. The recycled content of our advanced materials varies between 70% and 90% depending on the grade and Outokumpu stainless steel is also fully recyclable. The properties of our advanced materials, also make them an economically sustainable solution.

Our vision of a world that lasts forever not only reflects these properties but also our ongoing commitment to innovation and the development of lasting customer relationships.



Advanced materials for harsh conditions

The scale of projects in the oil and gas industry is massive and the production chain is only as strong as its weakest link. Though oil is not corrosive in itself, production takes place in harsh and highly corrosive environments. Today stainless steels – especially duplex – tends to

replace traditional carbon steel in many applications. The benefits – superior corrosion resistance, excellent mechanical properties and significant cost savings are compelling, both for topside construction and applications for production fluids.

Meeting your challenges

Outokumpu has been a key supplier of stainless steel to the oil and gas industry for more than 50 years. Our products can be found in upstream and downstream applications – from oil and gas production to transport and storage, refineries, LNG plants and petrochemical units. Tried and tested in these extreme conditions we have earned approvals from leading oil and gas companies worldwide.

As wells are explored at greater depths, the piping becomes heavier. The superior mechanical strength of duplex stainless steel benefits the industry by allowing for lighter design. Outokumpu offers a wide range of duplex stainless steel grades, from lean duplex up to superduplex stainless steels. We have pioneered the development of duplex during the years and we are producing roughly half of all duplex stainless steel in the world today and we continue actively to develop new duplex applications for the industry.

Also on the platform, the increased mechanical strength of the duplex grades can be utilized. The most recently developed Outokumpu EDX 2304™ which, thanks to enhanced levels of strength and corrosion resistance, is set to deliver significant material savings and lifecycle advantages. The present lifetime of a platform in stainless steel is more than 50 years with the intention to increase it even further.

The technical challenges for the industry, such as increased depths, tar sands, heavy oils, more sour wells, arctic and high pressure / high temperature conditions require materials able to cope with these harsh environments. Outokumpu, with its large product portfolio, offer not only superduplex but also a variety of superaustenitic stainless steel grades, tailor made for the most demanding processes. In addition, we deliver solutions that include training in stainless steel grades and guidance in welding and other technical services.



The right choice of grades

Chemical composition

	International steel No				Chemical composition, % by wt. Typical values						
	Outokumpu Steel name	EN	ASTM	UNS	ISO	C	N	Cr	Ni	Mo	Others
Duplex	LDX 2101 [®]	1.4162	–	S32101	4162-321-01-E	0.03	0.22	21.5	1.5	0.3	5Mn Cu
	2304 ¹	1.4362	–	S32304	4362-323-04-I	0.02	0.10	23.0	4.8	0.3	Cu
	LDX 2404 [®]	1.4662	–	S82441	4662-824-41-X	0.02	0.27	24.0	3.6	1.6	3Mn Cu
	2205	1.4462	–	S32205 ²	4462-318-03-I	0.02	0.17	22.0	5.7	3.1	
	4501	1.4501	–	S32760	4501-327-60-I	0.02	0.27	25.4	6.9	3.8	W Cu
	2507	1.4410	–	S32750	4410-327-50-E	0.02	0.27	25	7	4	
Wet corrosion and general service											
Austenitic	4404	1.4404	316L	S31603	4404-316-03-I	0.02		17.2	10.1	2.1	
	904L	1.4539	904L	N08904	4539-089-04-I	0.01		20.0	25.0	4.3	1.5Cu
	254 SMO [®]	1.4547	–	S31254	4547-312-54-I	0.01	0.20	20.0	18.0	6.1	Cu
	4565	1.4565	–	S34565	4565-345-65-I	0.02	0.45	24	17	4.5	5.5Mn
	654 SMO [®]	1.4652	–	S32654	4652-326-54-I	0.01	0.50	24	22	7.3	3.5Mn Cu
	4529	1.4529	–	N08926	4529-089-26-I	0.01	0.20	20.5	24.8	6.5	Cu
Heat and creep											
	153 MA [™]	1.4818	S30415	S30415	4818-304-15-E	0.05	0.15	18.5	9.5		Ce
	253 MA [®]	1.4835	S30815	S30815	4835-308-15-U	0.09	0.17	21	11		Ce
	4845	1.4845 ²	310S ²	S31008	4845-310-08-E	0.05		25	20		

¹also available as EDX 2304[™] with modified composition for enhanced properties. ²also available as S31803 with PRE minimum 28

Duplex

With its higher mechanical strength, the benefits of using duplex grades can give quite significant weight savings, as thinner materials in many cases can be specified.

LDX 2101[®]

Resistance to pitting, crevice corrosion and stress corrosion cracking (SCC) is higher than for 4307 (304L). This, combined with superior strength, makes it to a cost effective material. LDX 2101[®] is a maintenance-free alternative for cable trays, stairs and walkways. Thanks to its high strength it is also a candidate for sub-sea applications.

2304

Replaces 4404 (316L), especially where there is a risk of stress corrosion cracking or when greater mechanical strength is needed. Typical applications include blast and firewalls.

EDX 2304[™]

An enhanced duplex stainless steel grade with a guaranteed PRE value of at least 28 adhering to the UNS S32304/EN 1.4362 standards. The grade improves on mechanical strength and corrosion resistance compared to standard 2304 and other similar grades. Outokumpu EDX 2304[™] can be used to significantly reduce material thickness in a number of applications, for example blast and firewalls, as well as structural components made from beams and hollow sections. The production process has been approved according to the NORSOK framework.

LDX 2404[®]

A duplex stainless steel with high contents of chromium and nitrogen. This grade combines a higher mechanical strength than for other common duplex grades with a generally high corrosion resistance. Typical applications are piping systems and storage tanks.

2205

The most widely used duplex grade, ideal for a number of applications ranging from main process piping to gravity and centrifugal separators, pump castings and shells to tube heat exchangers. Grade 2205 offers a high overall corrosion resistance, particularly in chloride bearing environments.

2507 and 4501 (Superduplex)

The superduplex stainless steel grades are with their excellent corrosion resistance, high mechanical strength and increased wear resistance, widely used within the oil and gas industry. Typical applications are topside construction, separators, process piping, umbilical tubing and flexible pipes.

Austenitic

4404 (316L) was the first stainless steel grade used in the oil and gas industry. This grade tends to be more and more replaced with duplex and superaustenitic grades.

904L

A highly alloyed austenitic grade with excellent resistance to uniform corrosion in sulphuric acid. It is also highly resistant to pitting, crevice

corrosion and stress corrosion cracking. Applications are typically found in downstream processes like the refinery and petrochemical industry.

254 SMO[®] and 4529 (6 Mo grades)

The 6 Mo superaustenitic stainless steel grades have excellent resistance to pitting, crevice corrosion, and stress corrosion cracking in seawater and marine environments. Due to their high corrosion resistance, applications are found in the harshest conditions such as flue gas cleaning, plate heat exchangers and process piping. The superaustenitic grades are also an excellent choice under arctic conditions.

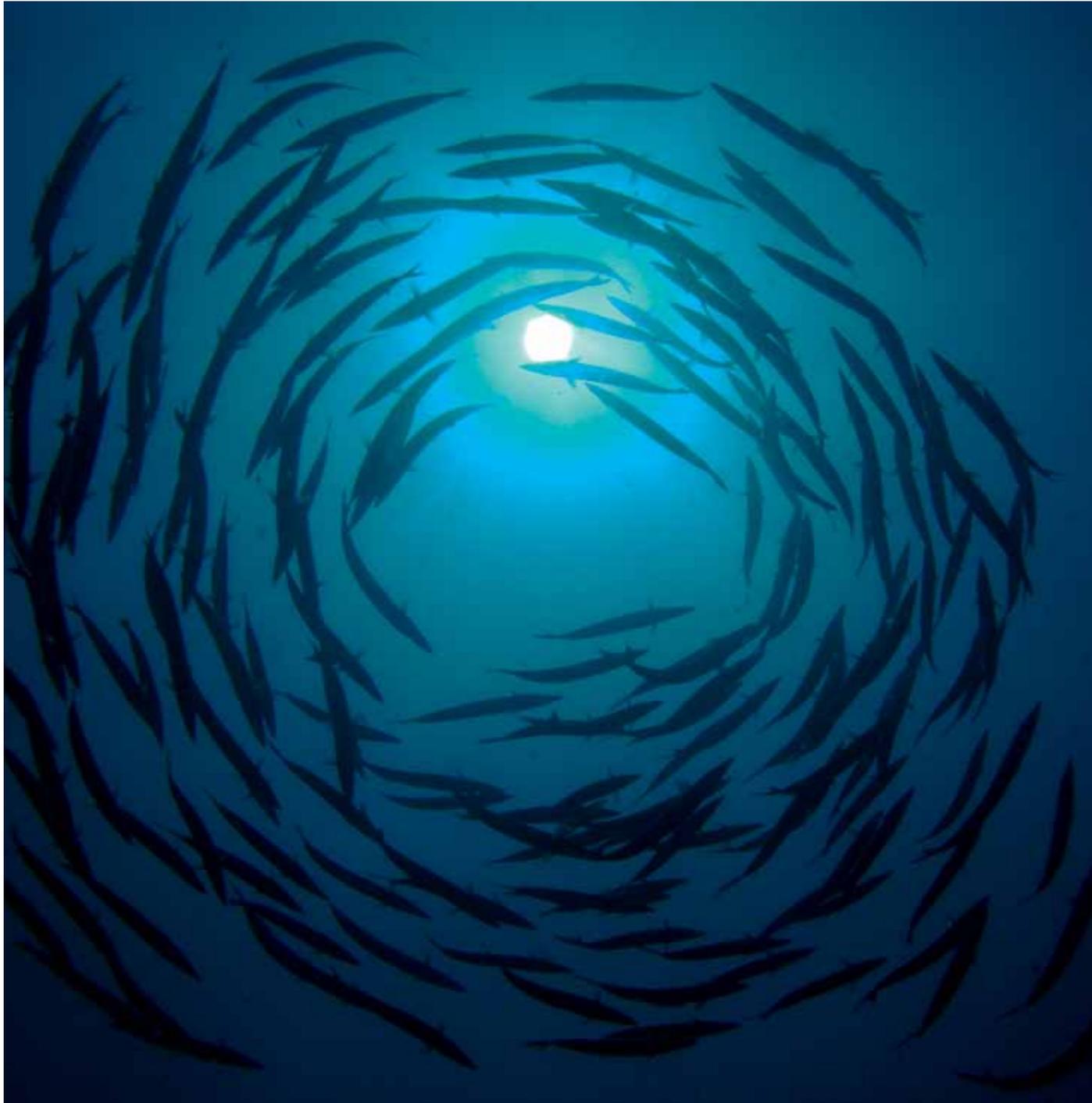
4565

4565 is a superaustenitic stainless steel grade with excellent resistance to pitting and crevice corrosion filling the gap between 254 SMO[®]/4529 and 654 SMO[®]/Ni-base alloys in marine environments.

654 SMO[®]

Superaustenitic 654 SMO[®] is the most corrosion resistant stainless steel grade in the world. With its 7% Mo content it can compete in terms of corrosion resistance with the Ni-base alloys. Moreover it gives several advantages for the oil and gas industry with its lower alloy content, lower density and higher strength. Typical applications are sea water handling where crevice corrosion is a problem.





Applications in exploration and production

Subsea – performance in depth

Subsea solutions play an ever-more important role in future oil and gas extraction with requirements for piping materials becoming more demanding as wells get deeper. That's why stainless steels with higher strength and superior corrosion resistance are needed.

Wellhead equipment and Xmas trees

Demand for reduced maintenance costs throughout the life cycle of offshore installations has made stainless steel the most popular construction material for a variety of units. For wellhead equipment and Xmas trees, martensitic grades (13% Cr) have been used over the years. However, these steels have their limitations. When hydrogen sulphide levels rise, an attack of sour SSC (sulphide stress cracking) or hydrogen embrittlement may set in. Duplex grades are less sensitive to this type of cracking and provide a better solution. Under very severe conditions 254 SMO® and 4529 might be needed as they have even better resistance to these environments. Wellhead and other subsea equipment usually consist of many different materials. In order to avoid corrosion on the carbon steel parts, cathodic protection is mandatory, which unfortunately increases the risk of hydrogen induced cracking. From that perspective, the superaustenitic grades 254 SMO®, 4529 and 654 SMO® are the best choices.

Flowlines

Due to the presence of carbon dioxide, chlorides, hydrogen sulphide and the formation of condensate, corrosion is a very real risk. If you take into account high flow rates and temperatures, it is easy to see

why the material used for flowlines and piping systems has to be durable. Thanks to its superior mechanical strength and high corrosion resistance, all duplex grades are excellent choices. They are economical too; installation costs are in many cases lower for duplex than for clad steel.

Furthermore, grades 254 SMO®, 4529, 2205, 2507 and 4501 are all included in ISO 15156-3 for sour service based on their proven corrosion resistance. Duplex stainless steel has been demonstrated to be one of the best solutions for flexible pipes in ultra-deep wells. As operating environments are becoming harsher, temper-rolled superaustenitic solutions have shown to be an interesting alternative solution.

Umbilicals

Subsea wellheads are connected to platforms by umbilical lines. In this application, reliability is the key. Stainless steel has gained interest against thermoplastic hoses as the construction material of choice. In light of this development, grade 2507 is an excellent choice. Until now umbilical stainless tubing has primarily been made using seamless tubes. In umbilical applications, duplex has been used for shallow water wells but for deep and future ultra-deep wells, it is the superduplex 2507 which is specified today. Longitudinal welded tubes in 2507 is the increasingly chosen alternative to the 2507 seamless solution. The advantages are tighter tolerances, higher mechanical properties and fewer orbital welds.

Topside construction requires advanced materials for top performance

Stainless steels are excellent choices for topside constructions – both technically and economically. In these applications the life cycle cost benefits are significant, while the weight reductions provided by duplex stainless steel help to reduce the overall cost of the project.

Blast and firewalls

Blast and firewalls are erected to protect living quarters and other vital areas. Thanks to reduced maintenance costs and a compelling combination of corrosion resistance and mechanical properties at high temperatures, 4404 (316L) is often used for firewalls. Blast walls need to absorb energy rapidly and possess good resistance to both buckling and corrosion. Duplex grades 2304 and EDX 2304™ provides the necessary properties, while also offering a significant weight and cost reduction compared to 4404 (316L).

Fire protection is vital on offshore platforms: superaustenitic and superduplex grades are replacing the soft Cu alloys in piping systems which have traditionally been used. The higher strength and lower density of stainless steel gives a possibility to downsize pipe diameters and consequently save weight, offering you significant savings.

Cable trays, stairs, tread plates and walkways

Because safety on an offshore platform is a vital consideration, the material used must be able to resist fire and heat. The integrity of cable trays must also be maintained in order to secure pumps, lighting and other auxiliary systems. Thanks to its high temperature properties and modest corrosion resistance, grade 4404 (316L) has become a benchmark. But this is changing and the high mechanical strength in combination with good corrosion resistance make LDX 2101®, 2304 and EDX 2304™ more economical choices.

Main process piping

In offshore wells, production can be complicated. In addition to the incoming mixtures of oil, gas and sand, the main process piping has to withstand seawater, erosion, hydrogen sulphide and carbon dioxide. Extreme conditions – at elevated temperatures and under high pressure process fluids are often highly corrosive – require extreme measures. Grades 2205, 254 SMO®, 2507 and 4501 lend themselves superbly to this type of piping.



Manifolds

The flows from several wells are combined through the use of manifolds - the fluids are just as corrosive as in the main process piping. Where pressures are high, the superduplex stainless steel grades 2507 and 4501 are perfect.

Oil and gas coolers

To combat high temperatures, which increase the corrosiveness of process fluids, coolers are mandatory. Once temperatures have been decreased, the oil and gas can safely be piped ashore or processed further. As many of the tube heat exchangers in these systems use seawater as a coolant, the key is to employ a stainless steel grade with superior corrosion resistance. In this case superduplex and superaustenitic grades are required. In extreme cases the 7% Mo grade 654 SMO®, the world's most corrosion resistant stainless steel grade, is the solution.

Gravity separators

Gravity separators separate the individual constituents of the incoming mixture. Since the environment within the separator is as corrosive as in the main process piping, 2205, 254 SMO®, 2507 and 4501 are used.

Seawater piping

The injection of chlorine into seawater to avoid biofilm formation is widely used in seawater piping applications. Outokumpu's 254 SMO®, 654 SMO® and 4529 have enjoyed widespread success in systems operating at up to 30°C. Furthermore, if you complement 254 SMO® or 4529 piping with 4565 for flanges or other parts with crevices, service temperatures can be increased.

Applications in onshore production, refinery and petrochemistry

Significant weight savings for storage tanks

The high strength of duplex grades has made them the material of choice for storage tanks due to the significant material thickness reductions they enable. Duplex grades have achieved up to 40% thickness reductions in some tank sections, with additional savings in welding material as well as transport and construction costs.

Increased heat transfer and longer service-life for heat exchangers

Replacing the conventional 4404 (316L) with the duplex grade Outokumpu 2205 improves heat transfer and can extend service life significantly. Welded heat exchanger tubes are today replacing seamless tubes in a wide range of applications.

Superior heat resistance for burners and flaring systems

Outokumpu's heat resistant grades have proven themselves over decades in some of the most demanding oil and gas industry applications, including chimneys, burners and flaring systems. The grades offer much better heat resistance than standard high temperature grades, with austenitic Outokumpu 153 MA™ and Outokumpu 253 MA® being the most popular choices.

A wide selection of grades for distillation columns and internal trays

The requirements placed on distillation columns and internal trays vary greatly within the oil and gas industry. For this reason a variety of grades are used depending on the specific application's temperature, pressure, corrosion resistance and other requirements. Outokumpu's decades of experience in these applications, combined with our industry-leading technical support, ensures that the optimal grade can be selected for the purpose.



Cases

Plate heat exchangers for Lanke, China

Gansu Lanke Petrochemical Equipment (Lanke) is one of China's largest heat exchanger manufacturers for the petrochemical industries. The operating conditions in oil refinery plate air-cooler and plate shell heat exchangers are characterized by temperatures of up to 140°C and 170°C respectively and chloride content of hundreds of parts per million (ppm). Lanke sought a solution to lengthen the service life of heat exchangers. In a pioneering solution Lanke successfully replaced



conventional austenitic 4404 (316L) stainless steel in plate air-cooler and plate shell heat exchangers with Outokumpu Duplex 2205. This application of duplex stainless steel in the plates of these types of heat exchangers, previously considered impossible, was realized with strong R&D support from Outokumpu. Using Outokumpu Duplex 2205 in plate air-cooler and plate shell heat exchangers, service life was extended to two years and beyond in oil refineries. The result is marked increase in refinery efficiency. Lanke's first plate air-cooler heat exchanger using Outokumpu Duplex 2205, installed at the Guangzhou Petrochemical Oil Refinery was still in operation after two years from start-up. As a comparison, 4404 (316L) plates normally have a service life of no more than three months (six months in some operating environments).

Liquid natural gas pipeline for EEW, Qatar

To expand the dock loading facility at Qatar's Port of Ras Laffan (the world's largest LNG export terminal with 18 km pipe running in several parallel lines between the storage tanks and loading points), the terminal has a projected flow of 1,120,000 m³ of LNG per year. Outokumpu delivered 4,600 metric tons of 12.7 mm thick continuously produced plate (CPP) and stainless steel quarto plate in grade 4301/4307 (304/304L) grades. Working together with EEW we were able to offer the perfect solution for the installation. Most of the pipes were welded from CPP, while a small volume of the pipes were produced from quarto plate. Stainless steel is increasingly used for LNG piping as natural gas from wells is becoming increasingly sour and requires higher corrosion resistance from pipes than carbon steel can offer. Outokumpu is also able to provide both the required CPP and quarto plates.

The Al Shaheen offshore oil field

Oil and gas have made Qatar one of the world's faster growing countries, with income per capita now equal to that of the EU. Oil and gas account for 70% of Qatar's government revenue. Proven oil reserves of more than 15 billion barrels are expected to ensure output at current levels for 23 years. Qatar's oil production was 790,000 barrels per day in 2005 (estimated). In December that year, Maersk Oil Qatar AS (an A.P. Moller - Maersk Group company) and Qatar Petroleum agreed on further development of the Al Shaheen offshore oil field, some 180 km north of the capital Doha. The field had been discovered in 1992 by Maersk Oil, and Maersk Oil Qatar became the operator. In the first quarter of 2006, the field produced 240,000 barrels per day, and it is projected to reach the level of 525,000 barrels. The number of platforms will peak at 18. Some of the pipes for sensitive sections in the top side equipment on the Al Shaheen platforms are manufactured

by a pipe producer specializing in stainless steel pipes and fittings for demanding applications including oil and gas. The topside equipment on offshore platforms must withstand very high corrosion, especially due to the aggressiveness of crude oil. The pipe producer placed an order with Outokumpu for 408 metric tons of the superaustenitic grade 254 SMO® for the Al Shaheen pipes, with an additional 140 tons in option. This high-alloyed superaustenitic grade was developed and patented by Outokumpu to withstand the most corrosive environments, including those presented by crude oil. Outokumpu has in the past supplied large volumes of this grade for pipes used on offshore platforms designed for 70-year life spans in the North Sea. The Outokumpu supply of superaustenitic 254 SMO® for pipe production comprises 253 tons of plate and 155 tons of coil.

More than material supply

Our service centres worldwide work closely with you to deliver tailor-made parts, and a wide range of options for polished and brushed surface finishes, plasma, laser and water-jet cutting, as well as sawing, press braking and edge preparation for welding.

Materials testing for optimal grade selection

We have extensive experience in testing stainless steels in many environments. The results of many of these tests, covering the most common corrosive elements are available to you in our Corrosion Hand-

book. In specific cases, we can also offer testing of different stainless steel grades in your own processes, supported by testing and evaluation by our specialists in our own corrosion laboratory. These tests, together with our long experience and tradition in the oil and gas industry, ensure that the grade you finally choose is the optimal solution. We study your needs on the spot, delivering professional help not only in material selection but also in planning, logistics advice and adapted service for optimal products, cost-efficient operations, and deliveries according to your schedule

Industry and corporate approvals and certification

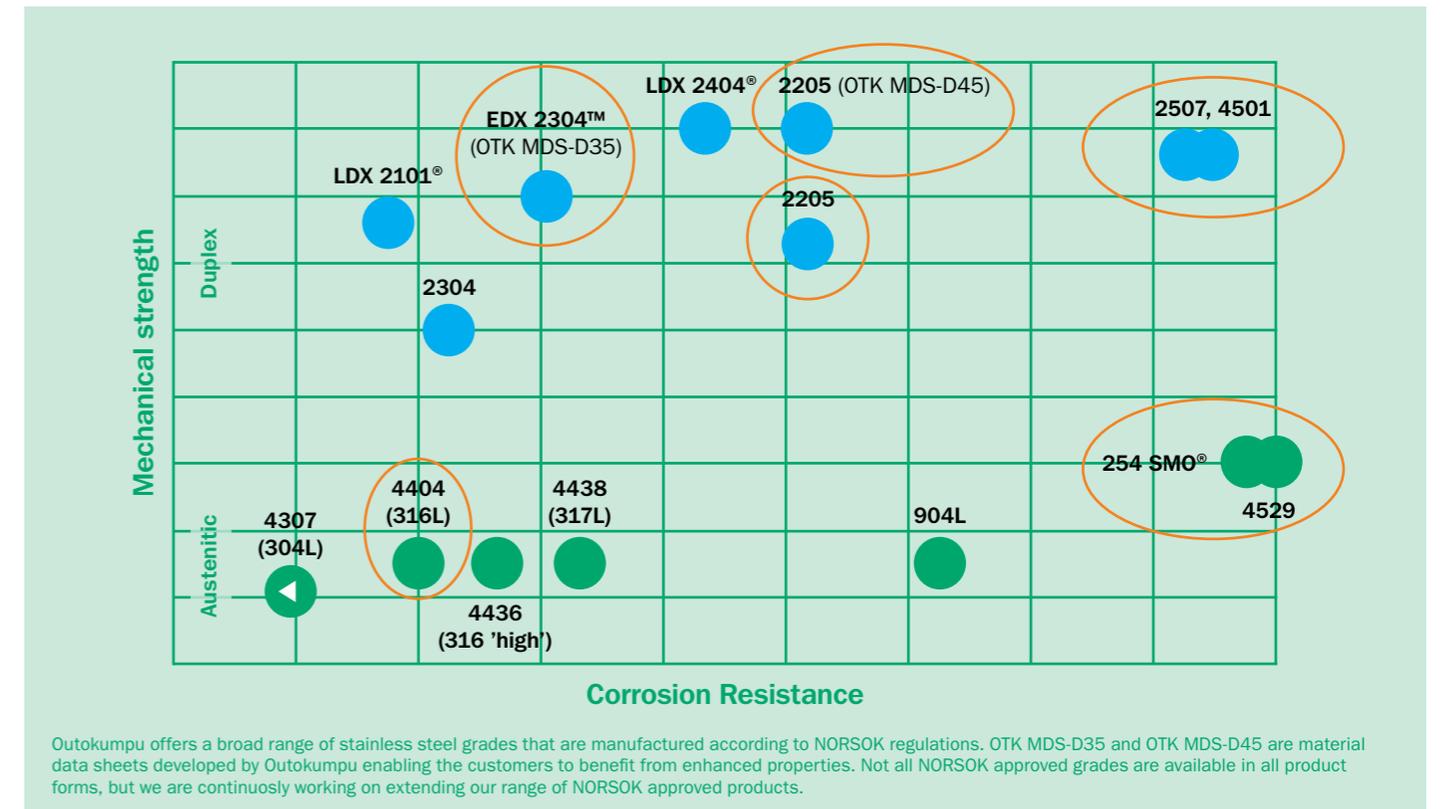
Industry approvals

We have earned key national and international approvals for the oil and gas industry and related applications. These include PED 97/23/EC, ASME, Norsok, AD 2000 Merkblatt, ISO 9001 and ISO 14001.

Company approvals

Our products are approved by major companies in the oil and gas industry. These include Shell, Exxon, Petrobras, Gasco, BASF, Agip, Total, Statoil ASA, Aker Solutions, Indian Oil, Saudi Aramco and Petroleum Development Oman.

Outokumpu approved Norsok portfolio



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.

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