







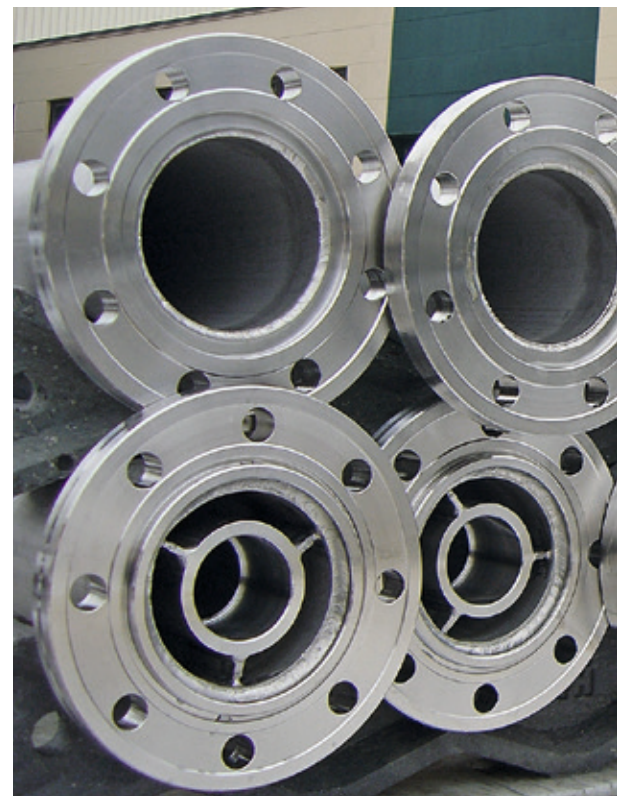


Duplex steels

-  Corrosion resistant pipes
-  Special pipes and components ready for installation
-  Clad pipes
-  Spools and components in CRA or clad materials
-  Vessels, tanks and apparatus
-  Assemblies



BUTTING



Duplex steels in use

All over the world, the name BUTTING stands for high quality pipes, pipelines and components which are used in a great many industries and areas of application.

The core skills of our family business are in the material, forming and welding technology and in quality assurance. Thus we can point to more than 50 years of experience in welding and processing corrosion resistant steels.

Besides austenitic steels, special alloys and titanium, BUTTING has specialised in the fabrication of duplex, superduplex and lean duplex materials.

Since 1979 we have processed more than 250 000 t of these materials to make:

- Pipes
- Components ready for installation
- Spools and welded components
- Vessels, tanks and columns





Table 1: Chemical analyses of some duplex steels

Material	Standard	% C	% Cr	% Mo	% Ni	% N
1.4462	DIN EN 10088-2	Max. 0.030	21.0 – 23.0	2.5 – 3.5	4.5 – 6.5	0.10 – 0.22
UNS S31803	ASTM A240	Max. 0.030	21.0 – 23.0	2.5 – 3.5	4.5 – 6.5	0.08 – 0.20
UNS S32205	ASTM A240	Max. 0.030	22.0 – 23.0	3.0 – 3.5	4.5 – 6.5	0.14 – 0.20

Table 2: Mechanical-technological properties for the raw material at room temperature

Material	Standard	R _{P0.2} [MPa]	R _m [MPa]	A [%]	KV (transverse) [J]	Hardness
1.4462	DIN EN 10088-2	≥ 450	700 – 950	≥ 25	≥ 60	–
UNS S31803	ASTM A240	≥ 450	≥ 620	≥ 25	–	HRC ≤ 31
UNS S32205	ASTM A240	≥ 450	≥ 655	≥ 25	–	HRC ≤ 31

Table 3: Tensile strength (R_{P0.2}) at elevated temperature

Material	100 °C [MPa]	200 °C [MPa]	250 °C [MPa]	280 °C [MPa]
1.4462	≥ 360	≥ 315	≥ 300	≥ 285
UNS S31803	≥ 360	≥ 315	≥ 300	≥ 285

Table 1 – 3: No guarantee for correctness

Pipes manufactured from plate customised for you

Duplex steel takes its name from its two-phase microstructure of ferrite and austenite in approx. equal proportions. “Duplex stainless steel” contains over 20% chromium and approx. 5% nickel, and it is part of the group of stainless steels.

Since around 1970, a series of stainless duplex steels has been developed which have been marketed in the trade under various names. In the final analysis, it was a nitrogen-alloyed version which penetrated the market, generally known today as UNS S31803 or UNS S32205 acc. to ASTM/ASME standards (ASTM A240, ASTM A789/A790, ASTM A928) or material number 1.4462 (X2CrNiMoN 22-5-3) acc. to the DIN EN/VdTÜV standards (DIN EN 10088-2/VdTÜV Material Data Sheet 418).

In material UNS S32205, the minimum chromium, molybdenum and nitrogen content has been increased compared to material UNS S31803.

The duplex materials acquire their optimum properties with a balanced ferrite-austenite ratio of approx. 50:50. Compared to the austenitic stainless steels, duplex steels contain less nickel (approx. 4% to 8%), which results in very good value for money.

Acc. to the VdTÜV Material Data Sheet 418, this material may be used in the temperature range between – 40 °C and + 280 °C.


Table 4: Chemical analyses of some super duplex materials

Material	C [%]	Cr [%]	Mo [%]	Ni [%]	N [%]	W [%]	Cu [%]
EN 1.4501	Max. 0.03	24.0 – 26.0	3.0 – 4.0	6.0 – 8.0	0.20 – 0.30	0.5 – 1.0	0.5 – 1.0
EN 1.4507	Max. 0.03	24.0 – 26.0	2.7 – 4.0	5.5 – 7.5	0.15 – 0.30	–	1.5 – 2.5
UNS S32750	Max. 0.03	24.0 – 26.0	3.0 – 5.0	6.0 – 8.0	0.24 – 0.32	–	0.5
UNS S32760	Max. 0.03	24.0 – 26.0	3.0 – 4.0	6.0 – 8.0	0.20 – 0.30	0.5 – 1.0	0.5 – 1.0
UNS S32520	Max. 0.03	24.0 – 26.0	3.0 – 5.0	5.5 – 8.0	0.20 – 0.35	–	0.5 – 3.0
UNS S32550	Max. 0.03	24.0 – 27.0	2.9 – 3.9	4.5 – 6.5	0.10 – 0.25	–	1.5 – 2.5

Table 5: Mechanical-technological properties for the raw material at room temperature

Material	Standard	RP ⁰² [MPa]	Rm [MPa]	A ⁵ [%]	KV (transverse) [J]	Hardness
UNS S32750	ASTM A240	≥ 550	≥ 795	≥ 15	–	HRC ≤ 32
UNS S32760	ASTM A240	≥ 550	≥ 750	≥ 25	–	HBW ≤ 270

Table 4 and 5: No guarantee for correctness

Superduplex steel

The typical composition of a superduplex steel is illustrated by UNS S32760 with 25% chromium, 7% nickel, 4% molybdenum and 0.25% nitrogen. The material is also alloyed with tungsten and/or copper. The group of superduplex steels is also distinguished by its increased resistance to pitting, crevice and stress corrosion cracking, and an additional increase in its mechanical strength values.

The UNS S32750 and UNS S32760 superduplex grades are currently the most widespread variants and are distinguished by outstanding application properties and by high availability in all the relevant product forms (steel plate, bar, seamless and welded pipes, shaped parts and cast steel).

Since the 1990s, BUTTING has been processing superduplex steel in grades UNS S32760, UNS S32750 (VdTÜV Material Data Sheet 508) and UNS S32550 – mainly to make pipes for the oil and gas industry, but also for desalination plants and geothermal energy production. The underlying requirements for this work depended on project-related specifications, including those from SHELL, Statoil, PDO, Exxon Mobil, BP and other renowned companies.

Table 6: Chemical composition of selected lean duplex materials

Material	C [%]	Mn [%]	Si [%]	P [%]	S [%]	Cr [%]	Ni [%]	Mo [%]	Cu [%]	N [%]
LDX2101 UNS S32101 1.4162	≤ 0.040	5	≤ 1.0	≤ 0.040	≤ 0.030	21.5	1.5	0.50	0.50	0.22
AL2003 UNS S32003	≤ 0.030	≤ 2.0	≤ 1.0	≤ 0.030	≤ 0.020	21.0	3.5	1.75	-	0.17
Uranus 35N UNS S32304	≤ 0.030	≤ 2.0	≤ 1.0	≤ 0.030	≤ 0.002	23.0	4.4	0.25	0.25	0.11

Table 7: Mechanical properties of selected lean duplex materials

Material	R _{P0.2} [MPa]	R _m [MPa]	A50 mm [%]
LDX2101 UNS S32101 1.4162	> 450	> 665	30
AL2003 UNS S32003	≥ 450	> 620	25
Uranus 35N UNS S32304	≥ 430	> 620	25

Table 6 and 7: No guarantee for correctness

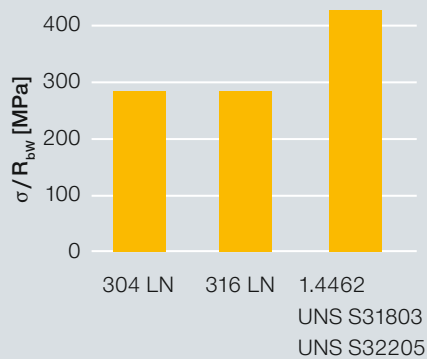
Lean duplex steel

Austenitic-ferritic steels with a lower alloy content than standard duplex steels are grouped together in the so-called “lean duplex” group of alloys. Application areas of lean duplex steel plates to date include vessel construction for the paper and pulp industry and as structural steel civil engineering and bridge construction, where the potential weight saving can be exploited.

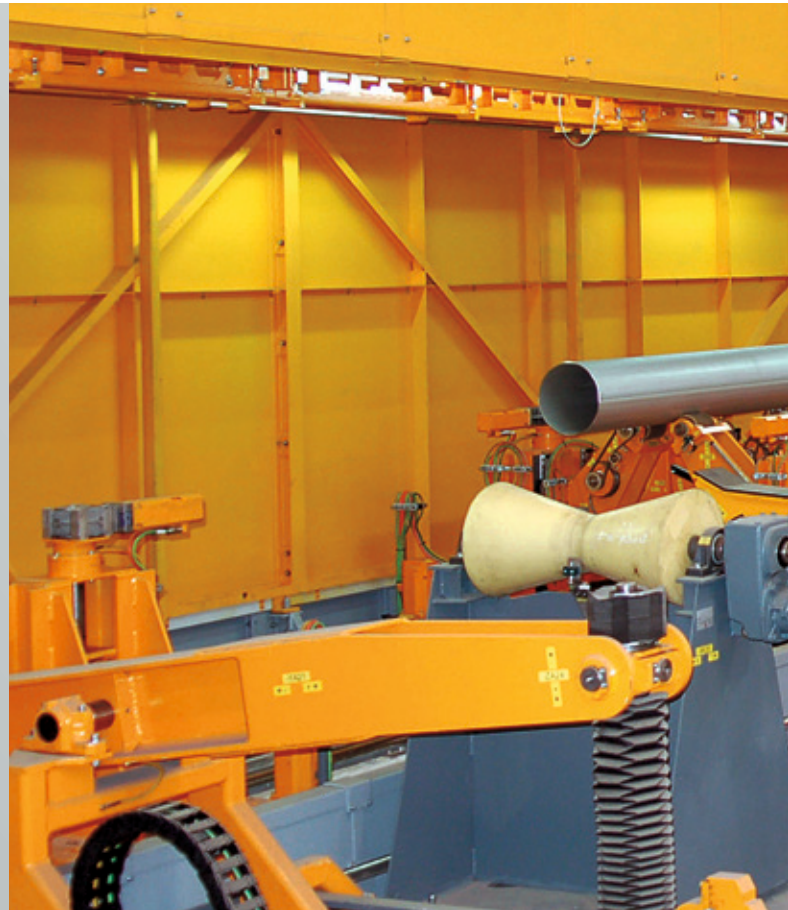
Because of their lower nickel and molybdenum content – compared to standard duplex steels – lean duplex materials are economically attractive and have greater resilience, reliability and ease of working than lower alloy austenitic or carbon steels.

Compared to standard stainless steels, such as TP304L and TP316L, the lean duplex steels offer the benefit that their yield strengths of 430 – 450 MPa represent nearly double the values, and hence allow substantial savings in wall thicknesses. Apart from the high mechanical strength values, the low cost price of these materials at particular relative prices of nickel, chromium and molybdenum may favour the use of lean duplex steels.

Diagram 1: Corrosion fatigue cracking behaviour of smooth samples (Rotating Bending Test) in a 3 % NaCl solution, pH = 7



No guarantee for correctness



Benefits of duplex steels

The duplex steel UNS S31803/UNS S32205/1.4462 is distinguished by high corrosion resistance, due to its high Pitting Resistance Equivalent (PRE = %Cr + 3.3x%Mo + 16x%N) of around 34 in conjunction with its ferritic-austenitic material condition. It is superior to the normal austenitic steels of 1.4571/TP 316L type, mainly in neutral to medium acidic media. It offers particular benefits in relation to:

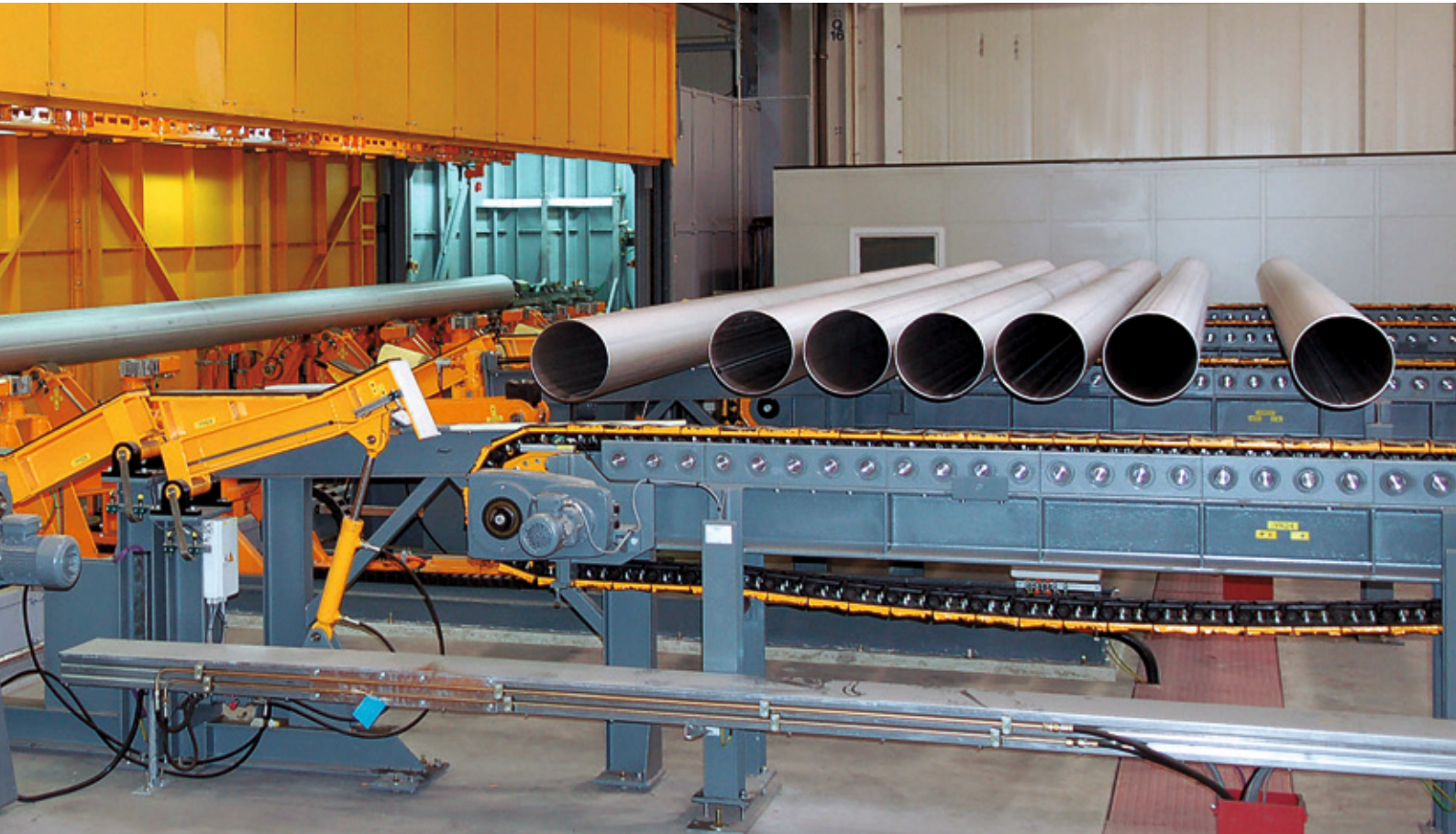
- Pitting corrosion
- Stress corrosion cracking
- Corrosion fatigue cracking

The abrasive behaviour of materials is determined in the first instance by the surface hardness and strength.

Hardness and strength are available in a very favourable combination in UNS S31803/UNS S32205/1.4462 steel, which leads us to expect high resistance to abrasion.

The particular advantage of duplex steels as abrasion resistant steels is the fact that these steels are fully suitable for welding, which is only the case to a limited extent with purely abrasion resistant steels.

Parallel to the high mechanical strength values, super duplex steels have very high resistance to abrasive stress.



Your benefits

We offer our customers:

- Extensive capacities for the production of longitudinally welded pipes and components
- Economic benefits through continuous production processes
- Extensive expertise in processing appropriate to the materials
- Skilful application of all current welding processes, including plasma, TIG, SAW, laser beam and electron beam welding processes
- Guarantee of optimal corrosion resistance through a clean metallic surface as all the products are always subjected to chemical cleaning (pickling)
- Assurance of product quality through consistent quality assurance
- We implement your project-specific requirements through mechanical processes such as grinding or peening the inner and outer surfaces
- Materials available at short notice due to keeping pipes and steel plate of standard sizes in store

The Quality Management System at BUTTING is certified under DIN EN ISO 9001 by the DNV GL. We have a number of other approvals, particularly in the oil and gas industry, including the Norwegian Standards Agency NORSOK and acc. to customer specifications e.g. from Shell, BP, Petrobas, Aramco.



Duplex pipes for an offshore application in the North German Wadden Sea: transport of the pipelines using posts with roller bearings

Duplex steels in use

Duplex steels are used for two main reasons: the first is their corrosion resistance to various corrosive media that occur in the onshore and offshore environment, such as chlorides, CO₂ or low pH values. The second reason is their increased strength.

Typical uses are for:

- Underwater manifolds
- Flow lines
- Process piping and pipelines
- Underwater pipelines
- Topside process systems
- Well heads
- Pump pipes and riser pipes

Thus our duplex pipes are used in projects all over the world, including in:

- Oil and gas industry
- Chemical and petrochemical industry
- Water and waste water technology
- Desalination plants
- Paper and pulp industry
- Drilling and well construction
- Shipbuilding technology



Extensive product range

A wide range of high-performance production facilities offers you a large number of possibilities:

- Longitudinally welded pipes which we produce ourselves
 - With outer diameters from 15 to 2032 mm (80")
 - The maximum ratio of wall thickness to outer diameter is around 1.2:10
 - With wall thicknesses up to 60 mm
 - In random lengths of up to 24 m
 - Acc. to internationally valid standards, including DIN EN, NORSOK, API and ASTM
 - Substantial amount of materials in stock

- Special pipes and components ready for installation
 - Pipes with demanding tolerance requirements
 - Pipes in special geometries
- Spools and welded components
- Vessels, tanks and columns

Our production technology ensures that your project-specific requirements can be implemented:

- Restricted tolerances
- Special sizes
- Special surface treatment
- Individual quality requirements



Rapid availability through extensive store

BUTTING stores a total of more than 5000 t of pipes for you. Thus we store in our parent plant in Knesebeck products including duplex pipes in sizes from 2" to 24" in 10S and 40S. The pipes made from UNS S31803/ UNS S32205/1.4462 are tested acc. to ASTM A928/DIN EN 10217-7.

Since 2012 we also have a store with duplex and superduplex pipes in Calgary, Canada. The sizes range from 6" to 24" in wall thicknesses 10S and 40S. We enable our customers to order pipes within a very short period.

The strengths of our store are supplemented by our comprehensive services. These include supplementary quality controls (destructive and non-destructive tests), making special bevels, laser cuts or individual marking.

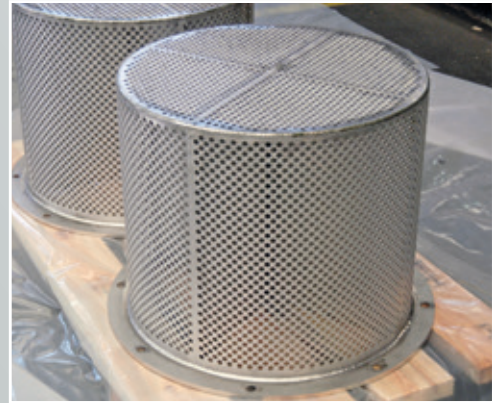
Our production departments can access an extensive steel plate store to cover requirements for pipes and components at short notice. This includes duplex steels with wall thicknesses between 3 and 35 mm, and superduplex steels with wall thicknesses between 3 and 25 mm.



Duplex references

Since 1979, BUTTING products have been used in numerous projects:

- **The Statoil “Sleipner Vest” project:**
2 300 t of pipes in size 508 x 14.5 mm
- **The Mittelplate production island in Germany:**
8.5 km of duplex pipes in sizes 273 x 8mm and 168.3 x 11 mm (in 18 m production lengths) as well as six vessels made from duplex
- **A gas collection station for the “Kela 2” project:**
Among other things, BUTTING supplied more than 4 500 m of pipe with a diameter of 508 x 15.9 mm
- **Lurgi for the generation of bio-energy:**
16 columns up to 20 m high, as well as 11 dryers and 2 flat bottom tanks
- **BHP Petroleum for the “BHP Billiton Zamzama Gas Plant” project:**
958 t of pipes in size 219.1 x 8.74 mm
- **Saipem for the Gbaran-Ubie field:** nearly 1 200 t of pipes made from plates in 12 m random lengths
- **ESSO for the “Gippsland Basin” project:**
276 t of pipes in size 219.1 x 10.9 mm
- **GDF Suez for the “L5a-D line pipe” project in the North Sea:**
2 000 t of pipes in size 273.1 x 15.09 mm
- **Stulz-Planaqua for water preparation:**
3 vessels with a diameter of more than 6.5 m and a height of 24 m
- **INPEX for the Australian “Ichthys” project:**
1 000 t of pipes in different sizes from 8” to 18”
- **McDermott Asia Pacific for the upstream “Ichthys” project:**
870 t of pipes in size 275.1 x 24.4 mm
- **PDO for the “Line Pipe Delivery” Programme 2014/2015:** 2 100 t pipes in sizes 8” x 5.6/6.4 mm



Superduplex references

BUTTING impresses for example with the following projects:

- **Woodside for the “Perseus-over-Goodwyn” project in Australia:** pipes in size 508 x 50 mm
- **Shell for the “Kingfisher” project:** more than 1 800 t of longitudinally welded pipes in size 273 x 13.75 mm, laid using the reeling procedure
- **Desalination plant in Asia:** processing of more than 162 t of plates made from superduplex into pipes of different sizes, including 36” x 23.84 mm
- **BG Tunisia for flow lines in the Miskar field:** approx. 6 000 m of pipes in size 273 x 14.3 mm, as well as 600 m of riser pipes and a variety of elbows
- **Desalination plant in the United Arab Emirates:** 70 t of duplex and superduplex pipes
- **Suction and feed pipe for sea water in the Emirate of Qatar:** prefabrication of spools with outer diameters of 24”, 28” and 88”
- **Superduplex filter screens for drilling and well construction technology**
- **CalEnergy in the USA for transfer lines:** more than 850 t of pipes with outer diameters of 20”, 24” and 30”
- **Subsea 7/Total for the “West Franklin” project:** 752 t of pipes in size 362 x 35 mm
- **Talisman for the “Montrose” project:** 116 t of pipes in different sizes from 8” to 18”
- **BG Norge for the “Knarr Development” offshore project:** 747 t of 8” pipes
- **TAQA for the “Cladhan” offshore project:** more than 17 000 m of pipes in size 273.1 x 16.1 mm



Lean duplex references

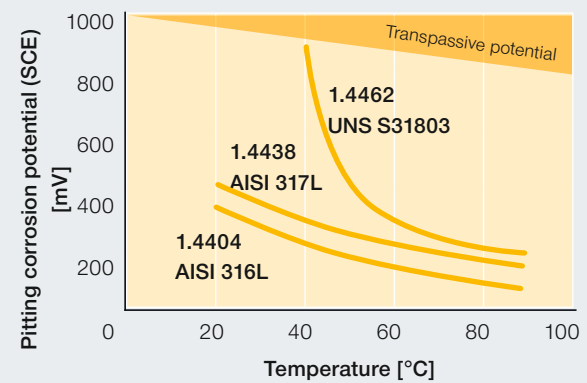
The first industrial applications of lean duplex materials took place in less critical areas, such as for mounting brackets or pressureless storage vessels. By now, we find lean duplex materials also in vaporiser units, supply pipes for offshore plants or as a decorative construction material in some architecture or construction projects, as well as in the paper and pulp industry or the chemical industry.

BUTTING was the chosen supplier for e.g.:

- **Production and installation of a pressure vessel** for a paper and pulp producer in Sweden with a total volume of more than 700 m³, a diameter of more than 7.60 m and a height of 20 m. More than 73 t of plates with wall thicknesses of 8 to 15 mm were processed during prefabrication in Schwedt
- **Production of vessels and on-site supervising** at a paper and pulp mill in South Africa: a 59 t pressure vessel with a carbon steel skirt support and 28 other tanks and vessels
- **Production of pipes** for an internationally-oriented chemical company. The order comprised around 1 900 m of longitudinally welded pipes from coil, measuring 114.3 x 3.6 mm in 12 m lengths. Pipes in size 88.9 x 3.2 mm were also made from individual plates in 6 m manufacturing lengths. Various flanges of standard duplex 1.4462 and the standard austenite 1.4571 were also made. The package also contained 100 elbows constructed in two halves as well as some reducers and tees in the appropriate sizes.



Diagram 2: Critical pitting corrosion potential of different steels depending on the temperature in a 3 % NaCl solution



No guarantee for correctness

Processing of duplex steels

UNS S31803/UNS S32205/1.4462 steel is suitable for cold forming. However, due to its high mechanical strength values, higher forming forces are required than for austenitic stainless steels. When performing cold forming, please note its high spring back properties. Duplex steels are also suitable for hot forming. This should be undertaken in the temperature range between 1000 °C and 1100 °C. After hot forming, rapid cooling is recommended, and subsequent heat treatment may be required.

Note: due to the high ferritic ratio of around 50%, UNS S31803/UNS S32205/1.4462 has a very low creep resistance at temperatures higher than 800 °C. When hot forming or heat treatments take place at higher temperatures than 1000 °C, a very high deformation has therefore to be expected.

Superduplex steels are also suitable for cold forming. The even higher mechanical strength values (and spring back properties) compared to normal duplex steels must be taken into account in that process.

In hot forming of superduplex steels, the temperature range between 1050 °C and 1280 °C should be maintained. Then rapid cooling should take place or further heat treatment should be carried out. The range between 1000 °C and 700 °C must be traversed within two minutes to avoid Sigma phases. Due to the possibility that other undesired metallic phases could arise, further cooling down to 300 °C should be undertaken as quickly as possible.



Welding of duplex steels

Duplex steels can be welded according to the processes generally used for highly alloyed steels, i.e. the following procedures or combinations can always be used: submerged arc welding, TIG process, plasma welding, metal-active gas process, laser beam welding, electron beam welding.

Welding with the addition of filler metal is generally recommended.

The cooling speed from the welding heat has a very great impact on the austenite-ferrite ratio that is produced at room temperature. Thus a retarded cooling leads to a higher austenite content than rapid cooling, after which up to 90% ferrite is to be expected. Depending on the welding procedure and the seam geometry, it is possible to influence the ferrite/austenite ratio in this way. It is advisable for retarded cooling to be undertaken,

in temperatures between 1 100 °C and 1 000 °C. With duplex steel it should be ensured that the temperature range between 950 °C and 700 °C is traversed in no more than two minutes. Due to the possibility that other undesired metallic phases could arise, further cooling down to 300 °C should be undertaken as quickly as possible.

Superduplex steels are also easy to weld acc. to the usual rules for welding stainless steels. Extremely low and extremely high heat input should be avoided, depending on the seam geometry, the thickness of the steel and the welding process.

Superduplex materials always react more sensitively towards precipitation. Therefore it is necessary to monitor the interpass temperature and the heat input during the welding process.



Heat treatment

The safest way to a balanced ferrite/austenite ratio in the weld seam is subsequent heat treatment, so-called solution annealing. For duplex materials, holding times of 2 to 3 minutes for each mm of wall thickness at temperatures around 1080 °C are sufficient to achieve a balanced austenite/ferrite ratio.

After annealing, cooling as rapidly as possible is advisable. In any case it should be ensured that the temperature range between 970 °C and 700 °C is traversed in no more than two minutes to avoid Sigma phase formation. Due to the possibility that other undesired metallic phases could arise, further cooling down to 300 °C should be undertaken as quickly as possible. Annealing eliminates hardening arising during further processing, while also ensuring the most favourable microstructure for corrosion stress. If annealing is carried out in an oxidising atmosphere, the resulting scaling must then be removed, e.g. by pickling.

Typical solution annealing temperatures:

- For duplex/lean duplex materials:
1040 °C to 1100 °C with water cooling
- For superduplex materials:
1080 °C to 1160 °C with water cooling



Surface treatment

Chromium-nickel steels have an optimal corrosion resistance with a metallic bright surface. The best solution for this purpose is a subsequent chemical surface treatment in the form of pickling treatment (full body pickling or spray pickling).

BUTTING always cleans and passivates all products by means of a chemical full body pickling process.

In order to achieve a clean and corrosion resistant surface, the oxide layers arising from the heat influence can also be removed by grinding, peening or brushing. However, corrosion tests show that pickling is the appropriate procedure for stainless steels.

If scale continues to attach itself stubbornly, peening may be undertaken before the pickling process. The type of further processing should be tailored to the demands made on the material in use as well as the on-site possibilities.



– more than pipes –

ООО «ТИ-СИСТЕМС» ИНЖИНИРИНГ И ПОСТАВКА ТЕХНОЛОГИЧЕСКОГО ОБОРУДОВАНИЯ
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