WELDING NEWS

Avesta Welding

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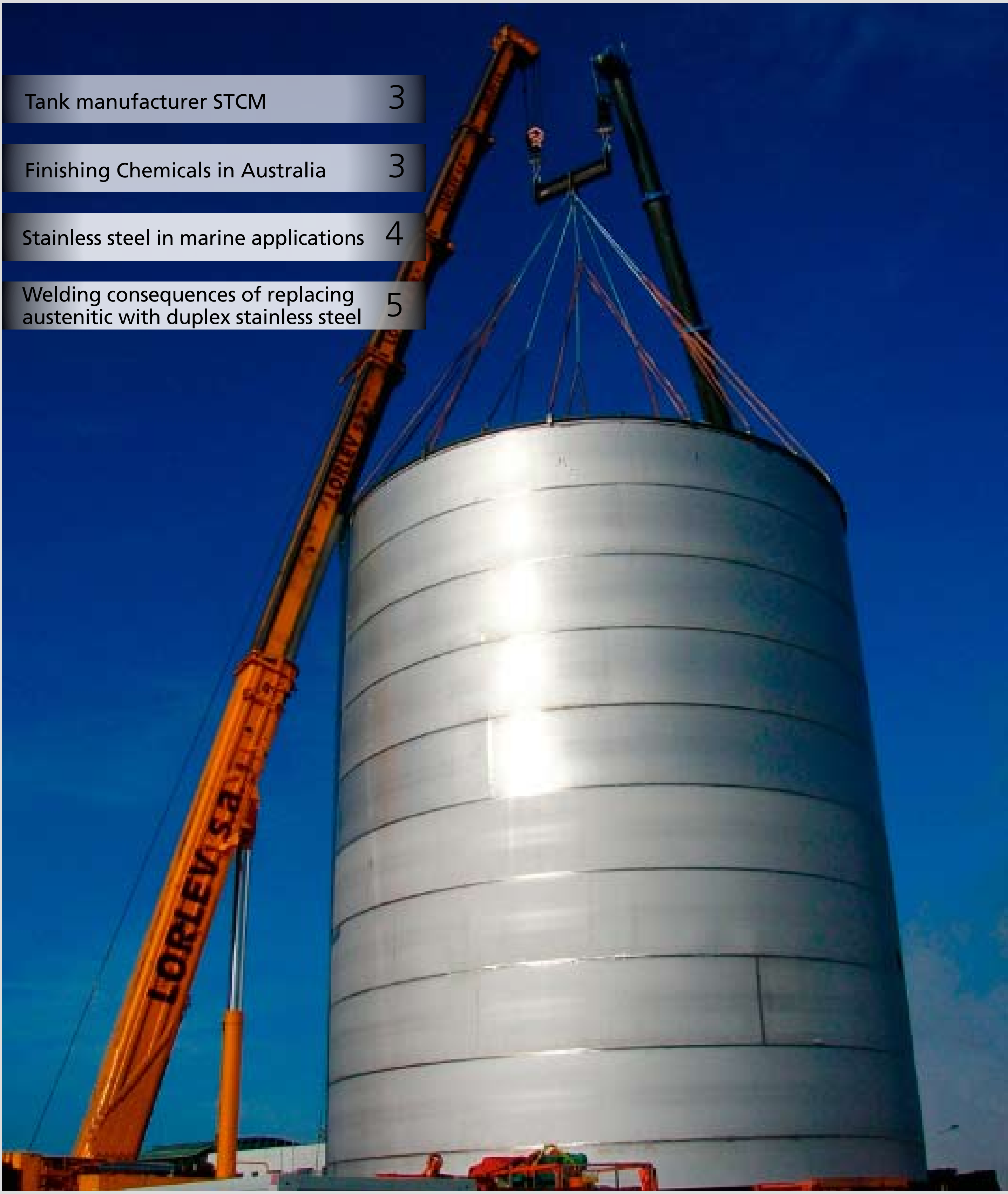

Strong presence at busy Beijing fair

The stand finally ready and the Avesta Welding team looking forward to meeting old and new customers at the 4-day event!

Since its premiere in 1987, the Beijing Essen Welding & Cutting Fair has developed into Asia's largest international welding fair. This year, Avesta Welding took the opportunity to have a strong presence at the 13th fair from 14 – 17 May.

The four days were very busy. Apart from meeting new potential customers, we also had the great pleasure of meeting many existing customers who called in at Avesta Welding's stand.

With special emphasis on LDX 2101, our focus at this fair was duplex stainless steels. Visitor interest was large and our latest information offerings proved so popular that we will have to restock! The following were amongst the highly appreciated materials:

- How to Weld Duplex Stainless Steel.
- The most recent edition of "The Avesta Welding Manual" (rapidly establishing itself as something of a stainless steel bible).
- Publications on our environment-friendly pickling and passivation products.

The official flower of Dalecarlia is "Ängsklocka" (Campanula patula).

Celebrating 75 years of Stainless Welding excellence

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Cover picture
A finished storage tank being lifted into place at Cristal Union's plant in Bazancourt.

Tank manufacturer STCM offers depth and experience

Offering its customers design and manufacturing of, amongst other things, welded high-capacity tanks and silos, French company STCM is a dynamic player on the European market.

STCM was founded in 1971 in Reims, northeastern France. This is still the company's base. Over the years, its operations have developed from the making of general equipment to today's highly specialised production of large welded containers and storage tanks (100 – 70,000 m^3) in carbon, stainless and duplex steels.

STCM offers everything from design to manufacture and assembly of various components. Furthermore, from drawing board to finishing and on-site assembly, the company can take care of all parts of the manufacturing process.

Exploiting its specialist expertise, STCM has also been able to develop new and efficient processes. Welding is just one area to have benefited in this respect. Since last year, the company's quality system has had ISO 9001:2000 certification. STCM's main operations centre on storage and transport tanks. The market for these is in staple industries such as agriculture, pulp and paper, oil, energy and chemicals. In all these sectors, STCM has acquired substantial experience and a large number of references.

Ethanol storage tanks, BNEP, Lillebonne

With its filler metals being used predominantly in stainless and duplex tanks, Avesta Welding has become an important partner. Last year, STCM built tanks in duplex 2304.

"STCM has always engaged Avesta Welding as experts in welding stainless steel," concludes Thomas Clemenceau.

Australia – a growing market for Avesta Finishing Chemicals

In recent years, sales of Avesta Finishing Chemicals' products for treating stainless steel surfaces have increased substantially in Australia. A major customer here is Perfab Engineering Pty Ltd, one of the leaders in stainless steel equipment for the wine, pharmaceutical, dairy, food and beverage industries.

Avesta Cleaner 401 was used to clean the tanks for Goro Nickel mine.

Australia is seeing markedly increased demand for Avesta Finishing Chemicals' products for stainless steel pickling, passivation and cleaning. Avesta FinishOne 630 is amongst the products that are doing well. **Richard Raper**, technical sales representative at Avesta Welding and Finishing Chemicals, a division of Bohler Uddeholm Pty Ltd in Australia, reveals: "Many of our customers choose this efficient and environment-friendly passivating agent."

In 2007, Australian sales were 50 percent up on 2006. The first quarter of 2008 has also seen a 50 percent rise compared to the same period in 2007. Furthermore, sales in the first three months of 2008 equal those for the whole of 2006. Two new products, RedOne240 spray and BlueOne130 paste, account for most of the increase.

We have very good support from Bohler Uddeholm in that country," says **Lesley Wendelrup**, product manager at Avesta Finishing Chemicals.

"Thanks to Richard Raper and national Avesta products manager **Bill Aitken**, we are doing extremely well in Australia.

Perfab Engineering Pty Ltd, an engineering services and manufacturing company, is one of the biggest users of stainless steel surface treatment chemicals in Australia. Earlier, Perfab was predominantly a manufacturer of wine tanks. However, drought has had a great effect on the wine industry and the company has turned its attention to water-based projects. Desalination, reverse osmosis and sewage treatment are a few examples of these.

The tanks the company is currently working on are for the Goro Nickel mine in New Caledonia, a South Pacific island a few hours flight off the northeast coast of Australia. The tanks weigh about 16 tonnes each and are all in various thicknesses of SS304.

At the moment, Perfab Engineering is installing a full-scale pickling facility. Throughout this construction project, which is now nearing completion, there has been consultation with Bill Aitken, Richard Raper and Lesley Wendelrup.

"I visit a lot of stainless workshops in Australia. Perfab Engineering is heading in a direction that will soon make it the premier manufacturer of stainless steel equipment in New South Wales, if not the East Coast of Australia," comments Richard Raper.

Stainless steel in marine applications discussed in Zagreb

Avesta Finishing Chemicals recently took part in a seminar, "Stainless steels – their use and corrosion problems in marine applications", in Zagreb, Croatia.

The seminar and adjacent fair were organised by Dr Ivan Juraga from the Faculty of Mechanical Engineering and Naval Architecture of the University of Zagreb.

Marine corrosion

At the seminar, **Gustaf Cid**, development engineer at Avesta Finishing Chemicals, gave a presentation on the chemical cleaning of stainless steels and the increased importance of such cleaning at coastal installations. Not least aesthetically, marine corrosion is a major problem. Gustaf demonstrated how regular cleaning with Avesta's products can restore a stainless finish to even the most corroded structures.

Pickling prevents corrosion

A visit to the water treatment plant at Krk highlighted the importance of pickling. After only 1.5 years in operation, severe corrosion problems have arisen here. The attacks, which are only found on welds that were not pickled, have meant that new replacement material has had to be fitted in large parts of the plant. Replacement has been very costly and necessitated the shutting down of operations.

Harmful microorganisms

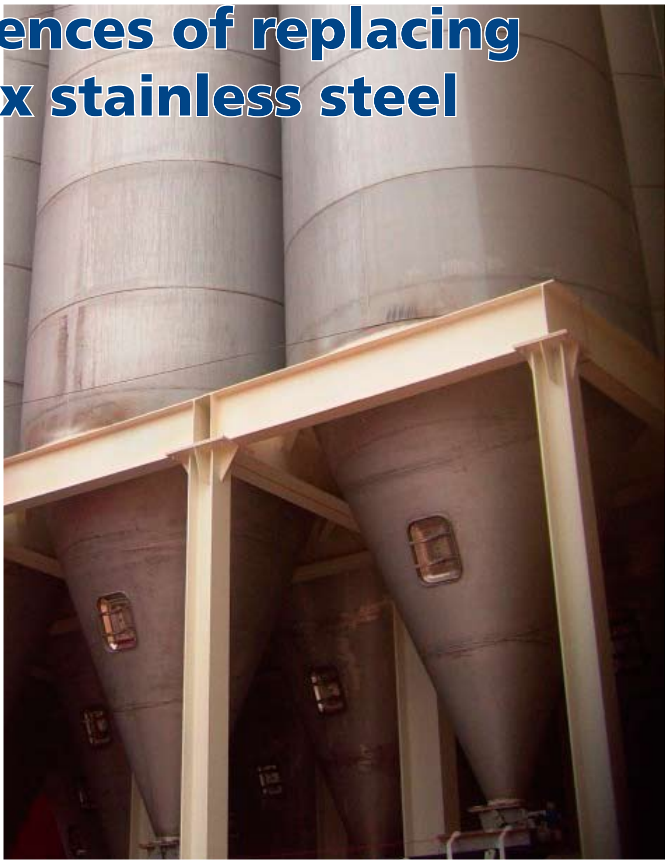
At the water treatment plant, **Dr Paul Linhardt** of the Vienna University of Technology noticed manganese-oxidising microorganisms (MOMOs). Dr Linhardt states that, in stainless steel plants with poorly passivated (i.e. not pickled) surfaces, these microorganisms cause great damage in the form of corrosion. This can be so severe that welded joints leak within a couple of weeks. As shown by Dr Linhardt's detection methods, the plant was indeed infected with MOMOs. These probably came from the plant having been pressure tested with raw water that contained bacteria.

Left to right: Dr Paul Linhardt, Dr Ivan Juraga, Gustaf Cid and Vinko Simunovic at the reservoir in Krk

Untreated welded joint showing severe corrosion after only 1.5 years in operation

Marine corrosion before and after cleaing with Avesta Rustremover™

The welding consequences of replacing austenitic with duplex stainless steel



Duplex stainless steels are increasingly replacing austenitic steels, e.g. in storage tanks and silos.

Modern duplex stainless steels provide an excellent combination of good corrosion resistance and high strength. In recent years, a further major force driving the switch from austenitic stainless steels to modern duplex stainless grades has been the much higher prices of, for example, nickel and molybdenum. Thanks to their chemical compositions, duplex grades can be produced and supplied at far more stable price levels than is the case for austenitic grades.

This article aims to give users a few guidelines on how to make the most of the shift from standard austenitic to duplex stainless steels. The paper will also give some typical examples of where the change in materials has caused unexpected problems. Finally, it will show how, by using a new standardised quality method (EN ISO 3834-2, "Quality requirements for fusion welding of metallic materials"), users can avoid unexpected phenomena.

Table 1: Composition and yield strength of some duplex grades (hot rolled plate)

Steel grade	ASTM	EN	Chemical composition, typical values, w%					Yield Strength (MPa)		
			C max.	N	Cr	Ni	Mo	*Others	Min.	Typical
LDX 2101®	S32101	1.4162	0.03	0.22	21.5	1.5	0.3	5 Mn	450	480
2304	S32304	1.4362	0.02	0.10	23	4.8	0.3		400	450
2205	S32205	1.4462	0.02	0.17	22	5.7	3.1		460	510
2507	S32750	1.4410	0.02	0.27	25	7	4		530	550
4401	316	1.4401	0.04	0.04	17.2	10.2	2.1		220	280

LDX 2101® trademark owned by Outokumpu Stainless

Guidelines for working with duplex steels

In the guidelines given below, most of the comparisons relate to austenitic stainless steels. These are still the dominant grades.

Cold forming and machining

The yield strength and spring-back of duplex steels are higher than those of austenitic steels. Consequently, forming tools must be designed for greater working forces. Due to the somewhat lower fracture elongation of duplex steels, bend radii should not be too sharp. In general, duplex steels are more difficult to machine than conventional austenitic grades. However, with excellent machinability, LDX 2101 is an exception.

Joint preparation

All common joint preparation methods used for stainless steels can be used for duplex steels. If thermal cutting is used, residual oxides must be removed before welding.

Joint types

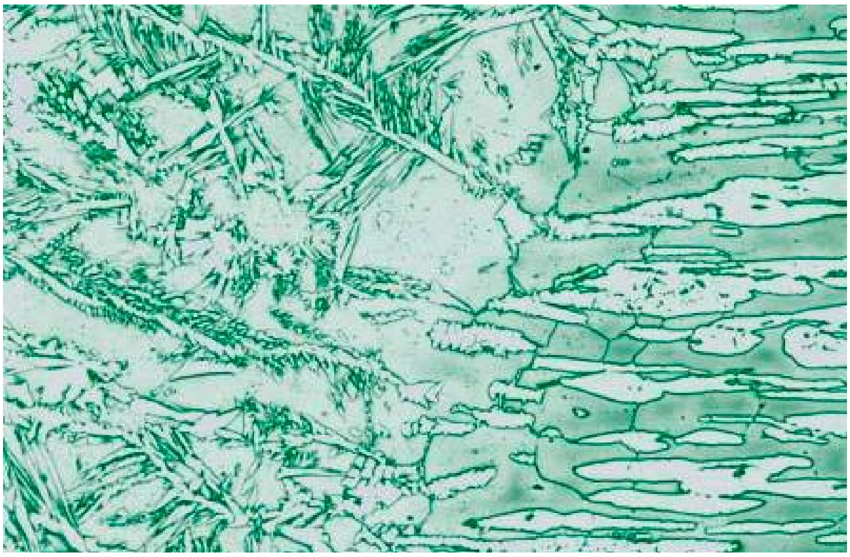
To facilitate good penetration and avoid slag inclusions and hot cracking, joint angles should be about 10° greater than those used when welding standard austenitic grades. Owing to somewhat lower penetration, the land should generally be smaller. For optimum mechanical and corrosion properties, a filler metal should be used in most cases. Where they are used, the weld can be made in a gap between the plates.

Tacking

Compared to tacks for austenitic grades, the tacks for duplex steels must be longer and more closely spaced. Fillers that match the parent metal must be used. Guidelines for austenitic grades must not be adhered to when tacking duplex steels – the higher residual stress of duplex welds could result in cracking.

Weldability in general

Modern duplex steels with well-balanced chemical compositions give a HAZ with limited grain growth. To achieve a good ferrite/austenite balance in the weld metal, specially designed duplex filler metals must be used. Avesta Welding's specially designed matching fillers are set out in table 2 below.


Duplex structure

Duplex steels can be welded using most methods used to weld stainless steel. Autogenous welding (common in resistance, laser and electron beam welding) can have a negative impact on microstructure and thus affect weld properties.

The effect of ferrite content excites much discussion. As regards corrosion and strength, the effect of ferrite contents between 20 and 75% cannot be measured in most cases. When welding without a filler, ferrite levels in the weld metal can sometimes exceed 90%. This can reduce elongation/strength and lead to problems when the weld is subject to strong deformation. The ferrite/austenite balance can also be influenced by: cooling rate; choice of filler; degree of fusion of the parent metal; and, to some extent, shielding gas composition.

Owing to the composition of duplex steels, the welding speed in fully automatic production lines is somewhat lower than when welding 300-series steels. Welders might notice decreased penetration and lower fluidity. To improve penetration and fluidity, argon with an addition of helium and hydrogen can be used as the shielding gas. In TIG and plasma welding, a 1 to 2% addition of nitrogen to the shielding gas improves ductility, strength and resistance to pitting. Purging gases containing nitrogen are also beneficial for corrosion resistance. In FCAW, the shielding gas is normally 80% Ar + 20% CO_2. However, pure CO_2 can also be used.

Table 2: Avesta Welding's matching duplex filler metals

	Avesta designation	EN	AWS
		EN 1600	**A5.4**
	LDX 2101	-	-
MMA	2304	-	-
	2205	22 9 3 N L R	E2209
	2507/P100	25 9 4 N L R	E2594
		EN 12072	**A5.9**
	LDX 2101	-	-
Tråd*	2304	-	-
	2205	22 9 3 N L	ER2209
	2507/P100	25 9 4 N L	ER2594
		EN 12073	**A5.22**
	LDX 2101	-	-
FCW	2304	-	-
	2205	-	-

* MIG, TIG and SAW wire

Post-weld cleaning

Like other stainless steels, to restore their full corrosion resistance, duplex steels must normally be pickled after welding. Post-weld cleaning is extremely important where the welded structure is to be exposed to an environment containing halogenides and where the media itself will not remove the weld tint.

Post-weld heat treatment (PWHT)

Compared to standard austenitic steels, PWHT can be a little more complicated for welded duplex grades. This is because the duplex steels relatively rapidly form sigma phase. In complex structures where thickness varies between different parts, the various sections are exposed to different thermal cycles. This could result in varying properties. In special cases, welded duplex structures can be stress relieved at 550 – 580°C. If possible, full annealing at about 1,000 – 1,100°C gives the best restoration of the material. To avoid the high temperature causing large deformations, it may be necessary to support complex structures.

Welding LDX 2101 (ASTM S32101/ EN 1.4162)

LDX 2101 reforms austenite very well during welding. When welding with fillers, the matching Avesta LDX 2101 should be used. The formation of intermetallic phases such as sigma is sluggish. However, nitride precipitates may form in the HAZ and in autogenous weld metals. Acceptable weld properties can be obtained by using a suitable heat input. In SAW, large fusion of the parent metal must be avoided. The use of a basic flux gives a weld metal with better ductility. Modern pulse equipment must be used for MIG welding. The best weldability has been obtained using a three component shielding gas, Ar + 30% He + 1.5 – 3% CO_2. As for many other duplex stainless steels, the heat input and interpass temperature are 0.5 – 1.5 kJ/mm and < 150°C respectively.

Welding 2304 (ASTM S32304/ EN 1.4362)

The best weld properties are obtained using a specially designed filler such as Avesta 2304. Thanks to the relatively low nitrogen content, high speed welding and good penetration are both possible. Weldability is at least as good as that of duplex steel 2205 (i.e. very good). The low molybdenum content is the main reason for the steel not being prone to formation of deleterious precipitation during welding. However, traces of nitrides may be found in the HAZ and in the weld metal. To increase strength, nitrogen must be added to the shielding gas in autogenous welding. Gases for MIG can be of the same type as those used for LDX 2101. In SAW, to increase weld metal ductility, the use of a basic flux is advisable. Because of the steel's low nitrogen content, resistance welding procedures must be optimised to increase the austenite content in the weld and the strength / ductility / corrosion resistance of the weld metal / HAZ. When welding with other methods, the heat input range can be somewhat wider than that used for LDX 2101 and SAF 2507 (0.5 – 2.5 kJ / mm). As for most other duplex stainless steels, the interpass temperature should be below 150°C.

Welding 2205 (ASTM S32205/ EN 1.4462)

With good and well-documented weldability, 2205 is now the most widely used duplex steel. Highly efficient welding methods and procedures have been developed and used to good effect. The best weld properties are obtained using a specially designed filler such as Avesta 2205. To achieve good weld metal properties in autogenous TIG and plasma welding, nitrogen should be added to the shielding / purging gas. The cooling rate and ferrite content are both high in resistance welding. The heat input for welding 2205 is typically between 0.5 and 3.0 kJ / mm.

Welding 2507 (ASTM S32750/ EN 1.4410)

2507 is most commonly used when the structure is going to be exposed to high stress levels in highly corrosive environments. Its high alloy content makes the steel more sensitive to welding than are the other duplex grades presented above. Consequently, to minimise precipitates in the weld, the maximum recommended heat input is lower than that for these other steels. The minimum level can be somewhat lower (0.2 – 1.5 kJ / mm) and the interpass temperature must be below 100°C. As with most other duplex steels, it is advantageous to use a specially designed filler (e.g. Avesta 2507 / P100).

Typical weld metal properties

In most cases, weld metal strength is higher than that of the quench annealed parent metal. The ductility / fracture elongation is always lower. Similarly, the fracture elongation of duplex weld metals is lower than that of austenitic weld metals. The same is also true of the impact strength. Nonetheless, the results of fracture mechanics investigations of duplex welded joints have been very positive.

Corrosion resistance is often strongly dependent on post-weld cleaning, especially if there is a risk of localised corrosion. Any kind of geometric deviation may also reduce fatigue strength or initiate corrosion attack. Welds are normally vulnerable in this respect.

As regards impact strength, because of their high ferrite content, duplex stainless steels are much more sensitive at low temperatures than are standard austenitic grades. Table 3 gives some typical weld properties of different steels. As a general rule, impact properties resulting from slag bearing methods (MMA, FCAW, SAW) are somewhat inferior to those resulting from gas shielded methods (MIG, TIG, PAW, laser). This is because of the different content of oxides in the weld metal. In table 3, corrosion resistance properties are illustrated by the critical pitting temperature (CPT). The values are for thoroughly cleaned samples.

Table 3: Typical weld metal properties

Steel grade	ASTM	EN	Welding method	Pitting.[1] CPT (°C)	Mechanical properties, weld metal, typical		
					Rm (MPa)	Impact +20°C (J)	Impact -20°C (J)
LDX 2101®	S32101	1.4162	GMAW	>6[2]	725	180	160
			FCAW	>6[2]	725	45	38
2304	S32304	1.4362	GMAW	>10	640	160	120
			FCAW	>10	700	45	35
2205	S32205	1.4462	GMAW	>20	780	110	80
			FCAW	>25	770	55	40
SAF 2507®	S32750	1.4410	GMAW	35	850	110	90
			FCAW	37	830	60	45
4401	316	1.4401	GMAW	>8[2]	600	110	100
			FCAW	>8[2]	550	55	50

1) ASTM G 48-E 2) ASTM G 150

In the next issue: Unexpected problems

Despite all the recommendations provided for users, there are examples of where results have not been as expected. The next issue of Welding News will give some typical examples taken from on-site use.