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ZERON 100

Technical Data Sheet

Super Duplex Stainless Steel

ZERON◊ 100 is a highly alloyed duplex stainless steel for use in aggressive environments. Its properties include:-

- Guaranteed corrosion performance (PREN≥ 40)
- High resistance to pitting and crevice corrosion
- Excellent resistance to stress corrosion cracking in both chloride and sour environments
- High resistance to erosion corrosion and corrosion fatigue
- Excellent mechanical properties
- Possibilities for weight reduction over austenitic, standard duplex and nickel base alloys
- Good weldability

The combination of the above properties makes ZERON 100 the optimum choice in a range of industries. Oil and gas industry applications include process, seawater, firewater, and subsea pipework systems, with associated risers, manifolds, pressure vessels, valves and heat exchangers. Applications of ZERON 100 in other industries include pipework systems and associated engineering equipment for pollution control, pulp and paper, power generation, flue gas desulphurisation, chemical, pharmaceutical, desalination, mining, metallurgical and marine industries.

CHEMICAL COMPOSITION

	C	Si	Mn	S	P	Cr	Ni	Mo	W	Cu	N	Fe
MIN	–	–	–	–	–	24.0	6.0	3.0	0.5	0.5	0.2	BAL
MAX (S32760) WROUGHT	0.03	1.0	1.0	0.01	0.03	26.0	8.0	4.0	1.0	1.0	0.3	
MAX (J93380) CAST	0.03	1.0	1.0	0.025	0.03	26.0	8.5	4.0	1.0	1.0	0.3	

PREN = % Cr + 3.3% Mo + 16% N

PREN ≥ 40

PHASE BALANCE = 50 ± 15% FERRITE

It should be noted that the UNS S32760 designation merely specifies a broad compositional range, whereas the composition of Zeron 100 is tightly controlled in strict accordance with the requirements of our in house 'MDS' specifications. This ensures a consistent quality product is produced, and the stated corrosion, mechanical and physical properties are maintained.

STANDARDS

	UNS	EN No./W-Nr.	EN Name/DIN Name	ACI
Wrought	S32760	1.4501	X2CrNiMoCuWN 25-7-4	
Cast	J93380	1.4508	G-X2CrNiMoCuWN 25-8-4	CD3 MWCuN

NACE MR0175

PD5500 (formerly B.S. 5500) Enquiry Case 5500/111

ASME VIII Division 1 Cases 2244-1 and 2245-1, ASME III Division 1 Case N-564-1.

ASME B16.5, ASME B16.34, ASME B16.47

ASME B31.3

API 5LC

Pipe and Tube:	ASTM A790, A789, A928
Forged Flanges, Fittings, etc:	ASTM A182 (Grade F55)
HIP Flanges, Fittings etc:	ASTM A988
Plate and Sheet:	ASTM A240, BS EN 10028-7, BS EN 10088-2
Bars and Shapes:	ASTM A276, A479, BS EN 10088-3, BS EN 10273
Forgings:	ASTM A473
Forging Stock:	ASTM A314
Fittings:	ASTM A815
Castings:	ASTM A351, A890, A995
Fasteners:	ASTM A320*

**Currently available in accordance with the above standards. Formal applications for inclusion in the standards are awaiting approval.*

PRODUCT FORMS

In addition to the preceding product forms, ZERON 100 is available as welding wire and covered electrodes.

MECHANICAL PROPERTIES

The following guaranteed minimum properties are available in the solution annealed condition.

Room Temperature

	CAST (UNS J93380)	WROUGHT (UNS S32760)
YIELD STRENGTH (0.2% offset)	450 MPa (65 ksi)	550 MPa (80 ksi)
TENSILE STRENGTH	700 MPa (101 ksi)	750 MPa (109 ksi)
ELONGATION IN 50mm	25%	25%
HARDNESS	24 HRC MAX	28 HRC MAX

Elevated Temperature

PRODUCT FORM	TEMP (°C)	TEMP (°F)	YIELD STRENGTH 0.2% OFFSET (MPa)	YIELD STRENGTH 0.2% OFFSET (ksi)	TENSILE STRENGTH (MPa)	TENSILE STRENGTH (ksi)
CAST	20	68	450	65	700	101
	50	122	410	59	675	98
	100	212	380	55	650	94
	150	302	360	52	630	91
	200	392	350	51	600	87
	250	482	330	48	570	83
	300	572	320	46	540	78
FORGINGS BAR	20	68	550	80	750	109
	50	122	500	73	725	105
	100	212	470	68	700	102
PLATES (up to 30mm)	150	302	450	65	680	99
	200	392	430	62	670	97
	250	482	400	58	650	94
	300	572	385	56	635	92
PLATES (31 TO 70mm)	20	68	550	80	750	109
	50	122	470	68	700	102
	100	212	430	62	670	97
	150	302	400	58	620	90
	200	392	380	55	610	88
	250	482	370	54	600	87
	300	572	360	52	590	86

The above properties for forgings are typical values for section thicknesses up to 300mm solid or 250mm in an annulus with a minimum bore of 100mm. As the properties from forgings are very dependent upon the product route and the actual forging ratio then properties and design are by agreement for other than standard items.

ZERON 100 is not recommended for uses which involve extended exposure to temperatures greater than 300°C (572°F) as there is a substantial reduction in toughness.

Impact Strength

ZERON 100 has good impact strength. There is no true ductile brittle transition, just a gradual decrease in impact energy as the temperature is lowered. The impact energy varies according to product type and production route. Some typical values are shown in Figure 1. The impact strength of welded ZERON 100 is slightly less than that of parent metal. (See also figure 1).

Present data suggests that 40J (30ft. 1bf) is a suitable acceptance criterion for duplex stainless steels and Figure 1 shows that 40J is achievable with all product forms of Zeron 100 down to very low temperatures.

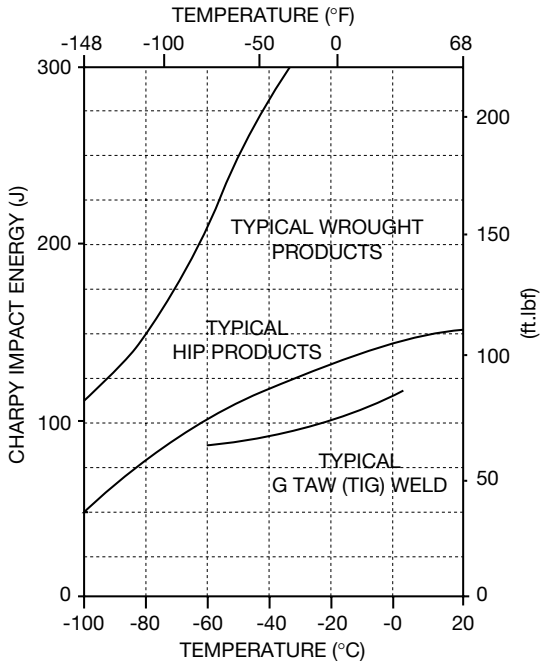

FIGURE 1

Fasteners

Solution annealed ZERON 100 has a high strength level which is satisfactory for many fastener applications.

For applications requiring higher tensile properties, ZERON 100 is available in two additional grades:

ZERON 100 FG meets the minimum tensile properties specified in ASTM A193-B7 and additionally has a Charpy impact toughness of 40 Joules (29.5 ft. lbf) minimum at -46°C (-50°F)

ZERON 100 FLT meets the minimum tensile and Charpy impact properties specified in ASTM A320-L7.

Both Zeron 100 FG and FLT meet the requirements of ASTM A276 S32760 Condition S.

PHYSICAL PROPERTIES

Density

The density of both wrought and cast ZERON 100 is 7.84 g/cm³ (7840 kg/m³ or 489 lb/ft³) at 20°C (68°F).

Specific Heat

Typical specific heats for both wrought and cast ZERON 100.

SI (METRIC) UNITS

TEMP (°C)	SP. HT. (J Kg⁻¹ K⁻¹)
20	482
100	500
150	513
200	523
250	535
300	547

INCH-POUND UNITS

TEMP (°F)	SP. HT. (Btu/lb °F)
68	0.115
100	0.116
200	0.119
300	0.122
400	0.125
500	0.128

Thermal Conductivity

Typical values for wrought ZERON 100.

SI (METRIC) UNITS

TEMP (°C)	THERMAL COND (Wm⁻¹ K⁻¹)
20	12.9
100	14.4
150	15.4
200	16.3
250	17.3
300	18.2

INCH-POUND UNITS

TEMP (°F)	THERMAL COND (Btu/hr ft °F)
68	7.5
100	7.7
200	8.3
300	8.9
400	9.5
500	10.1

Thermal Expansion

The typical thermal expansion coefficient of wrought and cast ZERON 100 is much lower than that of austenitic stainless steel and reasonably close to that of carbon steel, as follows:

SI (METRIC) UNITS

	LINEAR THERMAL EXPANSION COEFF (10^{-6} K^{-1})		
Temperature, °C	20-100	20-200	20-300
ZERON 100	12.8	13.3	13.8
CARBON STEEL	11.5	12.2	12.9
AUSTENITIC STAINLESS STEEL	16.8	17.2	17.6

INCH-POUND UNITS

	LINEAR THERMAL EXPANSION COEFF (10^{-6}in/in°F)		
Temperature, °F	70-200	70-400	70-600
ZERON 100	7.0	7.4	7.7
CARBON STEEL	6.4	6.8	7.2
AUSTENITIC STAINLESS STEEL	9.3	9.6	9.8

Resistivity

Typical values of resistivity are shown below.

		RESISTIVITY (10^{-6} ohm m)	
TEMP (°C)	TEMP (°F)	WROUGHT ZERON 100	CAST ZERON 100
20	68	0.851	0.916
100	212	0.897	0.955
150	302	0.927	0.980
200	392	0.956	1.005
250	482	0.985	1.030
300	572	1.014	1.055

Magnetic Permeability

At room temperature the peak relative magnetic permeability of ZERON 100 is typically 29.

Young's Modulus

The modulus is a function of austenite/ferrite ratio and production route. Variations of ± 5% are found with both wrought and cast products. The typical value for ZERON 100 at room temperature is 190 GPa (27600 ksi).

Poisson's Ratio

The typical value for ZERON 100 at room temperature is 0.32

CORROSION RESISTANCE

General Corrosion

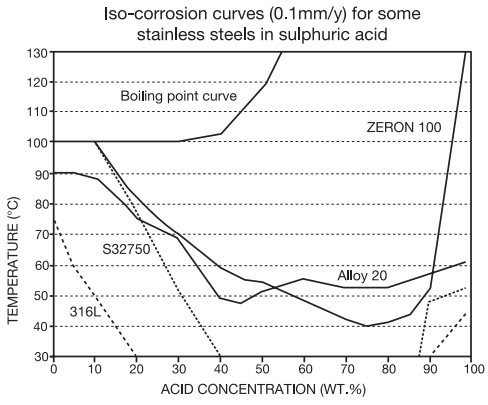

FIGURE 2

ZERON 100 is highly resistant to corrosion in a wide range of organic and inorganic acids. The copper content gives excellent resistance to corrosion in many non-oxidising acids. Figure 2 shows the typical performance for ZERON 100 in sulphuric acid compared to some other stainless steels. Figure 3 shows similar data for hydrochloric acid. Commercial acid applications often contain chlorides and other impurities which can cause corrosion of some stainless steels. ZERON 100 offers much improved corrosion performance in these environments.

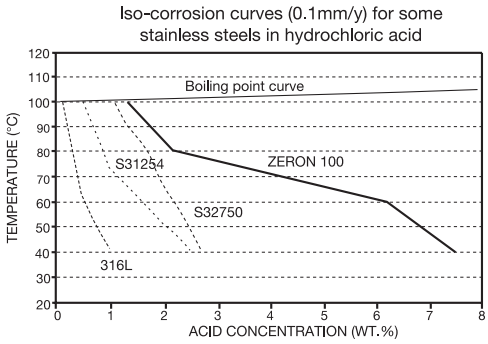

FIGURE 3

Zeron 100 is also highly resistant to strong alkalis. The production of caustic soda results in hot, strong solutions and even in 60wt% caustic soda, Zeron 100 has very low corrosion rates (<0.1mm/y). Caustic soda is often found with chlorides in extraction processes and even with 10g/l chloride, Zeron 100 has excellent corrosion resistance. Three years service experience of fabricated Zeron 100 pipework in 2M caustic soda with chlorides at 230°C has been excellent.

Pitting Corrosion

Exposure to 6% $FeCl_3$ for 24 hours in accordance with ASTM G48 method A to determine the maximum temperature at which no pitting occurs (the critical pitting temperature, CPT), has given the following results:

Solution annealed wrought and cast ZERON 100: 70-80°C (158-176°F) depending on product form and manufacturing route.

ZERON 100 welded with ZERON 100X filler metal: 35-60°C (95-140°F), depending on the welding variables, i.e. process, joint geometry, procedure etc.

These values are for single exposure testing; testing a single specimen at a series of increasing temperatures gives a higher CPT value.

Crevice Corrosion

The resistance to localised corrosion is often assessed by use of the PREN number (%Cr + 3.3%Mo + 16%N). ZERON 100 is made to a minimum PREN of 40, ensuring a guaranteed and high resistance to pitting and crevice corrosion. ZERON 100 has been in service in sea water since 1986 as castings, and since 1989 as wrought pipes and fittings giving satisfactory performance.

At sea water temperatures above ambient (20°C) the risk of crevice corrosion increases. ZERON 100 resists crevice corrosion up to 55°C but is limited by the pitting resistance of the welds to about 40°C. With the application of post weld treatments sea-water temperatures up to 65°C have been handled successfully. Short term elevated temperature upsets are not uncommon in cooling water circuits. Laboratory tests have shown that ZERON 100 does not suffer crevice corrosion easily during short upsets to 70°C, and when corrosion does initiate, repassivation occurs rapidly on cooling, from 42° C upwards.

Stress Corrosion Cracking

ZERON 100 has excellent resistance to stress corrosion cracking (SCC) in both chloride environments, and process environments containing H_2S and CO_2.

ZERON 100 is listed in NACE MR0175 as being suitable in sour service at 0.2 bar partial pressure of H_2S at 120,000 mg/l chloride, up to hardness HRC 34.

In brines with lower chloride contents ZERON 100 can tolerate much higher pressures of H_2S, as shown in Figure 4. As the pH, at temperature and pressure, increases, so does the resistance to sulphide SCC (Figure 4).

Hydrogen Embrittlement

In common with all high strength steels, duplex and super duplex stainless steels can be susceptible to hydrogen embrittlement if stressed above the specified minimum yield strength in the presence of hydrogen.

Hydrogen embrittlement therefore becomes an area for consideration when these steels are used subsea with conventional cathodic protection.

However, the proper application of normal design stress criteria and coating technology has allowed many subsea projects to utilize duplex and super duplex stainless steels successfully for a number of years.

Limits of use for Zeron 100 in brines containing H_2S

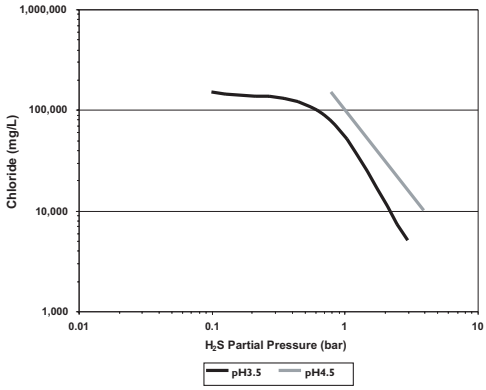

FIGURE 4

MANUFACTURING

Heat Treatment

ZERON 100 should be solution annealed in the temperature range 1100-1140°C (2012-2084°F) followed by water quenching.

Hot Forming

Hot forming of ZERON 100 should be carried out in the temperature range 1100°C TO 1280°C (2012-2336°F). It is recommended that this is followed by solution annealing and water quenching. Components should subsequently be pickled or fully machined.

Cold Forming

ZERON 100 can be adequately cold formed by various processes but the high mechanical properties should be taken into account. It is recommended that any cold work in excess of 10%-15% is removed by solution annealing and water quenching. It should be noted that cold working above these limits can result in hardness levels above those specified in standards such as NACE MR0175.

Welding

Where a solution anneal and quench as a post-weld heat treatment is to be carried out, ZERON 100 is usually welded with matching composition consumables (ZERON 100M). With overalloyed consumables (ZERON 100X), no post-weld heat treatment is necessary. Corrosion and mechanical properties similar to the parent metal can be obtained following recommended procedures. A separate brochure on the optimum parameters for a range of welding operations is available from our Sales Department.

Machining

ZERON 100 requires a little more care in machining than the 300 series austenitics. If heavy or uneven machining to tight tolerances is to be carried out on wrought ZERON 100 components, machining should be carried out in stages. As a last resort, a stress relieving heat treatment can be applied but this can result in a reduction of toughness and corrosion resistance. Literature giving details of cutting speeds, tool materials, etc. for a wide range of machining operations is available from our Sales Department.

APPLICATIONS

The properties outlined in this data sheet, combined with the availability of a wide range of product forms, make Zeron 100 ideally suited for use in a wide range of industries including oil and gas, marine, mining and metallurgical, desalination, flue gas desulphurisation, chemical and process. For details on specific applications in each of these industries contact Weir Materials & Foundries.

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