UTILITY FERRITIC STAINLESS STEELS

Unity	AISI	UNS	EN
U-3CR12			
U-3CR12L		S41003	1.4003
U-410S	410S	S41008	

3CR12®

Technical Brochure

COLUMBUS STAINLESS [Pty] Ltd ®

www.columbusstainless.co.za

Introduction

3CR12 is recognised as the original and now the world's most specified 12% chromium utility ferritic stainless steel.

The main advantage of these utility ferritics over other ferritic stainless steels is that they are tough, even when welded, in thicknesses of up to 30mm and retain their toughness at temperatures below freezing point.

The corrosion resistance of the utility ferritics is largely determined by their chromium content and is thus similar to other 12% chromium ferritic stainless steels.

In terms of atmospheric corrosion resistance, the utility ferritics are superior to mild steel, weathering steel, copper and aluminium.

When exposed to aggressive atmospheric conditions, staining may occur, but this does not affect the lifetime performance. However, if aesthetic appearance is important, it is recommended that the utility ferritics are painted or a more corrosion resistant stainless steel is used.

The utility ferritics have also found widespread use in wet sliding abrasion conditions and in aqueous environments involving exposure and/or immersion.

The applications include materials handling (bulk handling, coal, sugar, agriculture, abattoirs), road transport (passenger vehicles, coaches and buses, trucks, freight and utility vehicles), rail transport (freight, passenger rail, light rail, rail infrastructure), petrochemicals and chemical, power generation, telecommunication cabinets and electrical enclosures and water and sewage treatment.

Product range

The latest revision of the Product Catalogue should be consulted, as the product range is subject to change without notice.

The Product Catalogue is available from the Technical Department or can be found at www.columbusstainless.co.za

Specifications and tolerances

Columbus Stainless (Pty) Ltd supplies the utility ferritics to the Columbus Stainless mill specification, ASTM A240, ASME SA240, EN 10028-7 and EN 10088-2.

Columbus Stainless (Pty) Ltd normally supplies material to the following tolerances:

HOT ROLLED

ASTM A480M
ISO 9444 - material processed as coil
ISO 18286 - material processed as plate

COLD ROLLED

ASTM A480M
ISO 9445

Other specifications and tolerances may be available on request. Further information is available in the Product Catalogue, which can be obtained from the Technical Department or can be found at www.columbusstainless.co.za

Further information

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Disclaimer

Chemical composition

In accordance with the Columbus Stainless mill specification, ASTM A240 and EN 10088-2.

Unity	C	Si	Mn	P	S	N	Cr	Ni	Others
U-3CR12	0.03	1.0	2.0	0.040	0.030		10.5 12.5	1.5	Ti: 4x(C+N) 0.6
U-3CR12L	0.03	1.0	1.5	0.040	0.015	0.03	10.5 12.5	0.3 1.0	
U-410S	0.08	1.0	1.0	0.040	0.015		11.5 13.5	0.6	

Compositions are ranges or maximum values.

Mechanical properties

In accordance with ASTM A240 and EN 10088-2.

Unity	R_m (MPa)	$Rp_{0.2}$ (MPa)	El (%)	Max BHN	Impact Energy (J/cm^2)
U-3CR12	460	280 (<3mm) 300 (≥3mm)	18 (≤4.5mm) 20 (>4.5mm)	220	35
U-3CR12L	455 650	320 (≤6mm) 280 (>6mm)	20 (≤6mm) 18 (>6mm)	223	50
U-410S	415	205	20 (<1.27mm) 22 (≥1.27mm)	183	

- *Minimum values, unless max or range is indicated.*
- *( ) indicates applicable gauge range.*
- *The table assumes certification to both ASTM A240 and EN 10088-2.*
- *Impact test is optional in hot rolled gauges only, to be agreed at time of order.*

PROPERTIES AT ELEVATED TEMPERATURES

The properties quoted below are typical of annealed U-3CR12 and U-3CR12L. These values are given as a guideline only, and should not be used for design purposes.

Temperature (°C)	100	200	300	400	500
Tensile Strength (MPa)	545	464	415	368	333
0.2% Proof Stress (MPa)	350	308	280	262	236
Young's Modulus (GPa)	231	215	184	202	150

Maximum recommended service temperature

Continuous (°C)	Intermittent (°C)
620	730

- *In oxidising conditions*

Representative creep properties

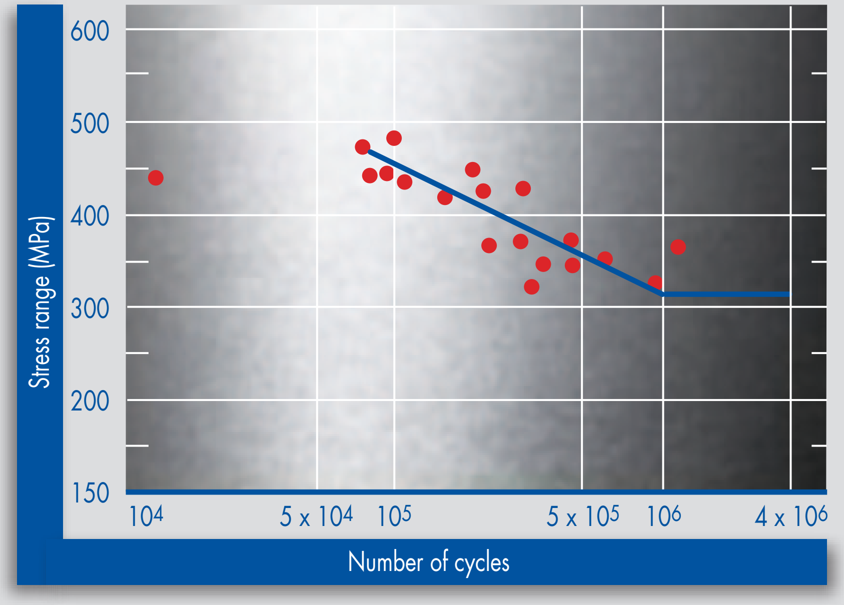
	Stress (MPa) to Produce 1% Strain		
Temperature (°C)	1 000 hours	10 000 hours	100 000 hours
400	315	283	270
450	195	151	134
500	88	65	56
550	34	29	28

FATIGUE CONSIDERATIONS

Fatigue data for unwelded U-3CR12 is shown. The data described here refers to tests performed under constant amplitude loading (R=0, i.e. zero to tension loading) at a frequency of 10Hz.

The steel plates had a nominal thickness of 6mm. The mean fatigue strengths at 10^5, 10^6 and $2x10^6$ cycles are 428 MPa, 311MPa and 310MPa respectively. The S-N diagram contains original data points.

The fatigue strength of welded joints in U-3CR12 using austenitic stainless steel electrodes is similar to that of identical joints in constructional steels such as BS4360 Grade 43A. Accepted procedures when designing for fatigue loaded structures should be followed.



Physical properties

The values given below for utility ferritics are at 20°C, unless otherwise stated.

Density (kg/m^3)		7 680
Modulus of elasticity in Tension (GPa)		200
Modulus of elasticity in Torsion (GPa)		77
Specific heat capacity (J/kg K)		478
Thermal conductivity at	100°C (W/m K)	30.0
	500°C (W/m K)	40.0
Electrical resistivity (x10^{-9} Ω m)		678
Mean coefficient of thermal expansion from	0 to 100°C (x10^{-6} K^{-1})	11.1
	0 to 300°C (x10^{-6} K^{-1})	11.7
	0 to 500°C (x10^{-6} K^{-1})	12.3
	0 to 700°C (x10^{-6} K^{-1})	12.8
Melting range (°C)		1 430
		1 510
Magnetic		Yes

Thermal processing and fabrication

ANNEALING

Annealing is achieved by heating to between 700°C and 750°C for 90 minutes per 25mm thickness (3.5min/mm) followed by air cooling. Controlled atmospheres are recommended in order to avoid excessive oxidation of the surface.

STRESS RELIEVING

The utility ferritics can be stress relieved at 600°C to 650°C for 60 minutes per 25mm thickness (2.5min/mm). Stress relieving after welding is not normally required. Should this be necessary, temperatures between 200°C and 300°C are recommended.

HOT WORKING

The utility ferritics can be readily forged, upset and hot headed. Uniform heating of the steel in the range of 1 100°C to 1 200°C is required. The finishing temperature should not be below 800°C.

Upsetting operations require a finishing temperature between 900°C and 950°C. Forgings should be air cooled.

All hot working operations should be followed by annealing and then pickling and passivating to restore the mechanical properties and corrosion resistance.

Thermal processing and fabrication (continued)

COLD WORKING

The utility ferritics have good formability, but severe draws may require intermediate annealing. Roll forming, press braking, bending and pressing can be readily applied, but loadings will be about 30% higher than for mild steel. The minimum inner bend radius is twice the plate thickness. The utility ferritics exhibit greater spring back than mild steel and this should be compensated for by slight over bending.

MACHINING

The utility ferritics have machining characteristics similar to U-430 (i.e. a machinability rating of 60 compared to mild steel of 100). The reduced extent of work hardening compared to austenitic stainless steels eliminates the need for special cutting tools and lubricants. Slow speeds and heavy feed rates with sufficient emulsion lubricant will help prevent machining problems.

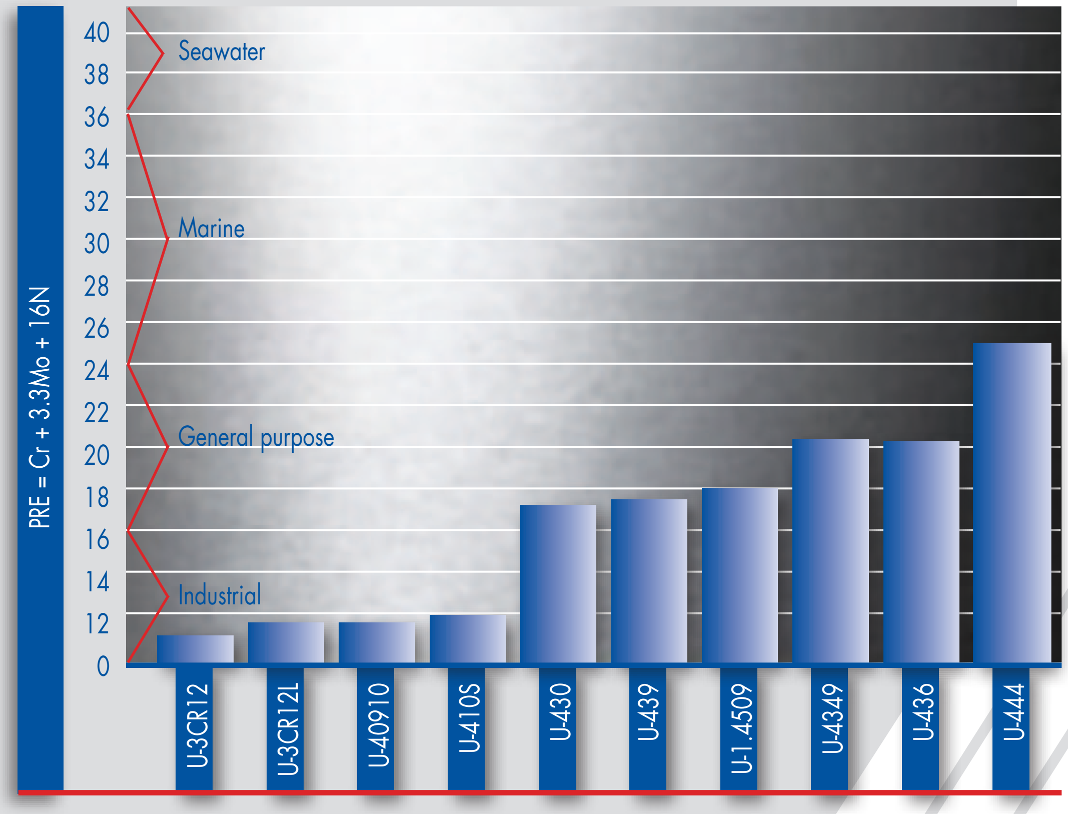
WELDING

The utility ferritics have good weldability and are suited to most standard welding methods (MMA/SMAW, MIG/GMAW, TIG/GTAW, FCAW and PAW). They can be welded to other ferrous metals, for example mild and stainless steels, quite satisfactorily.

The recommended grade of electrode is the AWS 309L type. It is important that this type of overalloyed consumable is used, rather than one which matches either of the base metals, in order to avoid martensite formation in the weld. When welding a utility ferritic to itself, E308L or E316L can also be used.

The heat input should be controlled to between 0.5kJ/mm and 1.5kJ/mm per pass. The weld discolouration should be removed by pickling and passivating to restore maximum corrosion resistance.

Corrosion resistance



The above diagram summarises the corrosion resistance of the ferritic stainless steels produced at Columbus Stainless. For the utility ferritic stainless steels, the corrosion resistance is largely a function of the chromium content and as such these steels are suitable for industrial applications.

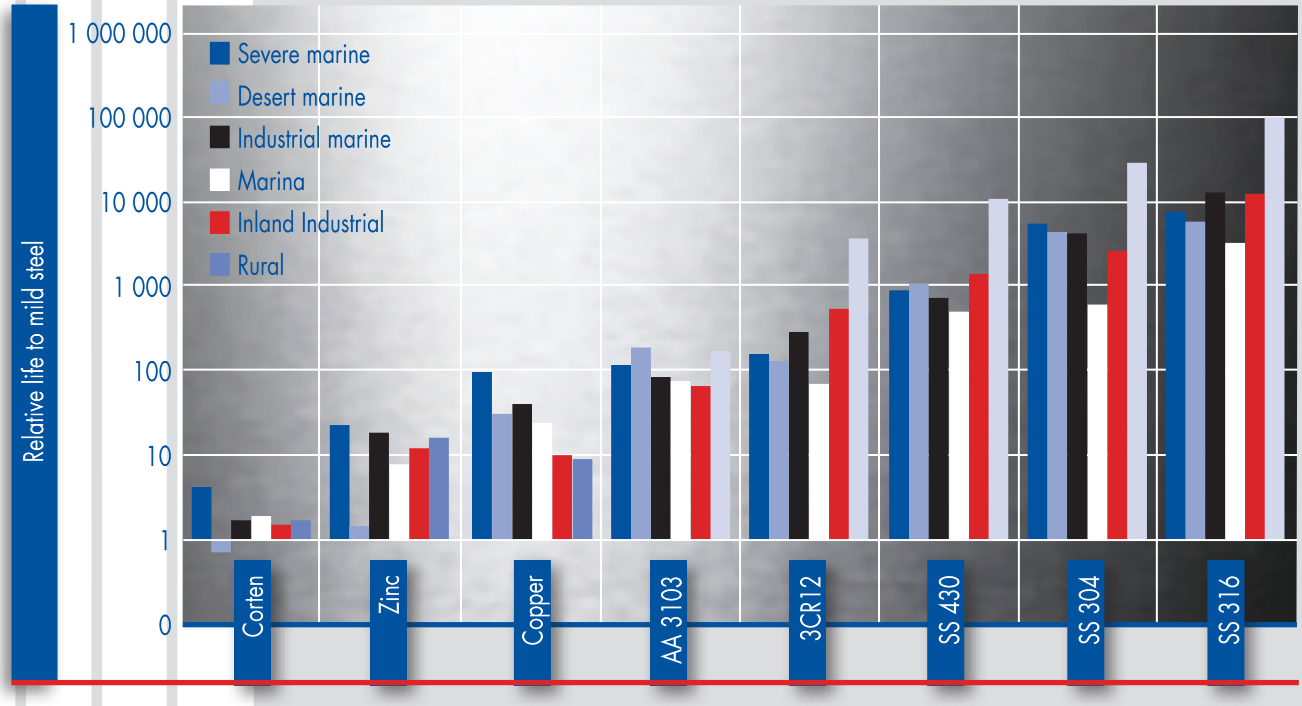
ATMOSPHERIC CORROSION

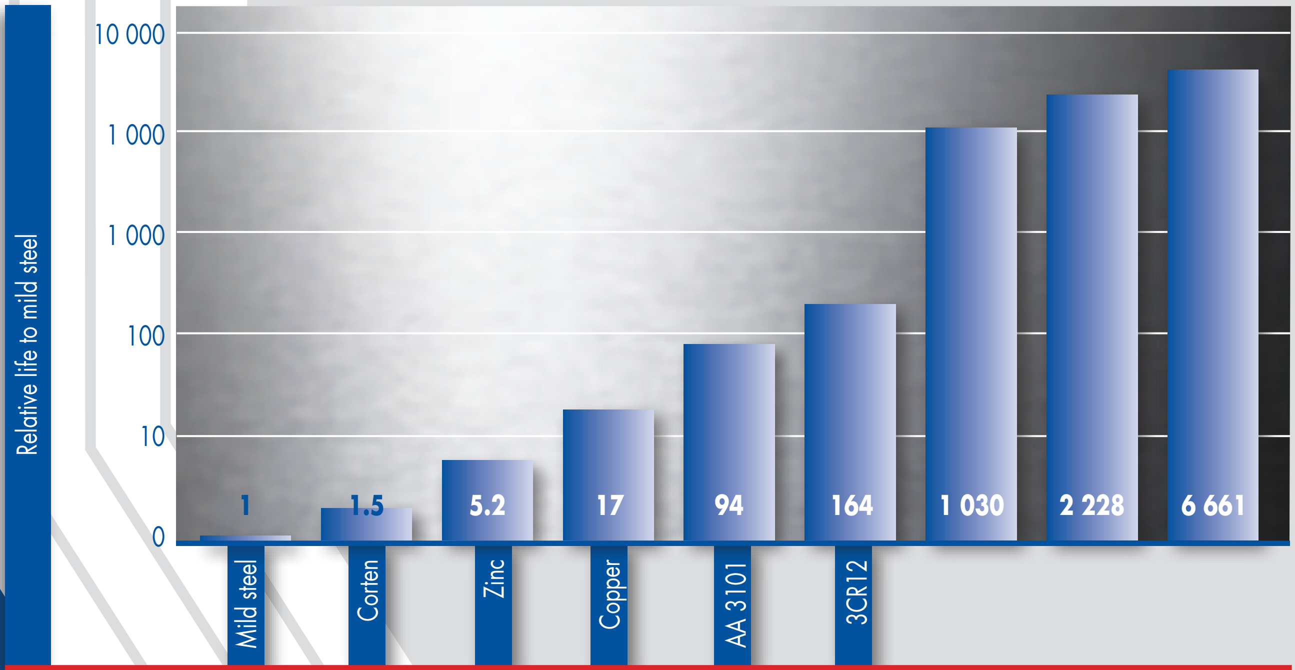
From the report 'Atmospheric Corrosion Testing in Southern Africa - Results of a Twenty Year Exposure Programme' by BG Callaghan, Division of Materials Science and Technology, CSIR, the following graphs were constructed.

The first graph shows the relative life of eight metals compared to mild steel in six different atmospheric environments. This can be summarised to give an average relative life of the different metals in atmospheric conditions and this is shown in the second graph.

ATMOSPHERIC CORROSION (CONTINUED)

In appearance, all the metals showed discolouration at the more severe sites after 20 years. None of the metals were washed during the exposure programme and this clearly emphasises the importance of keeping stainless steel clean and that stainless steel is a LOW maintenance (not NO maintenance) option in atmospheric corrosion applications. U-3CR12 showed some pitting, but the maximum pit depth after 10 years was 0.25mm.





GENERAL CORROSION

The utility ferritics are significantly more corrosion resistant than mild or low alloy corrosion resistant steels. However, they have a lower corrosion resistance than the higher chromium standard ferritics. The utility ferritics should only be used in mildly corrosive conditions where aesthetics is not a prime requirement. A light surface patina or discolouration will form in most corrosive environments and this patina will, to some extent, retard further corrosion.

PITTING CORROSION

Pitting corrosion is possible in applications involving contact with chloride solutions, particularly in the presence of oxidising media. These conditions may be conducive to localised penetration of the passive surface film on the steel and a single deep pit may well be more damaging than a much greater number of relatively shallow pits. The diagram below shows the critical temperature for initiation of pitting (CPT) at different chloride contents (+350mV vs SCE).

A model, shown in the second diagram, has been designed to predict the maximum concentration of chloride that can be permitted in water containing sulphate and nitrate ions before localised corrosion of 3CR12 takes place. A straight line, drawn between the concentrations of sulphate and nitrate, intersects the chloride axis at the maximum permissible chloride concentration for this water, at ambient temperature.