böhler welding
by voestalpine

Lasting Connections

WELDING SOLUTIONS FOR THE CHEMICAL INDUSTRY

voestalpine Böhler Welding
www.voestalpine.com/welding

voestalpine
ONE STEP AHEAD.

LASTING CONNECTIONS

As a pioneer in innovative welding consumables, Böhler Welding offers a unique product portfolio for joint welding worldwide. More than 2000 products are adapted continuously to the current industry specifications and customer requirements, certified by well-respected institutes and thus approved for the most demanding welding applications. As a reliable partner for customers, "lasting connections" are the brand's philosophy in terms of both welding and people.

Our customers benefit from a partner with

- the highest expertise in joining, rendering the best application support globally available
- specialized and best in class product solutions for their local and global challenges
- an absolute focus on customer needs and their success
- a worldwide presence through factories, offices and distributors

WELDING SOLUTIONS FOR DEMANDING INDUSTRIES

We focus on industries with high technological standards and deliver products tailored to industry-specific requirements. In the development and optimization of filler materials, we collaborate closely with customers, manufacturers, and research institutes.
Whether destined for use in challenging scenarios or in standard applications – our high quality filler materials are ideally suited for all applications in the following industry sectors:

- Oil & Gas
- Pipeline
- Chemical
- Power Generation
- Transportation & Automotive
- Maintenance & Repair
- Brazing Industries


böhler welding

CONSTRUCTION MATERIAL SELECTION & WELDING SOLUTIONS FOR THE CHEMICAL INDUSTRY

Specific Demands. Solutions at the Point.

Welding consumables for the Chemical Industry are a core competence of voestalpine Böhler Welding. With decades of experience, a unique product range to fulfill the most specific requirements and a world- wide distribution network voestalpine Böhler Welding is your partner.

The experienced welding engineers will assist you in matching the optimum and most economic welding solutions referring to your individual requirements. voestalpine Böhler Welding provides solutions at the point for the main chemical industries and processes:

Construction Materials Selection in the Chemical Industry

Factors to be taken into account for a proper material selection are multiple. A basic assumption is that raw materials and/or chemical reactions may produce corrosive environments generally at low and medium temperature combined with low to high pressure. Nevertheless some reactions are carried out at high temperature (e.g. Ti dioxide and VDC).

Sub segments	Products	Page
Inorganic Chemical	Inorganic Acids, Alkali and Salts, Inorganic Fine Chemicals	10
Organic Chemical	Wide Range of Monomers, Polymers, Fibers, Plastics, Adhesives, Films, Paints, ...	16
Urea	Ammonia, Urea and derived Fertilizers	19
Pulp & Paper	Pulp and Paper	22
Desalination	Fresh Water for Industrial, Agricultural and Drinking use	26
Food & Beverage	Beer, Wine, Destilleries, Drinks, Food ...	29
Pharmaceutical	Bio-Processing and Chemical Synthesis Pharmaceutical	30

More in detail, reacting agents may consist in:

- Reducing acids: the sole oxidizing agent is reducing hydrogen (e.g. phosphoric acid, sulfuric acid, hydrochloric acid and hydrofluoric acid)
- Oxidizing acids as well as oxygen and metallic ions, which are acting as oxidizing agents together with hydrogen ions (e.g. nitric acid, aerated solutions and metal ions: Fe^{3+}, Cu^{2+},...)
- Salt solutions (e.g. KCl, NaCl, -> chloride solutions)
- Alkaline solutions (e.g. KOH and NaOH)

Usually the real environment in the chemical industry might be a combination among the above with addition of impurities. Moreover, driving forces for material selection are specific requirements and restrictions due to general corrosion, localized pitting/crevice corrosion, intergranular (IGC) corrosion, strain induced corrosion mechanism (stress corrosion cracking SCC) and galvanic corrosion.

As a consequence, the chemical industry clearly requires a number of specific construction materials for the plants components (vessels, tanks, piping, pumps, mixers, etc.) based on the above mentioned factors, i.e. type of fluids handled, pressure, temperature, required corrosion properties and required mechanical properties.

Therefore, construction base materials involved in the chemical industry may vary from unalloyed/low alloyed heat resistant steels, to stainless steels (austenitic, duplex, special austenitic and superaustenitic) till nickel based alloys, Cu/Ni alloys, Ti alloys and Zr alloys.

As far as welding activity is concerned, fabrications methods, constraints and conditions lead to the use of a wide number of welding processes (SMAW/GTAW/GMAW/FCAW/SAW/ESW/PAW, etc.), which brings to a high demand of many different dedicated welding consumables.

A great importance has to be given to post weld cleaning (e.g. pickling and passivation) which is also crucial to meet the requirement of this industry.

WELDING OF CORROSION RESISTANT ALLOYS FOR THE CHEMICAL INDUSTRY

Assumed that the behavior of a corrosion resistant alloy depends upon its chemistry and media in which it is exposed, it is to be remarked that, even if a base material fits for the purpose, it is not said that the designed welded solution is likewise suitable.

Welded joints have in fact specific own features if compared to the base material, i.e.:

- The micro-structure of cast type
- The cooling rate may affect the microstructure and element distribution
- The structure is typically non-homogenous if the annealing treatment is not performed
- The chemistry is influenced by the dilution from base materials
- Loss/pick-up of alloying elements is always present in the welding process

As a consequence, the corrosion resistance of a welded joint has to be accurately proven by means of an appropriate testing method before to apply a welding procedure in the field. In this context, it is needless to emphasize that the welding consumables characteristics play an essential role for meeting the requirements.

Acceptance criteria are generally not following international standards; requirements are stated into end-users and engineering specifications and became more stringent and demanding in the last decade.

voestalpine Böhler Welding owns a wide database of corrosion tests of welded joints performed in different corrosive media with excellent qualitative (indications) and quantitative (corrosion rates and critical temperatures) results. In the following pages some results are presented linked to an industry section. It is to be remarked that the same solution is often applied also to the other industries within the chemical sector.

The table below illustrates the standardized corrosion tests in different corrosive media commonly used to prove the suitability of welded joints.

Standard	Method	Solution	Preparation	Duration & Temperature	Purpose
ASTM G28	A	$Fe_2(SO_4)_3$ 42 g/l + 50% H_2SO_4	Machined specimen, last layer brushed, cut edges ground with grid 80 wet	24 h or 120 h at boiling temperature	Reducing media * Intergranular corrosion detection (Sulfuric acid + metallic ions) * Corrosion rates evaluation (mm/yr)
ASTM A 262 EN ISO 3651	Practice 'C' "Huey Test" 1	65% HNO_3	Machined specimen, last layer brushed, cut edges ground with grid 120 wet	5 cycles x 48 h at boiling temperature. Fresh solution for each cycle, water rinsing and drying before testing	Oxidizing media * Intergranular corrosion detection (in nitric acid) * Mass loss rate evalution (at each cycle and test-end).
EN ISO 3651	2 "Strauss Test"	Cu shavings, $CuSO_4$ + 16% H_2SO_4	Sensitization Heat treatment at 700 °C x 30 min, Pickling to remove oxide scale, Machined specimen, cut edges ground with grid 120 wet	20 h at boiling temperature	Sensistization test * Intergranular corrosion detection for low carbon or stabilized steels (magnification 10X)
ASTM G48	C	6% wt $FeCl_3$ + 1% HCl	Machined specimen, last layer brushed, cut edges ground with grid 80 wet	Incr. 5 °C/24 h each session. Start temperature is function of the material to be tested	Pitting for nickel based welds * Pitting corrosion detection (chloride containing solution) * Corrosion rates evaluation (mm/yr) * Critical Pitting Temperature (CPT) determination
ASTM G48	E	6% wt $FeCl_3$ + 1% HCl	Machined specimen, last layer brushed, cut edges ground with grid 80 wet	Incr. 5 °C/24 h each session. Start temperature is function of the material to be tested. Use fresh samples for each temperature.	Pitting for stainless steel welds * Pitting corrosion detection (chloride containing solution) * Corrosion rates evaluation (mm/yr) * Critical Pitting Temperature (CPT) determination
ASTM A923	C	6% wt $FeCl_3$ + 1% HCl	Machined specimen, last layer brushed, cut edges ground with grid 80 wet	T function of the base material (e.g. duplex steel 22 °C superduplex 40 °C). Duration: 24 h	* Intermetallic phases detection, e.g. Sigma phase (chloride containing solution) * Mass loss rate evaluation (mg/day dm^2)
-	"Green Death"	7% H_2SO_4 + 3% HCl + 1% wt $FeCl_3$ + 1% wt $CuCl_2$	Machined specimen, last layer brushed, cut edges ground with grid 80 wet	24 h each session: start Temperature 85 °C for Ni alloys (used for the C-type, e.g. C-276, 59, 686) incr. 5 °C/24 h	* Pitting corrosion detection * Corrosion rates evaluation (mm/yr) * Critical Pitting Temperature (CPT) determination

Corrosion Resistant alloys in the Chemical Industry

Aside the traditional old fashioned Ti or Nb stabilized stainless steels and low carbon grades e.g. 304L and 316L many other alloys are often selected according to the severity and type of the environment. A table of alloys for both wet corrosion and high temperature corrosion resistance used in the chemical industry is given below:

		EN	ASTM or UNS/ Alloy	C [%]	Ni [%]	Cr [%]	Mo [%]	Cu [%]	Fe [%]	N [%]	Others [%]	PRE_N
Stainless steels '300' Series		1.4306	304L	0,02	10,0	18,0			Bal,			18
		1.4432	316L	0,02	11,0	17,0	2,6		Bal,			26
		1.4335	310L	≤0,015	21,0	25,0	≤0,1		Bal,	0,10	Si<0,15	27
		1.4438	317L	0,02	14,0	18,0	3,0		Bal,			28
		1.4439	317LMN	0,02	14,0	17,0	4,1		Bal,	0,14		33
Duplex stainless steels		1.4162	S32101/LDX 2101®	0,03	1,5	21,5	0,3		Bal,	0,22	5 Mn	26
		1.4362	S32304/2304	0,02	4,8	23,0	0,3		Bal,	0,10		26
		1.4462	S82441/LDX 2404™	0,02	3,6	24,0	1,6		Bal,	0,27	3 Mn	34
		1.4462	S32205/2205	0,02	5,0	22,0	3,1		Bal,	0,17		35
		1.4410	S32750/2507	0,02	7,0	25,0	4,0		Bal,	0,27		43
		1.4501	Zeron 100®	0,02	7,0	25,0	3,5	0,5	Bal,	0,27	0,6 W	41
Special austenitic stainless steels		1.4539	904L	0,01	25,0	20,0	4,3	1,5	Bal,	0,1		37*
		1.4563	N08028/ 28	≤0,015	31,0	27,0	3,5	1,3	Bal,	0,05		40*
		1.4547	S31254	0,01	18,0	20,0	6,1	+	Bal,	0,2		46*
		1.4529	N08926/926	≤0,02	25,0	21,0	6,5	0,9	Bal,	0,2		48*
		1.4565	S34565/ 24	0,02	17,0	24,0	4,5		Bal,	0,5	5,5 Mn	52*
		1.4591	NR20033/33	≤0,02	31,0	33,0	1,6	0,6	Bal,	0,4		50*
		1.4562	N08031/31	≤0,015	31,0	27,0	6,5	1,3	Bal,	0,2		54*
		1.4652	S31654	0,01	22,0	24,0	7,3	+	Bal,	0,5	3 Mn	63*
Special 'urea' grades and nitric acid grades		1.4361	S30600	≤0,015	18,0	14,0	2,7		Bal,		4 Si	23
		1.4435	(724Mod.)316L UG	0,02	14,0	18,0	2,6		Bal,	+		28
		1.4466	S31050/725 LN	≤0,02	22,0	25,0	2,1		Bal,	0,13		34
Nickel based alloys for wet corrosion	Ni alloys	2.4066	N02200/200	≤0,1	>99,2							
		2.4068	N02201/201	≤0,02	>99,0							
	NiCrFe alloys	2.4817	N06600/600 L	≤0,025	74,0	16,0			9,0		0,2 Al 0,2 Ti	16*
		2.4642	N06690/690	≤0,015	61,0	29,0		0,4	9,0		0,25 Ti	29*
	NiFeCrMoCu alloys	2.4660	N08020/20	≤0,06	38,0	20,0	2,4	3,4	34,0		0,2 Nb	28*
		2.4858	N08825/825	≤0,05	40,0	23,0	3,2	2,2	31,0		0,8 Ti	34*
		2.4619	N06985/G-3	≤0,02	48,0	23,0	7,0	2,0	19,0		0,3 Nb W<1,5 2,5 Co	46*
		2.4603	N06030 / G-30™	0,02	43,0	30,0	5,0	1,5	15,0		2,5 W Co<5	47*
	NiCrMo (Fe) alloys	2.4856	N06625 / 625**	0,02	62,0	22,0	9,0		3,0		3,4 Nb	52*
		2.4602	N06022/22	0,01	56,0	22,0	13,0		3,0		3 W, V ≤0,35	65*
		2.4610	N06455/C-4	≤0,01	66,0	16,0	16,0		1,0			69*
		2.4819	N10276/ C-276	0,01	57,0	16,0	16,0		6,0		3,5 W, Co <2	69*
		2.4675	N06200/C-2000™	0,01	57,0	23,0	16,0	1,6	3,0		Al <0,5, Mn <0,5	76*
		2.4605	N06059/59	0,01	59,0	23,0	16,0		1,0		0,3 Al	76*
	NiMo alloys	2.4617	N10665/B-2	≤0,010	69,0	0,7	28,0	≤0,5	1,7		Co ≤1	93*
		2.4600	N10675/B-3	≤0,010	65,0	1,5	28,5		1,5		Co ≤3, W ≤ 3, Mn ≤3	96*

* $PREN_2$
** also for high temperature.

		EN	ASTM or UNS/ Alloy	C [%]	Ni [%]	Cr [%]	Mo [%]	Cu [%]	Fe [%]	N [%]	Others [%]	PRE_N
Stainless steels and nickel based alloys for high t	Stainless steels	1.4828	S30900/309S	0,08	12,0	22,0			Bal,		2Si	
		1.4835	S30815/253MA®	0,08	11,0	21,0			Bal,	0,17	0,05 Ce 1,6Si	
		1.4845	S31000/310S	0,05	20,0	25,0			Bal,			
		1.4876	N08810/800 H	0,08	31,0	21,0			47,0		0,25Al 0,35Ti	
		1.4862	N08330/DS	0,08	36,0	18,0			42,0		0,15Al 0,15Ti 2,2Si	
		1.4877	S33228/AC66	0,08	32,0	28,0			39,0		0,8Nb 0,1Ce	
	Nickel base	2.4816	N06600/600-600 H	0,08	74,0	16,0			9,0		0,2Al 0,2Ti	
		2.4851	N06601/601 H	0,06	60,0	23,0			14,0		1,4Al 0,5Ti	
		2.4633	N06025/602CA	0,2	62,0	25,0			9,5		2,3Al 0,2Ti 0,1Y 0,1Zr	
		2.4663	N06617/617	0,08	54,0	22,0	9,0		1,0		1Al 0,5Ti 12Co	
Nickel-Copper and copper- nickel alloys		2.4360	N04400/400	≤0,15	64,0			32,0	1,8			
		2.0872	C70600/CuNi 90-10		10,0			88,0	1,5		0,8% Mn	
		2.0882	C71500/CuNi 70-30		31,0			67,0	0,7		1% Mn	

* $PREN_2$
** also for high temperature.

	Alloying elements features	Corrosion resistance
Ni	Metallurgical Compatibility	Alkali, SCC, Mild Reducing
Cr	Forms Protective Oxide	Oxidizing Media Uniform and Localized
Mo	Reducing Environments, Stabilizes Chromium (if present)	Non-Oxidizing Media, Improved Localized Corrosion Resistance for Chromium alloys
W	Similar to Mo but less effective	Very Detrimental to Thermal Stability
N	Austenite Stabilizer	Localized Corrosion Mechanical Properties
Cu	Reducing Conditions	Seawater, HF, H_2SO_4

PRE_N Pitting Resistance Equivalent Number. Is a theoretical way of comparing the pitting corrosion resistance based on the chemical compositions of a Cr-Ni alloy. For severe working conditions suitability must be checked through an appropriate corrosion test.

PRE_{N1} %Cr + 3.3*%Mo + 16*%N
PRE_{N2} %Cr + 3.3*%Mo + 30*%N

INORGANIC CHEMICAL

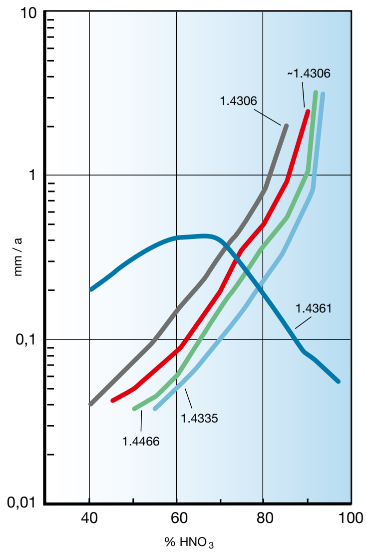
The inorganic chemical sector is the largest in the chemical industry and includes all chemical processes involving inorganic raw materials. Applications in this industry use a wide range of temperatures and pressures, different type of reactions requiring high performance base materials and welding consumables.

Just to mention a few, inorganic chemical industry deliveries end-products (e.g. aluminum sulfate, chlorine, hydrochloric acid, hydrogen, hydrogen peroxide, nitric acid, industrial gases from air, phosphoric acid). Some of those substances are reducing acids (e.g. hydrochloric, sulfuric and phosphoric), and some other oxidising acids (e.g. nitric acid). Demanding applications with hot and concentrated alkaline solutions are also quite diffused (caustic soda and potassium hydroxide, for instance), while the most of the salts synthesis are also corrosive containing in some cases halogens like chlorides or weak acids or alkali. Therefore the full scenario of corrosion behavior is included in such industry and needs a wide range of welding consumables.

Some examples of very popular inorganic chemical processes with consideration about materials and welding are reported in the following text.

Nitric Acid (HNO_3)

Produced by oxidation of ammonia at high temperature (800-900 °C) and used in production of fertilizers, explosives and polymers, nitric acid attacks grain boundaries specially in case of precipitation and segregation; main risk is for IGC (intergranular) and transpassive corrosion. Therefore material with very low content of C, P, S and high homogeneity are used such as EN 1.4306 (304LSi) < 0.1 Si, ≤ 0.02 P. It is also very important to get clean and smooth welds. At higher temperatures, higher alloyed grades are required.



Courtesy of Boehler Edelstahl

304L, 310L, S31050/725 LN are widely used for absorption column, absorption cooling coils and heaters. In components with high chloride cooling water also Alloy 28 and other high chromium alloys are applied.
High Si (~4%) austenitic grade EN 1.4361 is used in case of very high nitric acid concentration (>67%) This material shows high corrosion resistance up to boiling point.

Welding solution for high Si austenitic steel EN grade 1.4361

vailable as TIG rods and MMA electrodes, Böhler Welding consumables for austenitic steel EN grade 1.4361 produce weld metal higher alloyed in Si, Cr and N than the base material to be corrosion resistant also in as welded condition. Low heat input and stringer bead technique are essential to minimize principle risk for hot cracks in this specific case. Other standard stainless steel welding consumables obtain 5-15% delta-ferrite to avoid hot cracking.
GTAW is for the root pass, with 100% Ar as shielding and backing gas. SMAW or GTAW is then used for filling the joint. A low heat input process and Interpass temperature < 80 °C is recommended to avoid IGC; in this context water cooling might be beneficial.

PWHT is generally not required, however annealing at 1100-1170 °C with water quenching might be carried out to get the maximum corrosion resistance in the HAZ when used in highly concentrated acids at > 70 °C.
Tests performed according to Method ASTM 262 practice C 'Huey Test' after annealing treatment gave an average result of 0.072 mm/yr.

Details on the filler metals and trade names are in the product folder and handbook

Phosphoric acid (H_3PO_4)

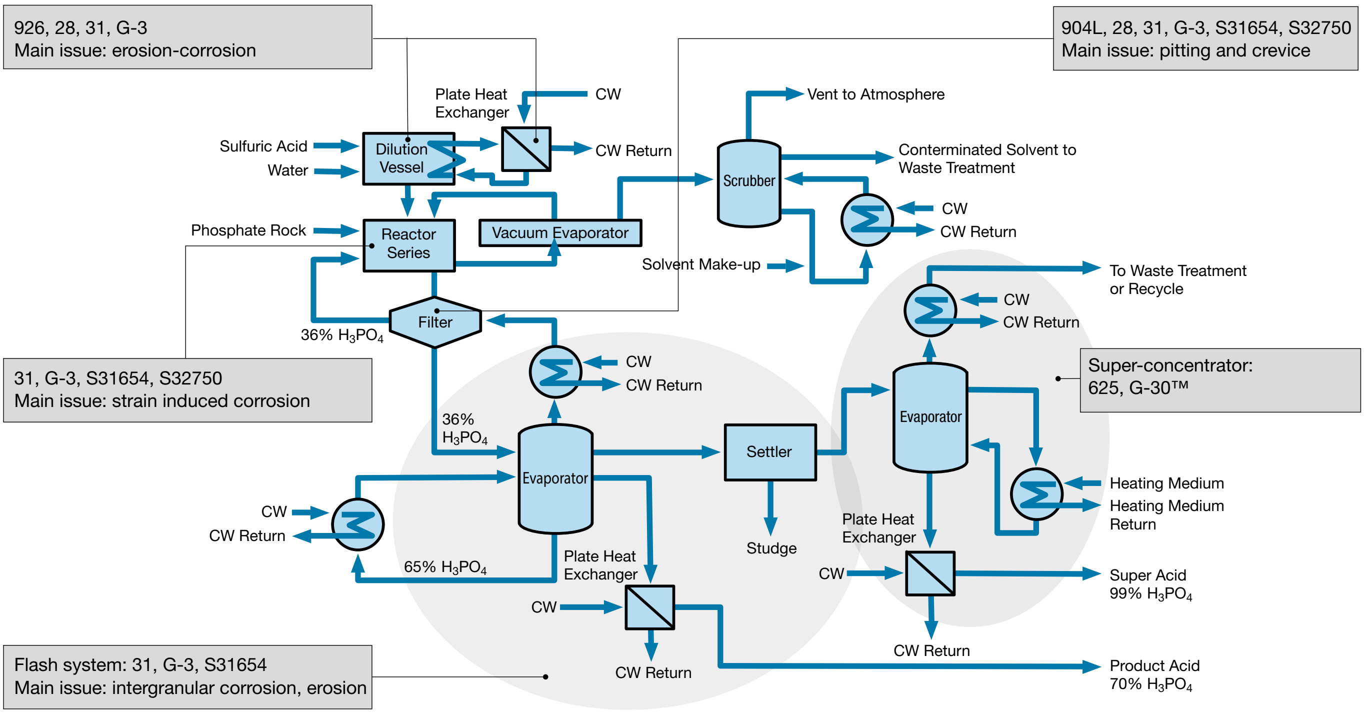
The most used 'wet' process is here illustrated: Phosphoric acid is obtained by reaction between mineral phosphates (apatite) with sulfuric acid.

The phosphoric acid is not very aggressive, but corrosion issues are due to the mentioned sulfuric acid and chloride, fluoride and Si present in the ores. Erosion phenomena are also associated to the corrosion due to the solid particles from the raw materials.

In general, erosion, high flow rate and surface deposition further affect the corrosion resistance. The reactor vessel is enameled with the mixer made in high alloy stainless steel and subjected to strain induced corrosion and wear. Recently also superduplex steels have been used for the agitator unit.

The filter unit might be affected by pitting and crevice corrosion so the material selection is to be made accordingly. Then the heat exchanger and the following chain of condensers and concentrators provide to concentrate the phosphoric acid as it is required. Austenitic and superaustenitic steels are widely used in this section.

When Super acid is delivered (from 70% to 99% concentration) Alloy 625 or even better UNS N06030 Alloy G-30TM have proven to be corrosion resistant and widely used, also due to the process temperature, higher than in the other stages.



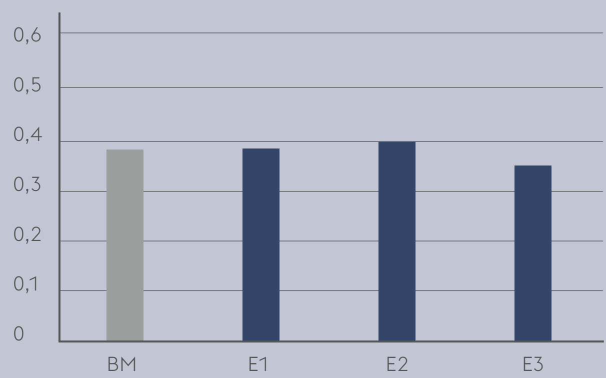
Welding solution for Alloy 625

Böhler Welding nickel based filler metals for Alloy 625 are high resistant to corrosive environment including stress corrosion cracking. Also used for welding of superaustenitic steels as well as heat resistant alloys.
As an example, here below results achieved with corrosion test ASTM G28 method A (120 h) are reported.

GMAW: (shielding gas Ar + 30% He + 2% H2 + 0,1% CO_2)
(V preparation joint 16 mm thickness).
Three specimens (dimensions: 55x22x16 mm)

Details on the filler metals and trade names are in the product folder and handbook.

ASTM G-28 A corrosion rate [mm/yr]



INORGANIC CHEMICAL

Sulfuric Acid (H_2SO_4)

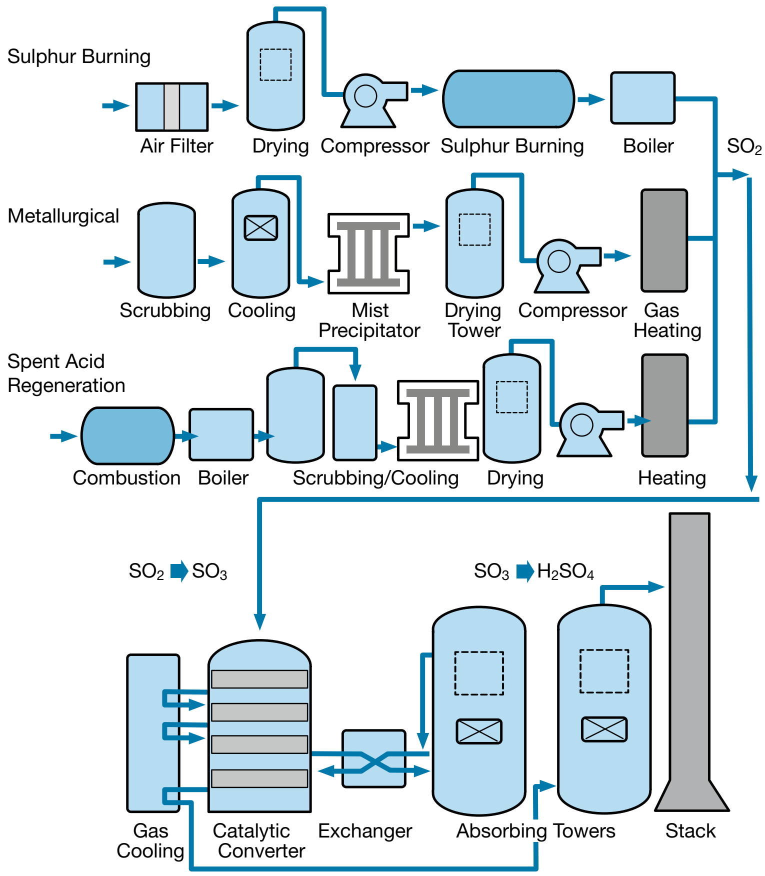
The sulfuric acid is a quite diffused intermediate product used in many processes in the chemical industry, to produce other inorganic acids, in the fertilizers field as well as in the organic chemical.

The figure here illustrates the three ways to obtain SO_2; via burning sulfur, or through minerals cooking or regenerating from spent acid. Then the SO_2 is transformed in SO_3 into a catalytic converter.

This high temperature application may be covered with alloys such as AC66 (S33228) or N12160. Finally the sulfuric acid is obtained by reaction in the absorbing towers.

Sulfuric acid is a strongly reducing agent, heavily affecting the plant construction materials, which are selected depending upon concentration and temperature.

The main corrosion damage mechanism is of IGC type; some commonly used test like the EN ISO 3651-2 “Strauss Test” or ASTM G28 method A and B can indicate the suitability of the material and welded joints (only method A for welded structure and cast).



IGenerally materials should have an adequate content of Cr, Ni and Mo at least as 904L type. Superaustenitic grades such as Alloy 31, or nickel based alloys like G-30 etc. (high chromium alloyed), can provide corrosion rates lower than 0.5 mm/year up to 90 °C. However, it is to be considered that presence of halides significantly decrease corrosion performance.

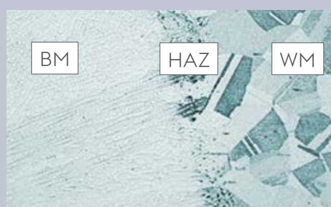
Care should be taken in the case of very high H_2SO_4 concentrations because of the oxidizing character of the acid above 95%. Driving force for a right material selection is higher chromium and less molybdenum content.

Welding solution for Alloy 31 and other 6% Mo and 7% Mo stainless steels: Böhler Welding nickel based filler metals

A nickel based is preferred for welding superaustenitic steels to avoid risk of segregations in the weld metal. In many cases, Böhler Welding filler metals Alloy 59 matching grade, 22% Cr with very high Mo content (16%), are the best solutions to improve the corrosion behavior with the exception of strongly oxidizing environments in pickling lines or in other very concentrated acids. In reducing media containing chloride it is the optimal choice.

Details on the filler metals and trade names are in the product folder and handbook

Micrograph of Alloy 31 welded with the Alloy 59 matching grade filler metal: HAZ and WM

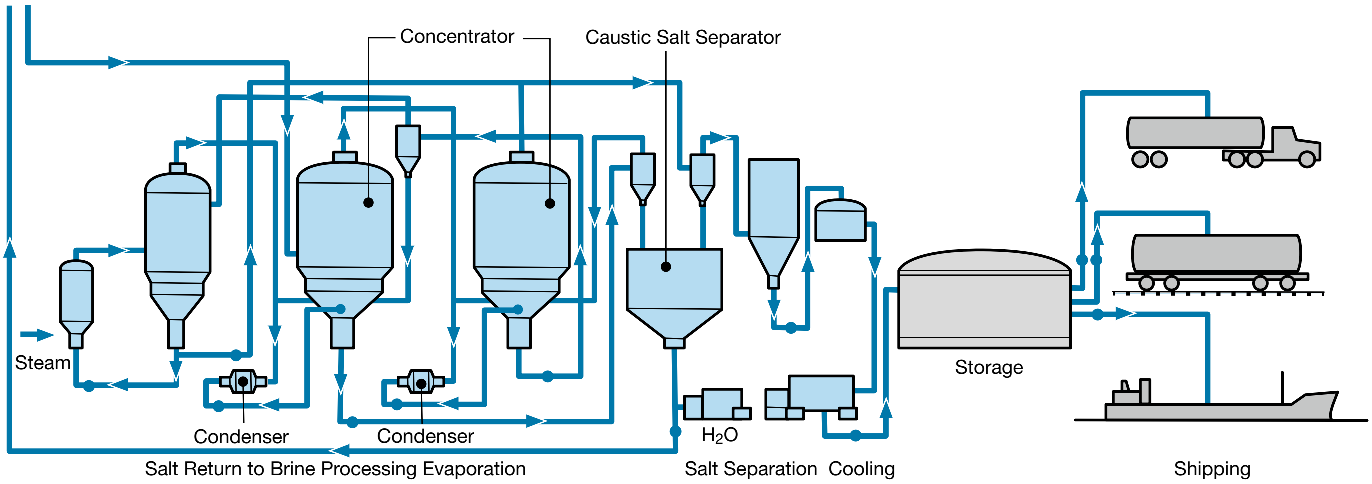


Caustic Soda (NaOH)

Caustic soda is a side product of the chlorine production by electrolysis. At low concentration and temperature below 100 °C usual austenitic stainless steels are suitable construction material.

At higher concentration and temperature, caustic soda is very aggressive; pure nickel has proven to be very resistant to corrosion attack, so it is widely used in the electrolytic cell for the membrane process, which is the most common industrial solution. Regarding the process plant, the multistage evaporation downstream, for concentration and purification purpose, is also in industrial pure nickel (Alloy 200).

When a falling-film system working at T> 350 °C is adopted, Alloy 201 is more indicated because of the lowest carbon content avoiding graphite precipitation at the grain boundary. As far as the welding consumable is concerned, the suitable grade is of course low carbon and titanium stabilized type for improved deoxidation behavior of the weld deposit, so that it can fit with both base materials. Finally in presence of impurities and oxidizing agents, or in order to increase the strength, Alloy 600L could be an alternative because of its chromium content.

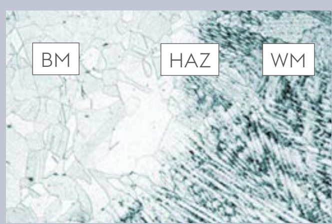


Welding solution for Alloy 600 and 600 L:
Nickel based filler metal grade 6082 (NiCr20Mn3Nb)

This nickel based filler metal is available for the SMAW, GTAW, GMAW, FCAW and SAW processes. It is Cr-Mn 20-3 alloyed, low C, Nb alloyed and Fe lower than Alloy 600. This solution is also used for ferritic-austenitic joints and for high temperature applications (Cr, Cr-Ni steels, nickel based alloys).

Details on the filler metals and trade names are in the product folder and handbook

Micrograph: weld joint of Alloy 600L welded with GMAW wire (HAZ and WM)



ORGANIC CHEMICAL

Organic chemical is the sector of the chemical industry working with organic compounds.

Basically it is the industry of production of organic acids as well as the transformation of oil and gas from olefins and aromatics to several monomers and polymers (basic and engineered) leading finally to end-products such as fibers, plastic, films, paints, adhesives. Chemical reactions at high temperatures (e.g. thermal cracking or pyrolysis) as well as medium and room temperature, often generate highly corrosive environments. Reagents, catalysts and stabilizers can have oxidizing or reducing effects and may contain aggressive salts, acids, alkali and chlorides. Below two examples of organic chemical process with considerations on material selection and welding are reported.

Acetic Acid (CH_3COOH) production

Acetic acid is a quite diffused intermediate product used in the transformation industry to get a wide range of monomers, fibers, plastics and other.

Acetic acid is not particularly corrosive, so that material as 304L is suitable for storage tanks and piping. In case of high temperature storage or risk of contamination from materials, 316L is preferred. Scenario changes in the synthesis process for catalysts are used which can introduce more severe corrosion issues. From the industrial processes (acetaldehyde oxidation, butane oxidation or methanol carbonylation) in the figure here the butane oxidation process is illustrated.

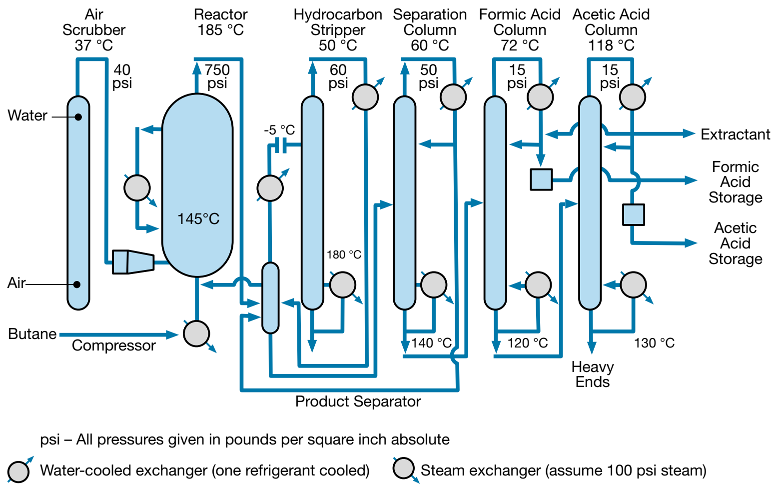
Acetic acid is obtained blowing oxygen or air in the butane, involving a catalyst. Side products due to the catalyst are formic acid, esters, peroxides and reducing agents, which can cause rapid attack or either pitting or crevice type. In addition HCl can be generated due to chlorine contamination at temperature above the acid boiling point.

Those aspects must be taken into consideration in the construction materials selection; in fact, while the 316L is generally suitable for the downstream, the reactor and part of the columns, working at higher temperature and pressure, require more resistant alloys, such as 904L, superaustenitic steels, Alloy 20 as well as Alloy 22 or C-276.

To be mentioned also a more modern process, the methanol carbonylation (Monsanto process), which involves iodine as catalyst activator, and generates a very corrosive reducing environment: therefore the most industrial resistant alloy for reducing condition, Alloy B-2 is used for reactor, flasher, piping and distillation columns.

Before the downstream, the iodine ions are separated from the end-products so that Alloys C-276, 59, G-3, 31, 904L, S31254 can be used.

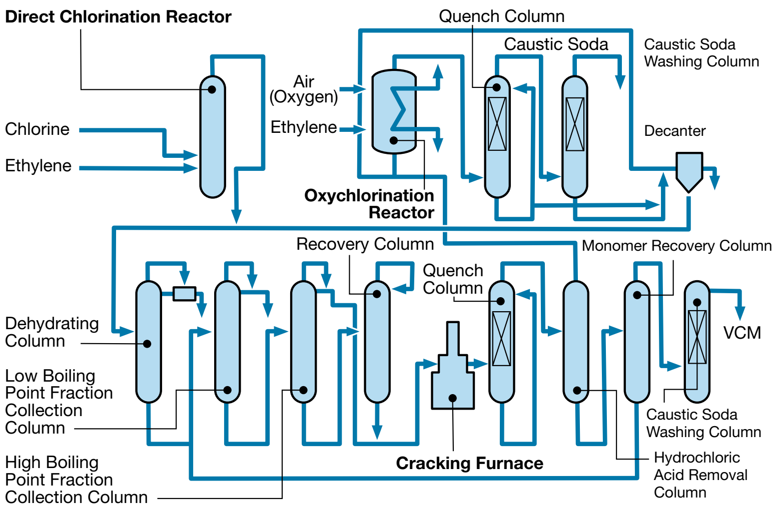
Simplified diagram of butane oxidation process



Vinyl Chloride Monomer (VCM) production

CM is a gasified monomer precursor of the well-known polymer PVC. VCM is obtained from ethylene through direct chlorination and oxy-chlorination processes usually combined in the same plant.

Both processes form the intermediate compound EDC (Ethylene DiChloride). Direct chlorination is a reaction between ethylene and chloride within a catalyst giving EDC and HCl (Hydrocloric) as side product. HCl, also reacting with ethylene and oxygen with a catalyst, gives again EDC after dehydration. Then EDC is thermally cracked at 450-550 °C to finally obtain VCM.



he construction issues are due to wet or high temperature corrosion depending on the process stages.

Reaction stage (oxychlorination and direct chlorination)
Presence of humidity leads to high corrosive HCl; therefore a number of different nickel based alloys are used in the different part of the reactors. The use of Alloy 59 and C-276 is for tube-sheets and catalysis sections in both full plate and weld overlay solutions. Tubes inside the reactors might be in Alloy 200 or Alloy 600 or Alloy 625. Tubes and flanges conveying chlorine into the reactor might be made in Alloy 825.

Purification columns and heat exchangers
Used to treat the EDC before pyrolysis, they are subjected to wet corrosion attack due to HCl. Strong reducing environment and elevated risk of pitting attack might address the selection toward Alloys B-2, 600 or also superaustenitic steels.

Thermal cracking (450-550 °C)
It needs alloys resistant to high temperature with chlorine agents as well as carburization due to the combustion gases. Alloy 800H is often suitable in this demanding environment.

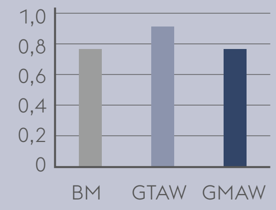
Welding solution for Alloy 59: Böhler Welding matching filler metals

Available as SMAW, GTAW, GMAW, those filler metals produce high corrosion resistant weld metal in above all reducing and oxidizing environments. They are also suitable for welding other nickel based alloys (e.g. C-4, 22 and C-276) as well as superaustenitic stainless steels, ensuring the best performance against corrosion in a number of applications.

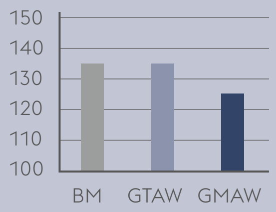
Test case:
Results achieved with corrosion Test ASTM G-28 A and "Green Death", for **GMAW** and **GTAW. GMAW** shielding gas: Ar + 30% He + 2% H_2 + 0,05% CO_2. **GTAW**: 100% Ar, (V preparation joint, 16 mm thickness). Specimen dimensions: 55x22x16 mm

Details on the filler metals and trade names are in the product folder and handbook

ASTM G-28 A corrosion rate [mm/yr]



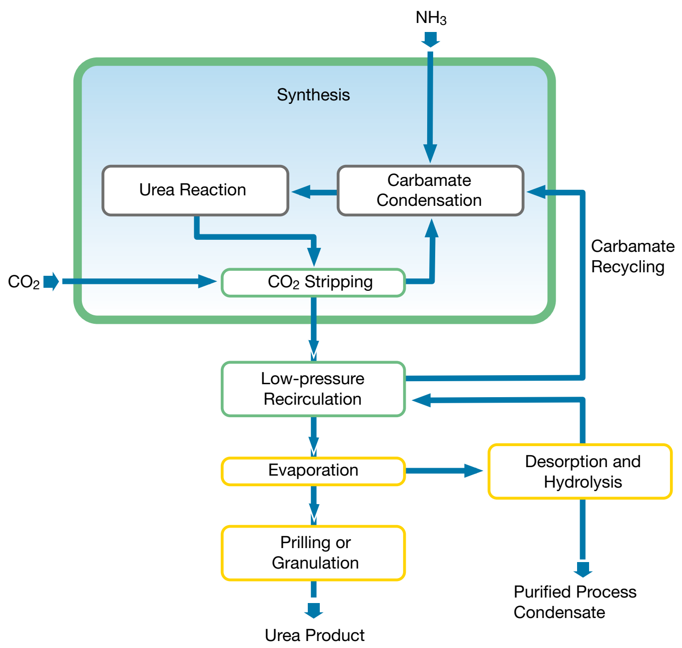
"Green Death" solution C.P.T [°C]

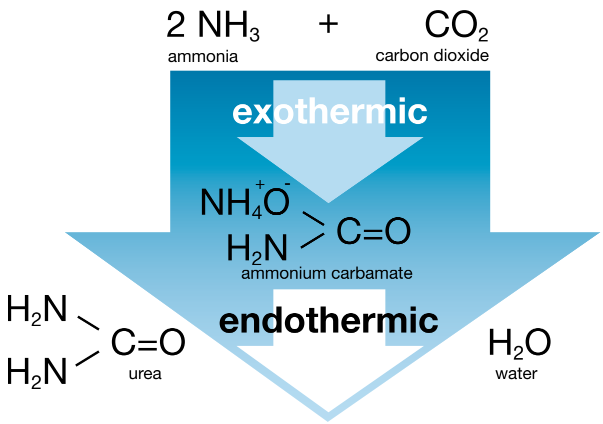


Microschliff:
SZW und BM. Legierung 59 geschweißt mit voestalpine Böhler Welding Schweißzusatz der passenden Güte

UREA

Urea or carbamide, an organic compound obtained from ammonia, is the most worldwide diffused fertilizer. The figures below shows the Urea chemical reaction as well as the process to obtain the end product.





High Pressure Equipment

The high pressure section of the process is composed by a reactor, stripper and condenser, which have the following main function:

- The urea synthesis takes place in the reactor.
- The stripper takes out vapors of unreacted CO_2 and ammonia.
- The condenser condenses these vapors into ammonia carbamate, which is finally recycled into the reactor.
- The pressure level might be about 150 bar, and temperature from 180 °C to 210 °C depending on the equipment and the selected process.

Welding of Urea High Pressure Equipment

Special grades materials and welding consumables are used for handling the very corrosive intermediate product carbamate at high pressure and temperature; risks are mainly for intergranular corrosion and stress corrosion cracking in a very hard oxidizing condition. The Huey test (boiling 65% HNO_3) is typically used to approve materials. For achieving an improved corrosion resistance in urea two specific grades have been developed starting respectively from 316L and 310L:

(724Mod.) 316L UG (UG stands for Urea Grade), typically low C, 18% Cr, 14% Ni, 2.7% Mo, alloyed with N, and characterized by a very low ferrite level at maximum 0.6%. Matching filler metal is actually over alloyed (i.e. 20% Cr, 16%Ni, 0.18%N), to take into account the specific characteristic of the welded joint compared to the base material and ensure sufficient corrosion performance.

S31050/725 LN. It is a modified 310L (25%Cr, 22%Ni, 2% Mo, low Si with 0.13% N to stabilize the austenitic phase). This material is for the most demanding conditions, such as in the high pressure strippers where the service temperature reaches the highest values, but it is also used in condensers and reactors. The maximum allowed ferrite is very low (<0.6%) so that it can be considered fully austenitic. This grade is free of intermetallic phases or carbide precipitations, which drastically affect its corrosion-resistance in Urea solutions.
Moreover specifically designed Urea grade duplex, as well as zirconmium are also used according to know-how and specification of the process engineering companies.
As far as the construction is concerned, shells are generally made in low alloyed steels (single or multi-layer design). Then, shells as well as tube-plates, are lined or overlay welded where the surfaces are in contact with the process fluid. Piping can be either bi-metallic or lined or fully made of Urea grades.
Regarding welding, special care must be taken to avoid undesired intermetallic phase precipitations accurately controlling welding parameters and interpass temperature. For this reason most applied welding processes for joining are GTAW and SMAW, while strip cladding is carried out with low amperage and travel speed.

Welding solution SAW and ESW strip cladding for Urea application

Test case:
BBase Material: Carbon Steel 0.18% with C 30 mm thickness
Strip 60x0.5 mm 310 Mod. type (Cr-Ni-Mo 25-22-2, C 0,01, Low Si)
SAW combination: 3 layers with specifically designed flux
ESW combination: 2 layers with specifically designed flux

Details on the filler metals and trade names are in the product folder and handbook

ASTM A 262 pract.
C Huey Test (65% boiling HNO3)
corrosion rate [mm/yr]

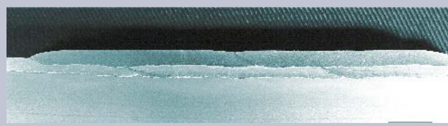
* 20 h @ 550 °C
** Sensitization 30 min.@ 700 °C

	Interpass T	V	A	Travel speed [cm/min]
SAW Combination	< 150 °C	28	750	12
ESW Combination	< 100 °C	26	1200	16

3 layers SAW deposit

	C	Mn	Si	Cr	Ni	Mo	Fe	N
3 layers SAW	0,025	3,7	0,6	24,5	22,2	2,1	Bal.	0,12
2 layers ESW	0,030	3,8	0,4	24	22,5	2,0	Bal.	0,15

Weld metal chemical analysis



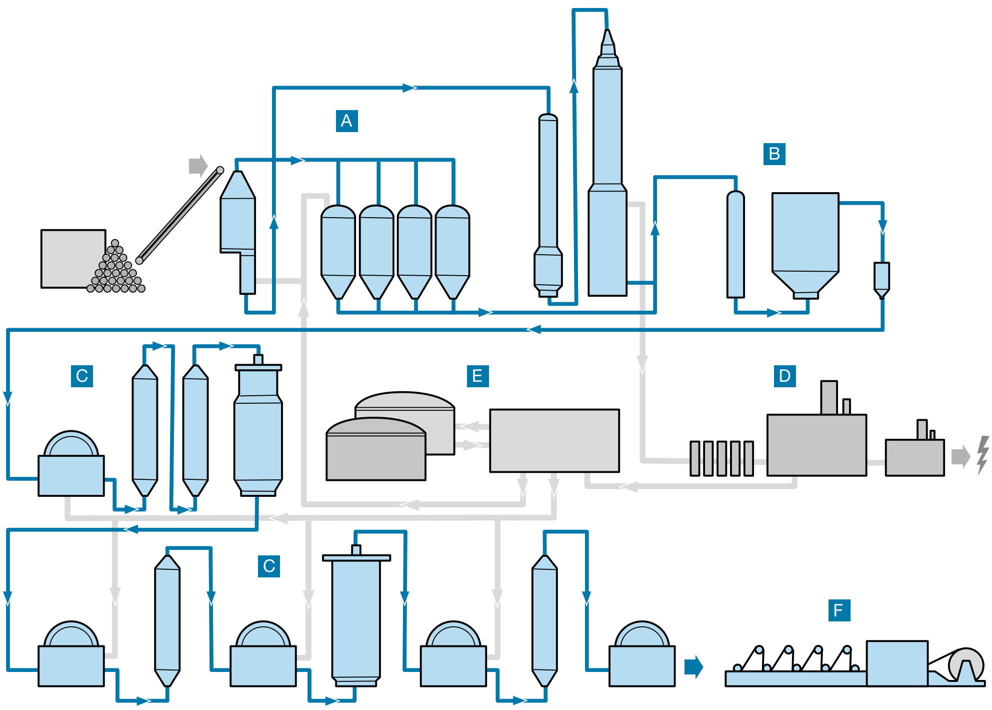
2 layers ESW deposit

PULP & PAPER

Correct materials selection is very important in the pulp and paper industry.
A good choice leads to reach the best for:

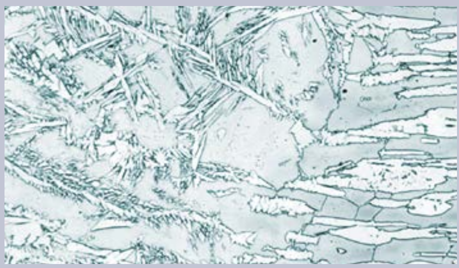
- Low investment cost
- Shorter erection time
- Performance of equipment
- Availability
- Reliability
- Process flexibility
- Low life cycle cost
- Appearance

In order to reach those targets, traditional and old fashioned alloys are often replaced by modern stainless steels as well as nickel based alloys, taking into account that each production stage works with specific media and specific corrosion issues; therefore different materials are needed. Welding consumables are often over alloyed with respect to the base material, and specifically dedicated and chemically fine-tuned to meet specific requirements. voestalpine Böhler Welding developed, among others, specific welding alloys for the superaustenitic grade S31254 or for the lean duplex family S32101, S82441 and S32304. As an example, for S31254, a special MMA electrode according to AWS A5.11:ENiCrMo-12 has been developed to combine excellent corrosion resistance in chloride environments with low sensitivity to hot cracking in the weld metal. Finally flux-cored wires are currently widely applied, especially for positional welding, and site operations, to increase productivity, improve weld appearance and make welding easier.



FCAW solution for Superduplex steels

Rutile positional flux-cored wire from voestalpine Böhler Welding offers weld metal properties fully matching those of the base material, in terms of strength, toughness and localized and stress corrosion resistance. Test case: Corrosion test ASTM G48 method E on pipe girth weld, 168 mm with thickness 7 mm.



Test case:
Corrosion test ASTM G48 method E on pipe girth weld, 168 mm with thickness 7 mm.

Details on the filler metals and trade names are in the product folder and handbook

ID	Temp (°C)	Exposed time (h)	Weight before (g)	Weight after (g)	Weight loss (g)	Surface			Weight loss (g/m²)	Corrosion Rate (g/m²h)
						B mm	H mm	T mm		
FX101	40	24	96,254	96,254	0	49,4	17,5	12,9	0,0000	0,00000
FX101	40	24	98,292	98,29	0,002	52	17,5	12,9	0,5535	0,02306

A Cooking

Main equipment consisting in digesters:

» Sulphate (kraft) process

Media:	NaOH	$Na_2S_2O_3$	NaHS
Environment:	pH 13-14	T=150-180 °C	P= 10-12 bar

» Materials: 2205 duplex is widely used, showing better stress corrosion cracking behavior than 304L. Best results have been obtained with lean duplex types S32101 as well as S32304 due to their lower Mo content, which can be detrimental in alkaline solution. Higher molybdenum stainless steels (e.g. 316L) are not preferred for this equipment for that reason.

» Sulfite (HSO_3)

Media:	Na...	Mg...	or NH4...
Environment:	pH 1.5-4	130-170 °C	10-12 bar

Materials: duplex S32205, 904L and 317LMN are often selected over 317L and 316L.

B Washing and Screening

HMain equipment consisting of screening and blow tanks

» Media: chlorides, thiosulphates, polysulfides. Their concentration increased in the last years due to the installation of closed loop systems to reduce emissions. It resulted in more corrosion and erosion issues.

» Material trend is from mild steel to 304L, 316L till the duplex grades S32101/S32304/S32205. Duplex can also guarantee a better wear resistance (erosion coming from particles in the pulp).

C Bleaching

The process of bleaching will use less or even eliminate chlorine and chlorine dioxide influencing the type of base materials and consumables used.

» **Total Chlorine Free TCF Bleaching**
Main equipment is consisting of reactors
Oxygen delignification reactor ‘O’ stage
Environment: T = 110-140 °C pH 11-12, Materials: 904L, S31254, C-276
Peroxyde reactor ‘P’ stage
Environment: T = 80-90 °C pH 11-12, Materials: S32101, S32205

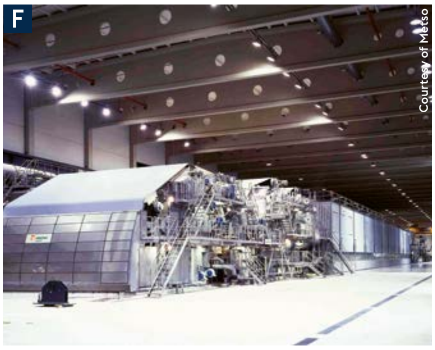
» **Elemental Chlorine Free ECF ‘D’ stage**
Main Equipment is consisting of washers and drum filters
Media: Dioxide Chlorine ClO2, Environment: T = 70-80 °C pH 3.5-4
Materials: S32750, S31254, S32654, C-276, Ti alloys. For economical reason superduplex S32750 is often replacing superaustenitic steels such as S31254

» **Chlorine ‘C’-stage**
Main Equipment is consisting in washers, drum filters
Media: Chlorine Cl_2, Environment T = 20-25 °C pH 2, Materials: S32750, S31254

D Chemical recovery (recovery boilers)

Main equipment is consisting in multi-stage evaporators

- Higher concentrations 75-80% dry solids increased the risk of corrosion, especially in the last evaporator
- Material trend is from carbon steel to 304L till duplex S32205 as well as lean duplex S32304
- S32205/S32304 has shown very good corrosion and SCC resistance in alkaline liqueurs treatment (for boilers and piping)



E Towers and tanks for liquor storage

304L material is generally suitable. Nevertheless trend is for lean duplex and duplex steels, to improve the corrosion resistance and save weights thanks to the highest strength.

F Paper mill

- Trend is to reduce water consumption leading to more corrosive environment.
- Suction rolls needs both strength and corrosion resistance
- Materials: 316L, S32205, S32304, S32101, 317L, N10622, C-276

DESALINATION

Desalination is by definition the removal of salts from the seawater to produce fresh water for industrial, agricultural and drinking use.

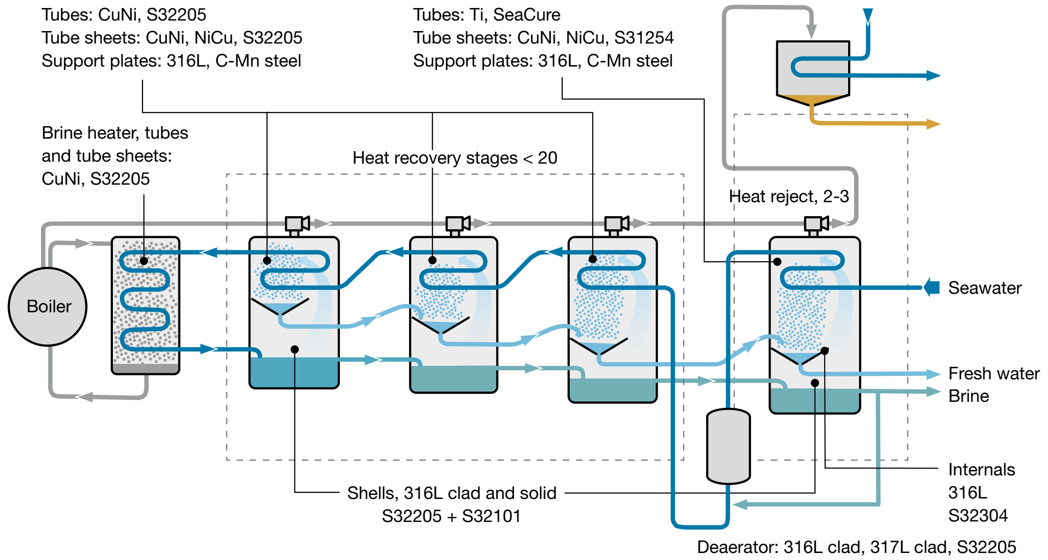
At present, mainly two types of desalination processes are industrially applied: distillation and reverse osmosis (RO). The distillation process can be multi stage flash (MSF), multiple effect distillation (MED) or vapor compression. Selection is made taking into account the needed production capacity and availability of power sources. The biggest plants are of MSF type with very high energy consumption, while the membrane technique applied in the RO delivers much less fresh water but with higher energy efficiency. The MED could be considered an intermediate size capacity plant. Pitting and crevice corrosion are the main issues for the desalination plants. Stages with different salt concentration combined with boiling temperature (for the distillation types) reflect in use of corrosion resistant alloys. Here below a selection of material is given for the three mentioned processes.

Multi Stage Flash Process

Basically the process is a multi-stage distillation in which heat is provided at the 1st stage to make the salty water boiling at 110-115 °C. By reducing pressure, water is boiling in each stage. The water obtained by the steam is more and more purified stage by stage until getting the desired freshness. Water so obtained is then filtered and ionized.

As shown in the figure below CRA might vary from the 316L, duplex and superaustenitic steel till the CuNi (for tubes and tube-plates), NiCu (Alloy 400) for tube-plates, as well as Titanium for tubes in the more demanding 1st stages (higher temperature and salt concentration).

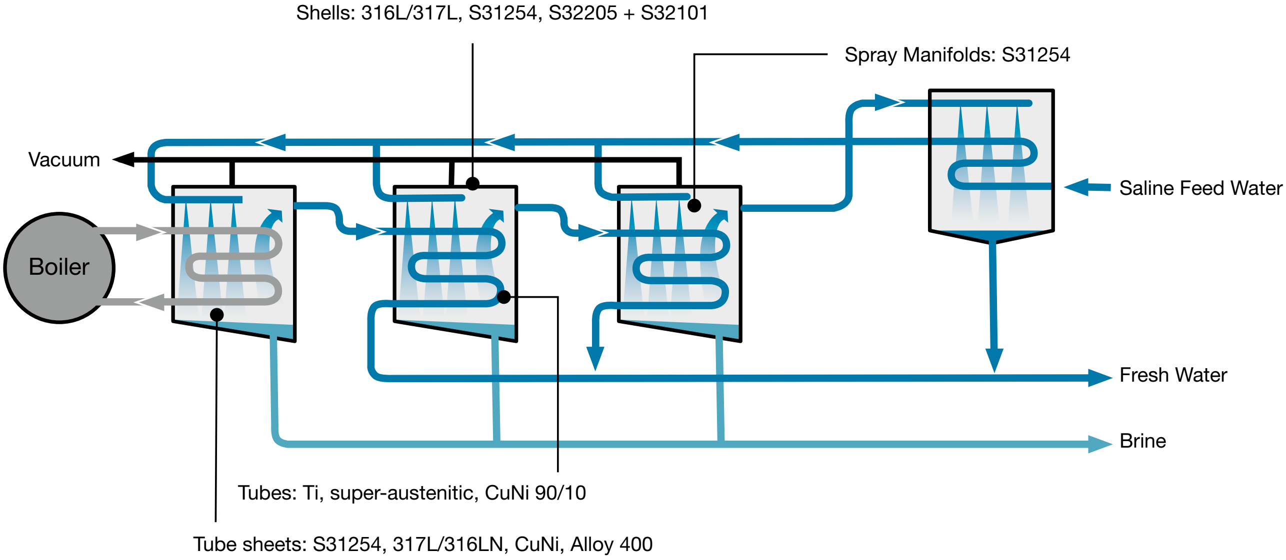
MSF material selection



Multiple Effect Distillation Process

MED uses a max temperature of 55-70 °C. The concept is quite similar to the MSF, i.e. vacuum to allow a multi-stage boiling. On the other hand the evaporators and condenser tubes design is different: instead of a flash system the evaporation is due to a falling film on hot tubes. Due to the lower temperature, the risk of corrosioning this system is lower than with MSF. Moreover the amount of solid deposits (scale, lime, etc.) is lower, resulting in a less erosive effect. The types of corrosion resistant alloys are similar but stainless steel is thus more frequently used for this process.

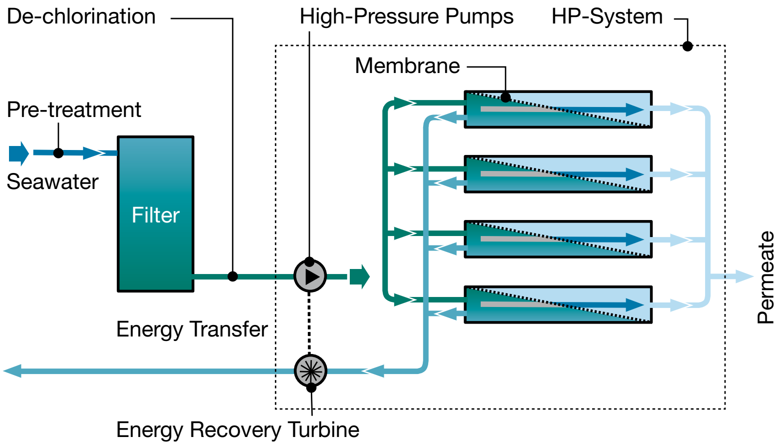
MED material selection



Reverse Osmosis Process (RO)

The RO uses a process at ambient temperature and high pressure. Water is pretreated and partly chemically de-chlorinated before to enter the membrane chambers, which separates the fresh water from the reject. The RO can be of multi-stage type (high pressure and low pressure stage). Use of welding is reduced compared to the distillation processes and involves less large use of CuNi and NiCu alloys even if pitting, crevice and strain induced corrosion issues are crucial. Need of strength combined with corrosion resistance is a good play-ground for introduction and use of superduplex steels together with superaustenitic (high pressure piping and energy recovery section). The 300 series stainless steels are also used in the less critical parts of the plant (e.g. for racks).

RO diagram



Welding solution for CuNi alloys: SMAW and GTAW filler metals

Böhler Welding CuNi filler metals 30% Ni alloyed are seawater resistant and can be used for welding CuNi alloys (90-10, 80-20, 70-30) to themselves and other alloys and steels. These products are widely applied in seawater desalination plants.

Details on the filler metals and trade names are in the product folder and handbook

FOOD & BEVERAGE

Breweries, distilleries, food treatment plants and storage facilities are the core of this industry. In terms of equipment the following requires corrosion resistant alloys:

» Storage tanks
» Autoclaves
» Process vessels
» Pipe systems
» Mixers
» Distillery devices

Materials and Welding

While standard 304L austenitic steels and Mo-alloyed 316L are still widely used and welded, the usage of higher alloyed materials is increasing; in fact, the material selection is heavily influenced by increasingly stringent and demanding requirements in the area of avoiding contamination of foods and beverages. The use of post-cleaning weld treatments such as pickling and passivation and/or electro-polishing is also a key factor to improve the corrosion resistance. The selection is anyhow made according to corrosion type and severity (which is mainly pitting and crevice corrision). Materials for the food and beverage applications can be as follows:

» Organic acids storage (acetic, citric, lactic) > 304L
» Dairy > 304L, 316L, S31254 or 926
» Mustard, ketchup, pickle, molasses > 316L, 904L, S31254, 926 or superduplex
» Sugar > 316L, duplex
» Jellies > 316L, 904L, S31254, 926 or superduplex
» Brewery, winery > 304L, lean duplex and duplex (for tanks)
» Soft drinks > 304L, lean duplex
» Other food > 304L, 316L, lean duplex

Duplex materials are often selected thanks to their favorable strain induced corrosion behavior (e.g. for mixers) and cost savings resulting from lighter tank walls (thinner gauges). The GTAW process is most widely used because it produces high-quality, as well as best bead appearance and corrosion-resistant welds with thin plates and pipes. GMAW, SMAW and FCAW are also common, the latter used predominantly in tank welding.

PHARMACEUTICAL

The pharmaceutical industry develops, produces, and markets drugs or pharmaceuticals licensed for medicational use. Pharmaceutical might be split in two main processes, bio-processing and chemical synthesis. As main equipment for the bio-processing plants, vessels for cultures, filters, as well as kill tanks have to be mentioned, while the chemical synthesis plants make a wide use of agitators, centrifuges, dryers and tanks.

Material Selection and Welding

As reagents are usually not very corrosive and the surface finish is of critical importance, 304L and 316L materials are dominating the pharmaceutical industry plants construction. Nevertheless it has to be remarked that requirements regarding the purity of the end-products dramatically increased in the last 20 years, so that special care has to be taken in construction and welding operations. According to the current regulation, either European or American, any product contamination is totally unacceptable.

Perfect polishing (pickling and if specified electro-polishing, then passivation) and surface smoothing are very important to avoid the end products are contaminated. The weld quality and appearance must be perfect, for any discontinuity could locally activate corrosion, especially where the weld joint is in contact with products. GTAW is for this reason the most used process. In addition, it has to be considered that media are often containing chloride in acid solution. The corrosion resistance of the series 300 stainless steels may not always be sufficient. In that case superaustenitic stainless steels such as S31254 or nickel alloys C-type (C-276, 22, 59) are used to resist to pitting and crevice corrosion.

Typical equipment for pharmaceuticals are also carbon steel enameled components such as mixers with agitators in nickel alloys C-type (C276, 22, 59) to get the best performance against the strain induced corrosion. Recently duplex and superduplex steels have been successfully applied.

Finally also high Si (4-6%) stainless steel UNS 30600 is used for tanks storing nitric acid (see inorganic chemical).

How to keep stainless 100% stainless within the Chemical Industry

Stainless steel equipment may be damaged after fabrication or in use and this can cause expensive corrosion problems. By using suitable products from Avesta Finishing Chemicals, it is possible to reduce these corrosion problems by keeping the surface 100% stainless.

Stainless steel is not equal to maintenance free

The self-healing capacity of stainless steel

Stainless steel is protected from corrosion by its passive layer. The chromium in the steel reacts with the oxygen to which the steel surface is exposed and thus forms this invisible layer. If the passive film is damaged it will be spontaneously healed if the surface is clean. On a contaminated stainless steel surface, however, the deposits will block this reaction. Chlorides may penetrate under the deposits leading to corrosion and rust. Proper cleaning of the surface will considerably reduce this risk.

Preventive maintenance

Cleaning should always be done before the surface becomes extremely dirty. The appropriate cleaning interval depends on the environment.

Avesta products and cleaning method

Avesta has a complete range of products designed to restore the corrosion resistance of stainless steel, whether it concerns cleaning, pickling and passivation.

REFERENCES

EPC:	Metso ND Engineering (Pty) Ltd, Durban, SA
Owner:	Sappi Saicor
Project:	Amakhullu new Fibre Line Project, South Africa Continuous Pulp Digesters, 11 pcs, 285 m3 + SO_2 Tank Farm and two Bleach Plant Reactors
Base material:	Duplex 2205 Hot Rolled Plate wt 10-18 mm,
Consumables:	
FCW:	Avesta FCW 2205-2D (AWS A5.22:E2209T0-4/1 EN 17633-A:T 22 9 3 NL R M(C)3) Avesta FCW 2205-PW (AWS A5.22:E2209T1-4/1 EN 17633-A:T 22 9 3 NL P M(C) 1) Avesta FCW P5-2D (AWS A5.22:E309LMoT0-4/1 EN 17633-A: T 23 12 2 L R M (C) 3)
GTAW:	Avesta 2205 (AWS A5.9:ER2209 EN 14343-A:W 22 9 3 NL)
SMAW:	Avesta 2205-3D (AWS A5.4:E2209-17 EN 3581-A:E 22 9 3 NL R 3 2)

Engineering:	CROW
Fabricator:	INTECNIAL
Owner:	METASA
Project:	Biodiesel Refining Plant (BSBios), Brazil
Base material:	STM A240 Gr. 304, Gr. 316, ASTM A36
Consumables:	
FCW:	BÖHLER EAS 2 PW-FD (AWS A5.22:E308LT1-4/1 EN ISO 17633-A: T 19 9 L P M (C) 1) BÖHLER EAS 4 PW-FD (AWS A5.22:E316LT1-4/1 EN ISO 17633-A:T 19 12 3 L P M(C) 1) BÖHLER CN 22/9 PW-FD (AWS A5.22:E2209T1-4/1 EN 17633-A:T 22 9 3 NL P M(C) 1)

This is a short list of some of our partners (EPC, Fabricators, Owners)

AgroLinz	Chema	International Paper	Montcalm	Stora Enso
Alfa Laval	Crow	Klabin	Praxair	Sulzer
Andritz	Ellimetal	Linde	Saipem	Technip
Apparatebau	Fibria	Lurgi	Schoeller-Bleckmann	Thyssen Krupp Uhde
BASF	G&G International	Mersen	Nitec	Veracel
BHDT	Intecnial	Metso	Solvay-Rhodia	Voith

Joining 1/10

	Alloy Group	Base Material Examples		Welding Process	Product Name	Classification AWS/EN
		ASTM-UNS/ALLOY	EN			
Austenitic Stainless Steel	Austenitic	304L	1.4307- 1.4306	SMAW	**Avesta 308L/MVR-3D**	AWS A5.4:E308L-17 EN ISO 3581-A: E 19 9 L R
					Avesta 308L/MVR-4D	AWS A5.4:E308L-17 EN ISO 3581-A: E 19 9 L R
					Avesta 308L/MVR-PW AC/DC	AWS A5.4:E308L-17 EN ISO 3581-A: E 19 9 L R
					BÖHLER FOX EAS 2-A	AWS A5.4:E308L-17 EN ISO 3581-A: E 19 9 L R 3 2
					BÖHLER FOX EAS 2	AWS A5.4:E308L-15 EN ISO 3581-A: E 19 9 L B 2 2
				SAW Wire	**Avesta 308L/SKR**	AWS A5.9:ER308L EN ISO 14343 S 19 9 L
				SAW Flux	**Avesta Flux 805**	- EN ISO 14174: SA AF 2 Cr DC
					Avesta Flux 801	- EN ISO 14174: SA CS 2 Cr DC
				GTAW	**Avesta 308L/MVR**	AWS A5.9:ER308L EN ISO 14343-A: W 19 9 L
					BÖHLER EAS 2-IG	AWS A5.9:ER308L EN ISO 14343-A: W 19 9 L
				GMAW	**Avesta 308L-Si/MVR-Si**	AWS A5.9:ER308LSi EN ISO 14343-A: G 19 9 L Si
					BÖHLER EAS 2-IG (Si)	AWS A5.9:ER308LSi EN ISO 14343-A: G 19 9 L Si
					BÖHLER EAS 2-MC	AWS A5.9:EC308L EN ISO 17633-A: T 19 9 L MM 1
				FCAW	**BÖHLER EAS 2-FD**	AWS A5.22:E308LT0-4/1 EN ISO 17633-A: T 19 9 L R M (C) 3
					BÖHLER EAS 2 PW-FD	AWS A5.22:E308LT1-4/1 EN ISO 17633-A: T 19 9 L P M (C) 1
		316L	1.4404- 1.4432	SMAW	**Avesta 316L/SKR-3D**	AWS A5.4:E316L-17 EN ISO 3581-A:E 19 12 3 L R
					Avesta 316L/SKR-4D	AWS A5.4:E316L-17 EN ISO 3581-A:E 19 12 3 L R
					Avesta 316L/SKR-PW AC/DC	AWS A5.4:E316L-17 EN ISO 3581-A:E 19 12 3 L R
					BÖHLER FOX EAS 4 M-A	AWS A5.4:E316L-17 EN ISO 3581-A:E 19 12 3 L R
					Böhler FOX EAS 4 M	AWS A5.4:E316L-15 EN ISO 3581-A:E 19 12 3 L B 2 2
				SAW Wire	**Avesta 316L/SKR**	AWS A5.9:ER316L EN ISO 14343-A:S 19 12 3 L
				SAW Flux	**Avesta Flux 805**	- EN ISO 14174: SA AF 2 Cr DC
					Avesta Flux 801	- EN ISO 14174: SA CS 2 Cr DC
				GTAW	**Avesta 316L/SKR**	AWS A5.9:ER316L EN ISO 14343-A:W 19 12 3 L
					BÖHLER EAS 4 M-IG	AWS A5.9:ER316L EN ISO 14343-A:W 19 12 3 L
				GMAW	**Avesta 316L-Si/SKR-Si**	AWS A5.9:ER316LSi EN ISO 14343-A: G 19 12 3 L Si
					BÖHLER EAS 4 M-IG (Si)	AWS A5.9:ER316LSi EN ISO 14343-A: G 19 12 3 L Si

Joining 2/10

	Alloy Group	Base Material Examples		Welding Process	Product Name	Classification AWS/EN	
		ASTM-UNS/ALLOY	EN				
Austenitic Stainless Steel	Austenitic	316L	1.4404- 1.4432	GMAW	**BÖHLER EAS 4 M-MC**	AWS A5.9:EC316L EN ISO 17633-A: T 19 12 3 L MM 1	
				FCAW	**BÖHLER EAS 4 M-FD**	AWS A5.22:E316LT0-4/1 EN ISO 17633-A: T 19 12 3 L R M (C) 3	
				FCAW	**BÖHLER EAS 4 PW-FD**	AWS A5.22:E316LT1-4/1 EN ISO 17633-A:T 19 12 3 L P M(C) 1	
		347	1.4550	SMAW	**BÖHLER FOX SAS 2-A**	AWS A5.4:E347-17 EN ISO 3581-A: E 19 9 Nb R 3 2	347 Nb stabilized grade
		321	1.4541				
					BÖHLER FOX SAS 2	AWS A5.4:E347-15 EN ISO 3581-A: E 19 9 Nb B 2 2	
				SAW Wire	**Avesta 347/MVNb**	AWS A5.9 ER347 EN ISO 14343 S 19 9 Nb	
				SAW Flux	**Avesta Flux 805**	- EN ISO 14174: SA AF 2 Cr DC	
				GTAW	**BÖHLER SAS 2-IG**	AWS A5.9:ER347 EN ISO 14343-A: W 19 9 Nb	
				GMAW	**BÖHLER SAS 2-IG (Si)**	AWS A5.9:ER347 EN ISO 14343-A: G 19 9 Nb Si	
				FCAW	**BÖHLER SAS 2-FD**	AWS A5.22:E347T0-4/1 EN ISO 17633-A: T 19 9 Nb R M(C) 3	
					BÖHLER SAS 2 PW-FD	AWS A5.22:E347T1-4/1 EN ISO 17633-A: T 19 9 Nb P M(C) 1	
		316Ti	1.4571	SMAW	**BÖHLER FOX SAS 4-A**	AWS A5.4:E318-17 EN ISO 3581-A: E 19 12 3 Nb R 3 2	318 Nb stabilized grade
					BÖHLER FOX SAS 4	AWS A5.4:E318-15 EN ISO 3581-A: E 19 12 3 Nb B 2 2	
				SAW Wire	**Thermanit A**	AWS A5.9:ER318 EN ISO 14343-A: S 19 12 3 Nb	
				SAW Flux	**Marathon 431**	- EN ISO 14174: SA FB 2 DC	
				GTAW	**BÖHLER SAS 4-IG**	AWS A5.9:ER318 EN ISO 14343-A: W 19 12 3 Nb	
				GMAW	**BÖHLER SAS 4-IG (Si)**	AWS A5.9:ER318 (mod.) EN ISO 14343-A: G 19 12 3 Nb Si	
				FCAW	**BÖHLER SAS 4-FD**	AWS A5.22:E318T0-4/1 EN ISO 17633-A: T 19 12 3 Nb R M(C) 3	
					BÖHLER SAS 4 PW-FD	AWS A5.22:E318T1-4/1 EN ISO 17633-A: T 19 12 3 Nb P M(C) 1	
		317L	1.4438	SMAW	**Avesta 317L/SNR-3D**	AWS A5.9:ER317L -	
					BÖHLER FOX ASN 5-A	AWS A5.4:E317L-17 mod. EN ISO 3581-A: E 18 16 5 N L R 3 2	
					BÖHLER FOX ASN 5	AWS A5.4:E317L-15 (mod.) EN ISO 3581-A: E 18 16 5 N L B 2 2	
				SAW Wire	**Avesta 317L/SNR**	AWS A5.9:ER317L EN ISO 14343-A: S 19 13 4 L	
				SAW Flux	**Avesta Flux 805**	- EN ISO 14174: SA AF 2 Cr DC	
				GTAW	**BÖHLER ASN 5-IG**	AWS A5.9:ER317L (mod.) EN ISO 14343-A: W Z18 16 5 N L	
					Avesta 317L/SNR	AWS A5.9:ER317L EN ISO 14343-A: W 19 13 4 L	
				GMAW	**Avesta 317L/SNR**	AWS A5.9:ER317L EN ISO 14343-A: G 19 13 4 L	

Joining 3/10

	Alloy Group	Base Material Examples ASTM-UNS/ALLOY	EN	Welding Process	Product Name	Classification AWS/EN
Austenitic Stainless Steel					**BÖHLER ASN 5-IG (Si)**	AWS A5.9:ER317L (mod.) EN ISO 14343-A: G Z18 16 5 N L Si
				FCAW	**BÖHLER E 317L-FD**	AWS A5.22:E317LT0-4/1 EN ISO 17633-A: T Z19 13 4 L R M(C) 3
					BÖHLER E 317L PW-FD	AWS A5.22:E317LT1-4/1 EN ISO 17633-A: T Z19 13 4 L P M(C) 1
	Special Austenitic and Super Austenitic	904L	1.4539	SMAW	**BÖHLER FOX CN 20/25 M**	AWS A5.4:E385-15 (mod.) EN ISO 3581-A: E 20 25 5 Cu N L B 2 2
					Avesta 904L-3D	AWS A5.4:E385-17 EN ISO 3581-A: E 20 25 5 Cu N L R
					Avesta 904L-PW AC/DC	- EN ISO 3581-A: E 20 25 5 Cu N L R
					BÖHLER FOX CN 20/25 M-A	AWS A5.4:E385-17 (mod.) EN ISO 3581-A: E 20 25 5 Cu N L R 3 2
				SAW Wire	**Avesta 904L**	AWS A5.9:ER385 EN ISO 14343-A: S 20 25 5 Cu L
				SAW Flux	**Avesta Flux 805**	- EN ISO 14174: SA AF 2 Cr DC
				GTAW	**BÖHLER CN 20/25 M-IG**	AWS A5.9:ER385 (mod.) EN ISO 14343-A: W Z20 25 5 Cu N L
					Avesta 904L	AWS A5.9:ER385 EN ISO 14343-A: W 20 25 5 Cu L
				GMAW	**BÖHLER CN 20/25 M-IG (SI)**	AWS A5.9:ER385 (mod.) EN ISO 14343-A: G Z20 25 5 Cu N L
					Avesta 904L	AWS A5.9:ER385 EN ISO 14343-A: G 20 25 5 Cu L
				FCAW	**BÖHLER NIBAS 625 PW-FD**	AWS A5.34:ENiCrMo3T1-4 EN ISO 14172: Typ Ni 6625 (NiCr22Mo9Nb)
		N08028/28	1.4563	SMAW	**Thermanit 30/40 EW**	- EN ISO 14172: E Ni 8025 (NiCr29Fe26Mo)
				SAW Wire	**Thermanit 625**	AWS A5.14 : ER NiCrMo-3 EN ISO 18274 : S Ni 6625 (NiCr22Mo9Nb)
				SAW Flux	**Marathon 444**	- EN 760: SA FB 2 AC
				GTAW	**Thermanit 30/40 E**	AWS A5.9:ER383 (mod.) EN ISO 18274: S Ni 8025 (NiFe30Cr29Mo)
				GMAW	**Thermanit 30/40 E**	AWS A5.9:ER383 (mod.) EN ISO 18274: S Ni 8025 (NiFe30Cr29Mo)
				FCAW	**BÖHLER NIBAS 625 PW-FD**	AWS A5.34:ENiCrMo3T1-4 EN ISO 14172: Typ Ni 6625 (NiCr22Mo9Nb)
		S31254/254SMo™ N08926	1.4547 1.4529	SMAW	**Avesta P12-R basic**	AWS A5.11:ENiCrMo-12 EN ISO 14172: E Ni 6627 (NiCr22Mo9)
					Thermanit NiMo C 24	AWS A5.11:ENiCrMo-13 EN ISO 14172: E Ni 6059 (NiCr23Mo16)
				SAW Wire	**Thermanit 625**	AWS A5.14 : ER NiCrMo-3 EN ISO 18274 : S Ni 6625 (NiCr22Mo9Nb)
				SAW Flux	**Marathon 444**	- EN 760: SA FB 2 AC
				SAW Wire	**Avesta P16**	AWS A5.14:ERNiCrMo-13 EN ISO 18274: S Ni 6059 (NiCr23Mo16)
				SAW Flux	**Avesta Flux 805**	- EN ISO 14174: SA AF 2 Cr DC
				GTAW	**Avesta P12**	AWS A5.14 : ER NiCrMo-3 EN ISO 18274 : S Ni 6625 (NiCr22Mo9Nb)

Joining 4/10

	Alloy Group	Base Material Examples		Welding Process	Product Name	Classification AWS/EN	
		ASTM-UNS/ALLOY	EN				
Austenitic Stainless Steel					**Thermanit NiMo C 24**	AWS A5.14:ERNiCrMo-13 EN ISO 18274: S Ni 6059 (NiCr23Mo16)	
				GMAW	**Avesta P12**	AWS A5.14 : ER NiCrMo-3 EN ISO 18274 : S Ni 6625 (NiCr22Mo9Nb)	
					Thermanit NiMo C 24	AWS A5.14:ERNiCrMo-13 EN ISO 18274: S Ni 6059 (NiCr23Mo16)	
				FCAW	**BÖHLER NIBAS 625 PW-FD**	AWS A5.34:ENiCrMo3T1-4 EN ISO 14172: Typ Ni 6625 (NiCr22Mo9Nb)	
		S34565 S31654/654SMo™	1.4565 1.4652	SMAW	**Thermanit NiMo C 24**	AWS A5.11:ENiCrMo-13 EN ISO 14172: E Ni 6059 (NiCr23Mo16)	
				SAW Wire	**Avesta P16**	AWS A5.14:ERNiCrMo-13 EN ISO 18274: S Ni 6059 (NiCr23Mo16)	
				SAW Flux	**Avesta Flux 805**	- EN ISO 14174: SA AF 2 Cr DC	
				GTAW	**Thermanit NiMo C 24**	AWS A5.14:ERNiCrMo-13 EN ISO 18274: S Ni 6059 (NiCr23Mo16)	
				GMAW	**Thermanit NiMo C 24**	AWS A5.14:ERNiCrMo-13 EN ISO 18274: S Ni 6059 (NiCr23Mo16)	
		NR20033/33 N08031/31	1.4591 1.4562	SMAW	**Thermanit NiMo C 24**	AWS A5.11:ENiCrMo-13 EN ISO 14172: E Ni 6059 (NiCr23Mo16)	
				GTAW	**Thermanit NiMo C 24**	AWS A5.14:ERNiCrMo-13 EN ISO 18274: S Ni 6059 (NiCr23Mo16)	
				GMAW	**Thermanit NiMo C 24**	AWS A5.14:ERNiCrMo-13 EN ISO 18274: S Ni 6059 (NiCr23Mo16)	
	Urea/Nitric Acid Special Grades	S30600	1.4361	SMAW	**BÖHLER FOX EAS 2 Si**	- EN ISO 3581-A: E Z19 14 Si B 2 2	Nitric Acid
				GTAW	**BÖHLER EASN 2 Si-IG**	- EN ISO 14343-A: W Z19 13 Si N L	
		(724Mod.)316L UG	1.4435	SMAW	**Thermanit 19/15 H**	AWS A5.4:E316LMn-15 EN ISO 3581-A:E 20 16 3 Mn N L B 2 2	Urea
				GTAW	**Thermanit 19/15 H**	AWS A5.9:ER316LMn EN ISO 14343-A: W 20 16 3 Mn N L	
				GMAW	**Thermanit 19/15 H**	AWS A5.9:ER316LMn EN ISO 14343-A: G 20 16 3 Mn N L	
		S31050/725 LN	1.4466	SMAW	**Thermanit 25/22 H**	- EN ISO 3581-A:EZ 25 22 2 L B 2 2	Urea and Nitric Acid
				GTAW	**Thermanit 25/22 H**	AWS A5.9:ER310 (mod.) EN ISO 14343-A: W 25 22 2 N L	
				GMAW	**Thermanit 25/22 H**	AWS A5.9:ER310 (mod.) EN ISO 14343-A: G 25 22 2 N L	
Duplex Stainless Steel	Lean Duplex	S32101/LDX 2101™	1.4162	SMAW	**Avesta LDX 2101-3D**	- EN ISO 3581-A: E 23 7 N L R	
					Avesta LDX 2101-4D	- EN ISO 3581-A: E 23 7 N L R	
				SAW Wire	**Avesta LDX 2101**	- EN ISO 14343-A: S 23 7 N L	
				SAW Flux	**Avesta Flux 805**	- EN ISO 14174: SA AF 2 Cr DC	
				GTAW	**Avesta LDX 2101**	- EN ISO 14343-A: W 23 7 N L	
				GMAW	**Avesta LDX 2101**	- EN ISO 14343-A: G 23 7 N L	
				FCAW	**Avesta FCW-2D LDX 2101**	- EN ISO 17633-A:T 23 7 N L R M(C) 3	

Joining 5/10

	Alloy Group	Base Material Examples		Welding Process	Product Name	Classification AWS/EN	
		ASTM-UNS/ALLOY	EN				
Duplex Stainless Steel					**Avesta FCW LDX 2101-PW**	- EN ISO 17633-A:T 23 7 N L P M(C) 1	
		S32304/2304	1.4362	SMAW	**Avesta 2304-3D**	- EN ISO 3581-A: E 23 7 N L R	
					Avesta 2304-4D	- EN ISO 3581-A: E 23 7 N L R	
				SAW Wire	**Avesta 2304**	- EN ISO 14343-A: S 23 7 N L	
				SAW Flux	**Avesta Flux 805**	- EN ISO 14174: SA AF 2 Cr DC	
				GTAW	**Avesta 2304**	- EN ISO 14343-A: W 23 7 N L	
				GMAW	**Avesta 2304**	- EN ISO 14343-A: G 23 7 N L	
				FCAW	**Avesta FCW-2D 2304**	- EN ISO 17633-A:T 23 7 N L R M(C) 3	
					Avesta FCW 2304-PW	- EN ISO 17633-A:T 23 7 N L R M(C) 1	
Duplex Stainless Steel	Duplex	S32205/2205	1.4462	SMAW	**Avesta 2205-3D**	AWS A5.4:E2209-17 EN ISO 3581-A:E 22 9 3 N L R	
					Avesta 2205-4D	AWS A5.4:E2209-17 EN ISO 3581-A:E 22 9 3 N L R	
					BÖHLER FOX CN 22/9 N-B	AWS A5.4:E2209-15 EN ISO 3581-A:E 22 9 3 N L B 2 2	
				SAW Wire	**Avesta 2205**	AWS A5.9:ER2209 EN ISO 14343-A:S 22 9 3 N L	
				SAW Flux	**Avesta Flux 805**	- EN ISO 14174: SA AF 2 Cr DC	
				GTAW	**Avesta 2205**	AWS A5.9:ER2209 EN ISO 14343-A:W 22 9 3 N L	
				GMAW	**Avesta 2205**	AWS A5.9:ER2209 EN ISO 14343-A:G 22 9 3 N L	
				FCAW	**Avesta FCW-2D 2205**	AWS A5.22:E2209T0-4/1 EN 17633-A:T 22 9 3 N L R M(C) 3	
					Avesta FCW 2205-PW	AWS A5.22:E2209T1-4/1 EN 17633-A:T 22 9 3 N L P M(C) 1	
	Super-Duplex	S32750/2507 S32760/2507 CuW	1.4410 1.4501	SMAW	**Avesta 2507/P100 rutile**	AWS A5.4:E2594-17 EN ISO 3581-A:E 25 9 4 N L R	
					Avesta 2507/P100-3D	AWS A5.4:E2594-17 EN ISO 3581-A:E 25 9 4 N L R	
					Thermanit 25/09 CuT	AWS A5.4:E2595-15 EN ISO 3581-A:E 25 9 4 N L B 2 2	
				SAW Wire	**Avesta 2507/P100**	AWS A5.9:ER2594 EN ISO 14343-A:S 25 9 4 N L	
				SAW Flux	**Avesta Flux 805**	- EN ISO 14174: SA AF 2 Cr DC	
				SAW Wire	**Thermanit 25/09 CuT**	AWS A5.9:ER2594 EN ISO 14343-A:S 25 9 4 N L	
				SAW Flux	**Marathon 431**	- EN ISO 14174: SA FB 2 DC	
				GTAW	**Avesta 2507/P100**	AWS A5.9:ER2594 EN ISO 14343-A:W 25 9 4 N L	
					Thermanit 25/09 CuT	AWS A5.9:ER2594 EN ISO 14343-A:W 25 9 4 N L	

Joining 6/10

	Alloy Group	Base Material Examples ASTM-UNS/ALLOY	Base Material Examples EN	Welding Process	Product Name	Classification AWS/EN	
				GMAW	**Avesta 2507/P100**	AWS A5.9:ER2594 EN ISO 14343-A:G 25 9 4 N L	
					Thermanit 25/09 CuT	AWS A5.9:ER2594 EN ISO 14343-A:G 25 9 4 N L	
				FCAW	**Avesta FCW 2507/ P100-PW**	AWS A5.22:E2594T1-4/1 EN 17633-A:T 25 9 4 N L P M(C) 2	
Wear Resistant Stainless Steel		248SV	1.4418	SMAW	**Avesta 248 SV rutile**	-	
					Avesta 248 SV	-	
				SAW Wire	**Avesta 248SV**	- EN ISO 14343-A: S 16 5 1	
				SAW Flux	**Avesta Flux 801**	- EN ISO 14174: SA CS 2 Cr DC	
				GTAW	**Avesta 248 SV**	- EN ISO 14343-A: G 16 5 1	
				GMAW	**Avesta 248 SV**	- EN ISO 14343-A: G 16 5 1	
		410 NiMo	1.4313 1.4407 1.4414	SMAW	**BÖHLER FOX CN 13/4**	AWS A5.11:E410NiMo-15 EN ISO 3581-A: E 13 4 B 6 2	
				SAW Wire	**BÖHLER CN 13/4-UP**	AWS A5.9:ER410NiMo (mod.) EN ISO 14343-A: S 13 4	
				SAW Flux	**BÖHLER BB 203**	- EN ISO 14174: SA FB 2 DC	
				GTAW	**BÖHLER CN 13/4-IG**	AWS A5.9:ER410NiMo (mod.) EN ISO 14343-A: W 13 4	
				GMAW	**BÖHLER CN 13/4-IG**	AWS A5.9:ER410NiMo (mod.) EN ISO 14343-A: G 13 4	
Dissimilar Welds and/or Buffer Layers				SMAW	**BÖHLER FOX CN 23/12-A**	AWS A5.4:E309L-17 EN ISO 3581-A: E 23 12 L R 3 2	309L grade
				SAW Wire	**Avesta 309L**	AWS A5.9 ER309L EN ISO 14343 S 23 12 L	
				SAW Flux	**Avesta Flux 805**	- EN ISO 14174: SA AF 2 Cr DC	
					Avesta Flux 801	- EN ISO 14174: SA CS 2 Cr DC	
				GTAW	**BÖHLER CN 23/12-IG**	AWS A5.9:ER309L EN ISO 14343-A: W 23 12 L	
				GMAW	**BÖHLER CN 23/12-IG**	AWS A5.9:ER309L EN ISO 14343-A: G 23 12 L	
					BÖHLER CN 23/12-MC	AWS A5.9:EC309L EN ISO 17633-A: T 23 12 L MM1	
				FCAW	**BÖHLER CN 23/12-FD**	AWS A5.22:E309LT0-4/1 EN ISO 17633-A: T 23 12 L R M (C) 3	
					BÖHLER CN 23/12 PW-FD	AWS A5.22:E309LT1-4/1 EN ISO 17633-A: T 23 12 L P M(C) 1	
				SMAW	**Avesta P5-3D**	AWS A5.4:E309LMo-17 EN ISO 3581-A: E 23 12 2 L R	309LMo grade
				SAW Wire	**Avesta P5**	AWS A5.9:ER309LMo (mod.) EN ISO 14343-A: S 23 12 2 L	
				SAW Flux	**Avesta Flux 805**	- EN ISO 14174: SA AF 2 Cr DC	
				GTAW	**Avesta P5**	AWS A5.9:ER309LMo (mod.) EN ISO 14343-A: W 23 12 2 L	
				GMAW	**Avesta P5**	AWS A5.9:ER309LMo (mod.) EN ISO 14343-A: G 23 12 2 L	

Joining 7/10

	Alloy Group	Base Material Examples		Welding Process	Product Name	Classification AWS/EN	
		ASTM-UNS/ALLOY	EN				
Difficult to be welded Steels				FCAW	**Avesta FCW-2D P5**	AWS A5.22:E309LMoT0-4/1 EN ISO 17633-A: T 23 12 2 L R M (C) 3	
					Avesta FCW P5-PW	AWS A5.22:E309LMo T1-4/1 EN ISO 17633-A: T 23 12 2 L P M(C) 1	
				SMAW	**BÖHLER FOX A 7 CN**	AWS A5.4:E307-15 (mod.) EN ISO 3581-A: E 18 8 Mn B 2 2	307 mod. grade
					BÖHLER FOX A 7-A	AWS A5.4:E307-16 (mod.) EN ISO 3581-A: E Z18 9 MnMo R 3 2	
				SAW Wire	**Thermanit X**	AWS A5.9:ER307 (mod.) EN ISO 14343-A: S 18 8 Mn	
				SAW Flux	**Marathon 431**	- EN ISO 14174: SA FB 2 DC	
				GTAW	**BÖHLER A 7 CN-IG**	AWS A5.9:ER307 (mod.) EN ISO 14343-A: W 18 8 Mn	
				GMAW	**BÖHLER A 7 CN-IG**	AWS A5.9:ER307mod EN ISO 14343-A: G 18 8 Mn	
					BÖHLER A 7-MC	AWS A5.9:EC307 (mod.) EN ISO 17633-A: T 18 8 Mn MM1	
				FCAW	**BÖHLER A7 FD**	AWS A5.22:E307T0-G EN ISO 17633-A: T 18 8 Mn R M(C) 3	
					BÖHLER A7 PW-FD (LMN)	AWS A5.22:E307T1-G EN ISO 17633-A: T 18 8 Mn P M(C) 2	
				SMAW	**Avesta P7 AC/DC**	AWS A5.4:E312-17 (mod.) EN ISO 3581-A: E 29 9 R	312 grade
				SAW Wire	**Avesta P7**	- EN ISO 14343-A: S 29 9	
				SAW Flux	**Avesta Flux 805**	- EN ISO 14174: SA AF 2 Cr DC	
				GTAW	**Avesta P7**	AWS A5.9:ER312 EN ISO 14343-A: W 29 9	
				GMAW	**Avesta P7**	AWS A5.9:ER312 EN ISO 14343-A: G 29 9	
Nickel - Base for Wet Corrosion	Ni alloys	N02200/200 N02201/201	2.4066 2.4068	SMAW	**UTP 80 Ni**	AWS A5.11:ENi-1 EN ISO 14172 : E Ni 2061 (NiTi3)	
				GTAW	**UTP A 80 Ni**	AWS A5.14:ERNi-1 EN ISO 18274 : S Ni 2061 (NiTi3)	
				GMAW	**UTP A 80 Ni**	AWS A5.14:ERNi-1 EN ISO 18274 : S Ni 2061 (NiTi3)	
	NiCrFe alloys	N06600/600 N06600/600L	2.4816 2.4817	SMAW	**Thermanit Nicro 82**	AWS A5.11 : E NiCrFe-3 (mod.) EN ISO 14172 : E Ni 6082 (NiCr20Mn3Nb)	
				SAW Wire	**Thermanit Nicro 82**	AWS A5.14:ERNiCr-3 EN ISO 18274 : S Ni 6082 (NiCr20Mn3Nb)	
				SAW Flux	**Marathon 444**	- EN 760: SA FB 2 AC	
				GTAW	**Thermanit Nicro 82**	AWS A5.14 : ER NiCr-3 EN ISO 18274 : S Ni 6082 (NiCr20Mn3Nb)	
				GMAW	**Thermanit Nicro 82**	AWS A5.14 : ER NiCr-3 EN ISO 18274 : S Ni 6082 (NiCr20Mn3Nb)	
				FCAW	**BÖHLER NIBAS 70/20-FD**	AWS A5.14:ENiCr3T0-4 EN ISO 14172: Typ Ni 6082 (NiCr20Mn3Nb)	
		N06690/690	2.4642	SMAW	**Thermanit 690**	AWS A5.14:ERNiCrFe-7 EN ISO 14172 : E Ni 6025 (NiCr30Fe9)	
				GTAW	**Thermanit 690**	AWS A5.14:ERNiCrFe-7 EN ISO 18274 :S Ni 6025 (NiCr30Fe9)	

Joining 8/10

	Alloy Group	Base Material Examples		Welding Process	Product Name	Classification AWS/EN	
		ASTM-UNS/ALLOY	EN				
Nickel - Base for Wet Corrosion				GMAW	**Thermanit 690**	AWS A5.14:ERNiCrFe-7 EN ISO 18274 :S Ni 6025 (NiCr30Fe9)	
	NiFeCrMoCu alloys	N08020 / 20 N08825/825 N06985/G-3	2.4660 2.4858 2.4619	SMAW	**Thermanit 625**	AWS A5.11 : E NiCrMo-3 EN ISO 14172 : E Ni 6625 (NiCr22Mo9Nb)	Filler Metal alloy 625 Matching Grade
				SAW Wire	**Thermanit 625**	AWS A5.14:ERNiCrMo-3 EN ISO 18274 : S Ni 6625(NiCr22Mo9Nb)	
				SAW Flux	**Marathon 444**	- EN 760: SA FB 2 AC	
				GTAW	**Thermanit 625**	AWS A5.14 : ER NiCrMo-3 EN ISO 18274 : S Ni 6625(NiCr22Mo9Nb)	
				GMAW	**Thermanit 625**	AWS A5.14:ERNiCrMo-3 EN ISO 18274 : S Ni 6625(NiCr22Mo9Nb)	
				FCAW	**BÖHLER NIBAS 625 PW-FD**	AWS A5.34:ENiCrMo3T1-4 EN ISO 14172: Typ Ni 6625 (NiCr22Mo9Nb)	
	NiCrMo (Fe) alloys	N06625 / 625	2.4856	SMAW	**Thermanit 625**	AWS A5.11 : E NiCrMo-3 EN ISO 14172 : E Ni 6625 (NiCr22Mo9Nb)	Also for High Temperature applications
				SAW Wire	**Thermanit 625**	AWS A5.14:ERNiCrMo-3 EN ISO 18274 : S Ni 6625(NiCr22Mo9Nb)	
				SAW Flux	**Marathon 444**	- EN 760: SA FB 2 AC	
				GTAW	**Thermanit 625**	AWS A5.14 : ER NiCrMo-3 EN ISO 18274 : S Ni 6625(NiCr22Mo9Nb)	
				GMAW	**Thermanit 625**	AWS A5.14:ERNiCrMo-3 EN ISO 18274 : S Ni 6625(NiCr22Mo9Nb)	
				FCAW	**BÖHLER NIBAS 625 PW-FD**	AWS A5.34:ENiCrMo3T1-4 EN ISO 14172: Typ Ni 6625 (NiCr22Mo9Nb)	
		N10276/ C-276	2.4819	SMAW	**UTP 776 Kb**	AWS A5.11:ENiCrMo-4 EN ISO 14172 : E Ni 6276 (NiCr15Mo15Fe6W4)	
				SAW Wire	**UTP UP 776**	AWS A5.14:ERNiCrMo-4 EN ISO 18274 : S Ni 6276 (NiCr15Mo15Fe6W4)	
				SAW Flux	**UTP UP FX 776/3**	- EN 760 : S A FB 2 55 AC H5	
				GTAW	**UTP A 776**	AWS A5.14:ERNiCrMo-4 EN ISO 18274 : S Ni 6276 (NiCr15Mo15Fe6W4)	
				GMAW	**UTP A 776**	AWS A5.14:ERNiCrMo-4 EN ISO 18274 : S Ni 6276 (NiCr15Mo15Fe6W4)	
		N06022/22	2.4602	SMAW	**UTP 722 Kb**	AWS A5.11:ENiCrMo-10 EN ISO 14172 : E Ni 6022 (NiCr21Mo13W3)	
				GTAW	**UTP A 722**	AWS A5.14:ERNiCrMo-10 EN ISO 18274 : S Ni 6022 (NiCr21Mo13W3)	
				GMAW	**UTP A 722**	AWS A5.14:ERNiCrMo-10 EN ISO 18274 : S Ni 6022 (NiCr21Mo13W3)	
		N06059/59 N06455/C-4 N06200/C-2000™	2.4605 2.4610 2.4675	SMAW	**Thermanit NiMo C 24**	AWS A5.11:ENiCrMo-13 EN ISO 14172: E Ni 6059 (NiCr23Mo16)	Filler Metal alloy 59 Matching Grade
				GTAW	**Thermanit NiMo C 24**	AWS A5.14:ERNiCrMo-13 EN ISO 18274: S Ni 6059 (NiCr23Mo16)	
				GMAW	**Thermanit NiMo C 24**	AWS A5.14:ERNiCrMo-13 EN ISO 18274: S Ni 6059 (NiCr23Mo16)	
	NiMo alloys	N10665/B-2	2.4617	SMAW	**UTP 703 Kb**	AWS A5.11:ENiMo-7 EN ISO 14172 : ENi 1066 (NiMo28)	
				GTAW	**UTP A 703**	AWS A5.14:ERNiMo-7 EN ISO 18274 : S Ni 1066 (NiMo28)	
				GMAW	**UTP A 703**	AWS A5.14:ERNiMo-7 EN ISO 18274 : S Ni 1066 (NiMo28)	

Joining 9/10

	Alloy Group	Base Material Examples		Welding Process	Product Name	Classification AWS/EN	
		ASTM-UNS/ALLOY	EN				
		N10675/B-3	2.4600	SMAW	**UTP 6202 Mo**	AWS A5.11:ENiMo-11 EN ISO 14172 : E Ni 1069 (NiMo28Fe4Cr)	
				GTAW	**UTP A 6202 Mo**	AWS A5.14:ERNiMo-11 EN ISO 18274 : S Ni 1069 (NiMo28Fe4Cr)	
				GMAW	**UTP A 6202 Mo**	AWS A5.14:ERNiMo-11 EN ISO 18274 : S Ni 1069 (NiMo28Fe4Cr)	
Heat Resistant Stainless Steel		310S 310	1.4845 1.4841	SMAW	**BÖHLER FOX FFB-A**	AWS A5.4:E310-16 EN ISO 3581-A: E 25 20 R 3 2	
				GTAW	**BÖHLER FFB-IG**	AWS A5.9:ER310 (mod.) EN ISO 14343-A: W 25 20 Mn	
				GMAW	**BÖHLER FFB-IG**	AWS A5.9:ER310 (mod.) EN ISO 14343-A: G 25 20 Mn	
		S30415 S30815 S30900/309S	1.4818 1.4835 1.4828	SMAW	**Avesta 253 MA-3D**	- EN ISO 3581-A: E 21 10 R	
				SAW Wire	**Avesta 253 MA**	- EN ISO 14343-A:S 21 10 N	
				SAW Flux	**Avesta Flux 801**	- EN ISO 14174: SA CS 2 Cr DC	
				GTAW	**Avesta 253 MA**	- EN ISO 14343-A:W 21 10 N	
				GMAW	**Avesta 253 MA**	- EN ISO 14343-A:G 21 10 N	
		N08810/800 H	1.4876 1.4958	SMAW	**UTP 2133 Mn**	- EN ISO 3581-A: EZ 21 33 B 4 2	
				GTAW	**UTP A 2133 Mn**	- EN ISO 14343: WZ 21 33 Mn Nb	
				GMAW	**UTP A 2133 Mn**	- EN ISO 14343: GZ 21 33 Mn Nb	
		N08330/DS S33228/AC66	1.4862 1.4877	SMAW	**Thermanit 625**	AWS A5.11 : E NiCrMo-3 EN ISO 14172 : E Ni 6625 (NiCr22Mo9Nb)	
				SAW Wire	**Thermanit 625**	AWS A5.14:ERNiCrMo-3 EN ISO 18274 : S Ni 6625(NiCr22Mo9Nb)	
				SAW Flux	**Marathon 444**	- EN 760: SA FB 2 AC	
				GTAW	**Thermanit 625**	AWS A5.14 : ER NiCrMo-3 EN ISO 18274 : S Ni 6625(NiCr22Mo9Nb)	
				GMAW	**Thermanit 625**	AWS A5.14:ERNiCrMo-3 EN ISO 18274 : S Ni 6625(NiCr22Mo9Nb)	
				FCAW	**BÖHLER NIBAS 625 PW-FD**	AWS A5.34:ENiCrMo3T1-4 EN ISO 14172: Typ Ni 6625 (NiCr22Mo9Nb)	
Nickel - Base for High Temperature		N06600/600 H	2.4816	SMAW	**Thermanit Nicro 82**	AWS A5.11 : E NiCrFe-3 (mod.) EN ISO 14172 : E Ni 6082 (NiCr20Mn3Nb)	
				SAW Wire	**Thermanit Nicro 82**	AWS A5.14:ERNiCr-3 EN ISO 18274 : S Ni 6082 (NiCr20Mn3Nb)	
				SAW Flux	**Marathon 444**	- EN 760: SA FB 2 AC	
				GTAW	**Thermanit Nicro 82**	AWS A5.14 : ER NiCr-3 EN ISO 18274 : S Ni 6082 (NiCr20Mn3Nb)	
				GMAW	**Thermanit Nicro 82**	AWS A5.14 : ER NiCr-3 EN ISO 18274 : S Ni 6082 (NiCr20Mn3Nb)	
				FCAW	**BÖHLER NIBAS 70/20-FD**	AWS A5.14:ENiCr3T0-4 EN ISO 14172: Typ Ni 6082 (NiCr20Mn3Nb)	
		N06617/617	24.663	SMAW	**Thermanit 617**	AWS A5.11 : ~ ENiCrCoMo-1 (mod.) EN ISO 14172 : ~ E Ni 6117~ (NiCr22Co12Mo9)	

Joining 10/10

	Alloy Group	Base Material Examples ASTM-UNS/ALLOY	EN	Welding Process	Product Name	Classification AWS/EN	
				GTAW	**Thermanit 617**	AWS A5.14 : ER NiCrCoMo-1 EN ISO 18274 : S Ni 6617 (NiCr22Co12Mo9)	
				GMAW	**Thermanit 617**	AWS A5.14 : ER NiCrCoMo-1 EN ISO 18274 : S Ni 6617 (NiCr22Co12Mo9)	
		N06601/601-601H N06025/602CA	2.4851 2.4633	SMAW	**UTP 6225 Al**	AWS A 5.11 : E NiCrFe-12 EN ISO 14172 : E Ni 6025 (NiCr25Fe10AlY)	
				GTAW	**UTP A 6225 Al**	AWS A 5.14 : ER NiCrFe-12 EN ISO 18274 : S Ni 6025 (NiCr25Fe10AlY)	
				GMAW	**UTP A 6225 Al**	AWS A 5.14 : ER NiCrFe-12 EN ISO 18274 : S Ni 6025 (NiCr25Fe10AlY)	
Copper-Nickel /Nickel-Copper alloy	NiCu alloys	N04400/400 K-500	2.4360	SMAW	**UTP 80 M**	AWS A5.11 : E NiCu-7 EN ISO 14172 : E Ni 4060 (NiCu30Mn3Ti)	
				GTAW	**UTP A 80 M**	AWS A5.14 : ER NiCu-7 EN ISO 18274 : S Ni 4060 (NiCu30Mn3Ti)	
				GMAW	**UTP A 80M**	AWS A5.14 : ER NiCu-7 EN ISO 18274 : S Ni 4060 (NiCu30Mn3Ti)	
	CuNi alloys	C71500/CuNi 70-30 C70600/CuNi 90-10	2.0872 2.0878 2.0882	SMAW	**UTP 387**	AWS A5.6:ECuNi DIN 1733 : EL-CuNi30Mn	
				GTAW	**UTP A 387**	AWS A5.7:ERCuNi EN ISO 24373 : S Cu 7158 (CuNi30Mn1FeTi)	
				GMAW	**UTP A 387**	AWS A5.7:ERCuNi EN ISO 24373 : S Cu 7158 (CuNi30Mn1FeTi)	
		R50400H ASTM gr.1-4		GTAW	**BÖHLER ER Ti 2-IG**	AWS A5.16:ERTi-2 -	

JOIN! voestalpine Böhler Welding

We are a leader in the welding industry with over 100 years of experience, more than 50 subsidiaries and more than 4,000 distribution partners around the world. Our extensive product portfolio and welding expertise combined with our global presence guarantees we are close when you need us. Having a profound understanding of your needs enables us to solve your demanding challenges with Full Welding Solutions - perfectly synchronized and as unique as your company.

Lasting Connections – Perfect alignment of welding machines, consumables and technologies combined with our renowned application and process know-how provide the best solution for your requirements: A true and proven connection between people, products and technologies. The result is what we promise: Full Welding Solutions for Lasting Connections.

Tailor-Made Protectivity™ – The combination of our high-quality products and application expertise enables you to not only repair and protect metal surfaces and components. Our team of engineers, experienced in your specific applications, offer you customized solutions resulting in increased productivity for your demanding challenge. The result is what we promise: Tailor-Made Protectivity™.

In-Depth Know-How – As a manufacturer of soldering and brazing consumables, we offer proven solutions based on 60 years of industrial experience, tested processes and methods, made in Germany. This in-depth know-how makes us the internationally preferred partner to solve your soldering and brazing challenge through innovative solutions. The result is what we promise: Innovation based on in-depth know-how.

The Management System of voestalpine Böhler Welding Group GmbH, Peter-Mueller-Strasse 14-14a, 40469 Duesseldorf, Germany has been approved by Lloyd's Register Quality Assurance to: ISO 9001:2015, ISO 14001:2015, OHSAS 18001:2007, applicable to: Development, Manufacturing and Supply of Welding and Brazing Consumables.
More information: www.voestalpine.com/welding

156/2018/EN/GL

voestalpine Böhler Welding
www.voestalpine.com/welding

voestalpine
ONE STEP AHEAD.