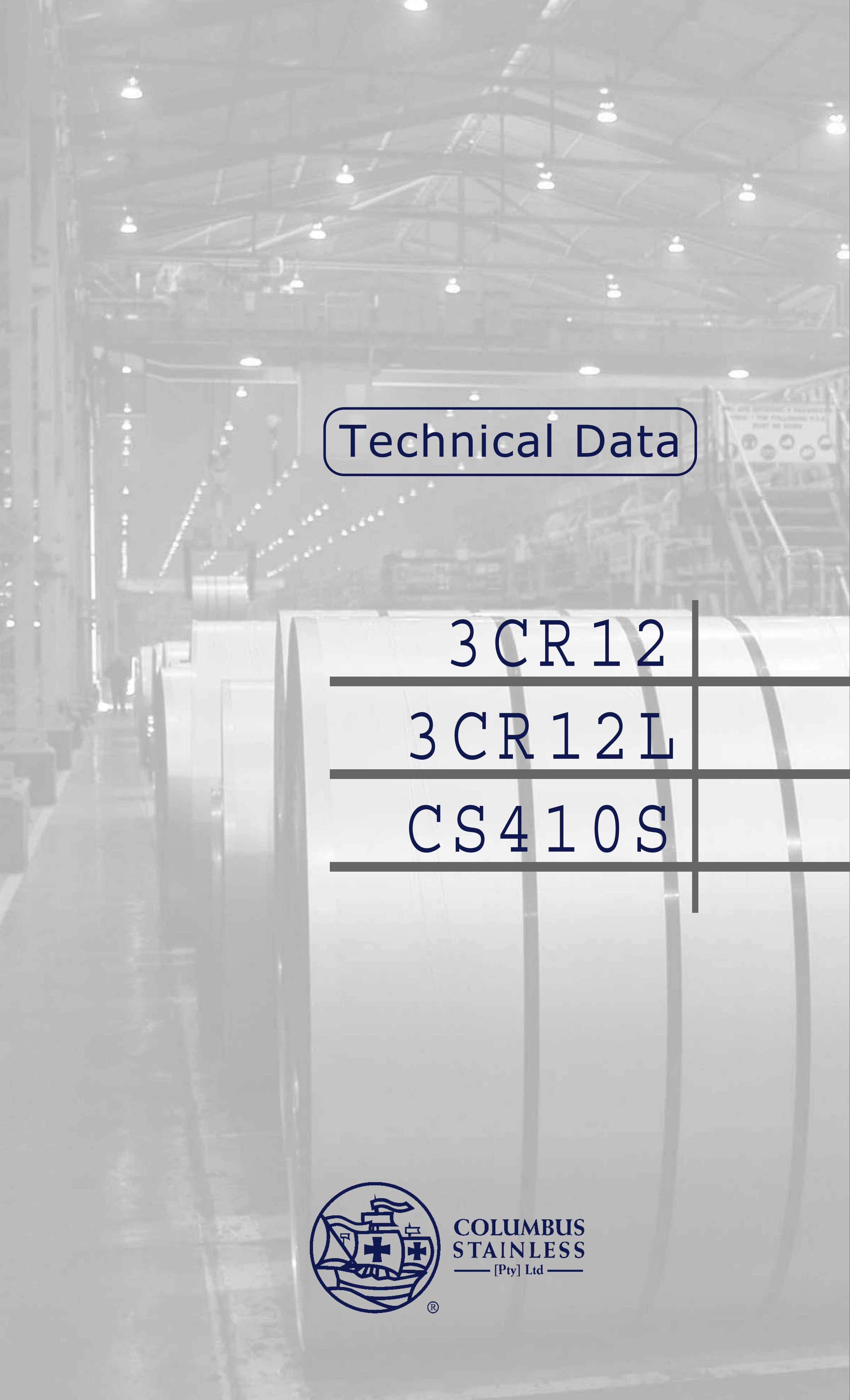

Technical Data

3CR12

3CR12L

CS410S

COLUMBUS STAINLESS
[Pty] Ltd

Technical Data

www.columbusstainless.co.za

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INTRODUCTION

3CR12 is recognised as the original and now the world's most specified 12% chromium utility ferritic stainless steel. The main advantage of 3CR12 over other ferritic stainless steels is that it is tough, even when welded, in thicknesses of up to 30mm and retains this toughness at temperatures below freezing point.

3CR12 has a similar corrosion resistance to other 12% chromium ferritic stainless steels, but it is not as resistant to corrosion or high temperature oxidation as the higher chromium containing type CS430 or CS304 stainless steels. It is, however, superior to mild steel and low alloy corrosion resisting steels and most coated mild steels. When exposed to aggressive atmospheric conditions, staining may occur. It is thus recommended that, in applications where aesthetic appearances are important, 3CR12 is painted or a more corrosion resistant stainless steel is used.

3CR12 has 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 & 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 Guide should be consulted, as the product range is subject to change without notice. The Product Guide is available from the Technical Customer Services Department or can be found at www.columbusstainless.co.za

SPECIFICATIONS & TOLERANCES

Columbus Stainless (Pty) Ltd supplies 3CR12 to the Mill Specification, (3CR12/3CR12L), to ASTM A240 (S41003 and 410S) and EN 10088-2 and EN 10028-7 (1.4003).

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

HOT ROLLED

ASTM A480M

ASME SA480M

EN 10051 and EN 10029 Class B

COLD ROLLED

ASTM A480M

ASME SA480M

EN ISO 9445

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

CHEMICAL COMPOSITION

In accordance with the Mill Specification (3CR12/3CR12L), ASTM A240 (S41003 and 410S), and EN 10088-2 and EN 10028-7 (1.4003).

Type	%C	%Si	%Mn	%P	%S	%Cr	%Ni	%N	%Ti
3CR12	0.030 max	1.00 max	2.00 max	0.040 max	0.030 max	10.50 12.50	1.50 max		4(C+N) 0.6
S41003	0.030 max	1.00 max	1.50 max	0.040 max	0.030 max	10.50 12.50	1.50 max	0.030 max	
410S	0.080 max	1.00 max	1.00 max	0.040 max	0.030 max	11.50 13.50	0.60 max		
1.4003	0.030 max	1.00 max	1.50 max	0.040 max	0.015 max	10.50 12.50	0.30 1.00	0.030 max	

MECHANICAL PROPERTIES

In accordance with the Mill Specification (3CR12), ASTM A240 (S41003 and 410S) and EN 10088-2 and EN 10028-7 (1.4003).

Type	Product Form[1] or Gauge (mm)	0.2% Proof Stress (MPa)	Tensile Strength (MPa)	Elongation (%)	Brinell Hardness	Impact Energy (J)
3CR12	<3	280 450	460 min	18 min[2]	220 max	
	3 to 4.5	300 450	460 min	18 min[2]	220 max	35[4]
	>4.5 to 12	300 450	460 min	20 min[2]	220 max	35[4]
	>12	300 450	460 min	20 min[2]	250 max	35[4]
S41003	All	275 min	455 min	18 min[2]	223 max	
410S	□1.27	205 min	415 min	20 min[2]	183 max	
	>1.27	205 min	415 min	22 min[2]	183 max	
1.4003	C, H	320 min	450 650	20 min[3]		50[5]
	P	250 min	450 650	18 min[3]		50

1) C = cold rolled strip, H = hot rolled strip ≤ 8mm,

P = hot rolled plate > 8mm.

2) Elongation over a gauge length of 50mm.

3) Gauges ≥ 3mm, proportional elongation with the gauge

length = $5.65\sqrt{S_0}$ (S_0 = cross-sectional area of the test piece).

For gauges < 3mm, elongation over a gauge length of 50mm.

4) In J/cm^2 on hot rolled gauges.

5) Hot rolled only.

PROPERTIES AT ELEVATED TEMPERATURES

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

SHORT TIME ELEVATED TEMPERATURE TENSILE PROPERTIES

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

(In oxidising conditions)

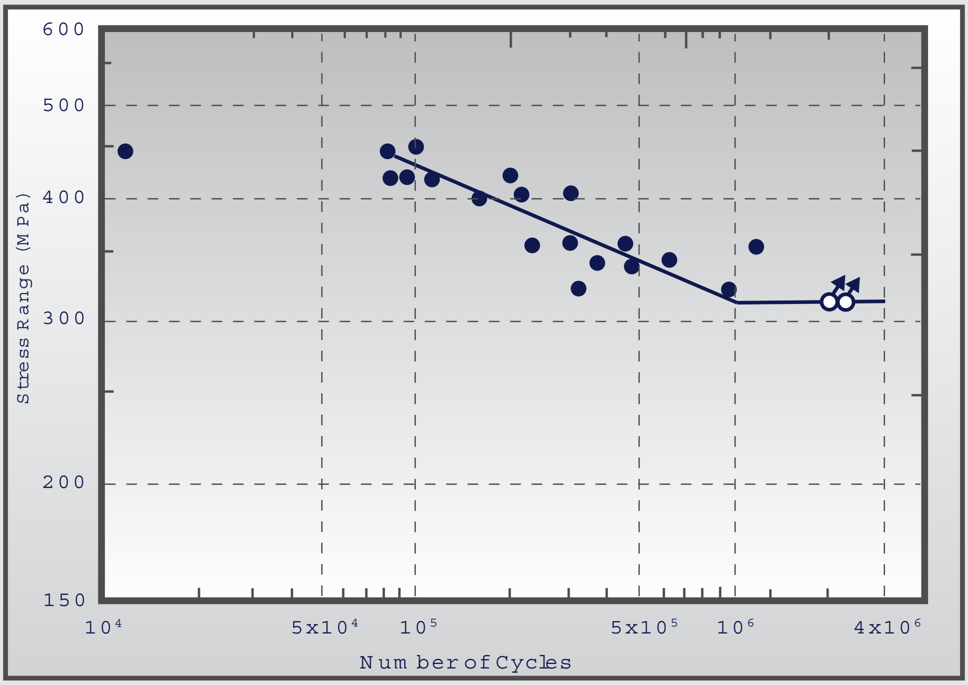
Operating Conditions	Temperature (°C)
Continuous	620
Intermittent	730

REPRESENTATIVE CREEP PROPERTIES

Temperature (°C)	Stress to Produce 1% Strain (MPa)		
	1 000 hours	5 000 hours	10 000 hours
400	315	283	270
450	195	151	134
500	88	65	56
550	34	29	28

FATIGUE CONSIDERATIONS

Fatigue data for unwelded 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 shown below contains original data points.



The fatigue strength of welded joints in 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 are for 20°C, unless otherwise specified.

Density	7 680 kg/m^3
Modulus of Elasticity in Tension	200GPa
Modulus of Elasticity in Torsion	77GPa
Poisson's Ratio	0.32
Specific Heat Capacity	478J/kg K
Thermal Conductivity: @ 100°C @ 500°C	30.0W/mK 40.0W/mK
Electrical Resistivity	678η□m
Mean Co-efficient of Thermal Expansion: 0 – 100°C 0 – 300°C 0 – 500°C	11.1µm/mK 11.7µm/mK 12.3µm/mK
Melting Range	1 430°C-1 510°C
Relative Permeability	Ferromagnetic

THERMAL PROCESSING & FABRICATION

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

STRESS RELIEVING
3CR12 can be stress relieved at 600°C to 650°C for 90 minutes per 25mm thickness.

HOT WORKING
3CR12 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 pickling and passivating to restore the mechanical properties and corrosion resistance.

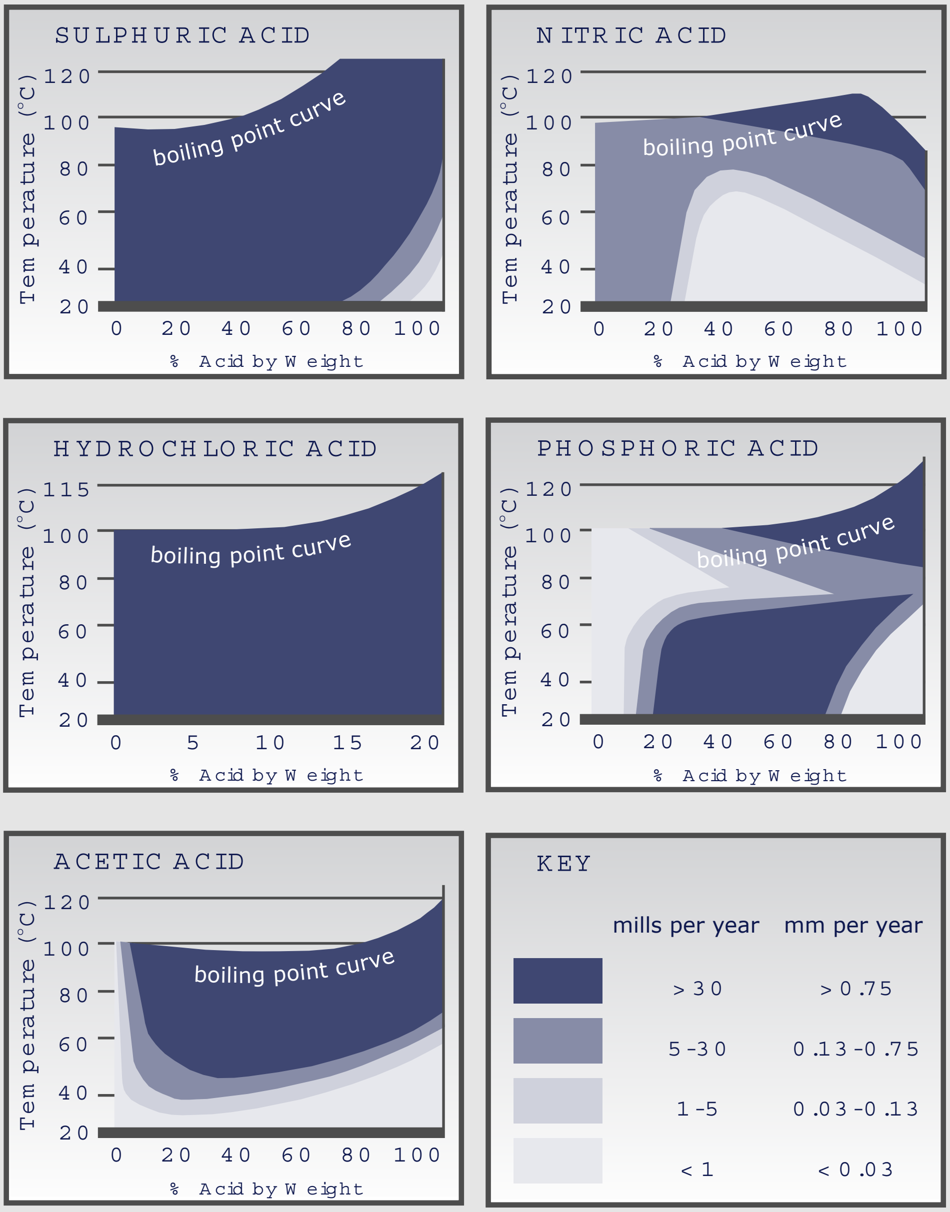
COLD WORKING
3CR12 has good formability, but severe draws may require intermediate annealing. Roll forming, press braking, bending and pressing can be readily applied to 3CR12, but loadings will be about 30% higher than for mild steel. The minimum inner bend radius for 3CR12 is twice the plate thickness. 3CR12 exhibits greater spring back than mild steel and this should be compensated for by slight over bending.

MACHINING
3CR12 has machining characteristics similar to AISI 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
3CR12 has good weldability and is suited to most standard welding methods (MMA/SMAW, MIG/GMAW, TIG/GTAW, FCAW and PAW). 3CR12 can be welded to other ferrous metals e.g. 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, to avoid excessive weld metal dilution. When welding 3CR12 to itself, E308L and 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.

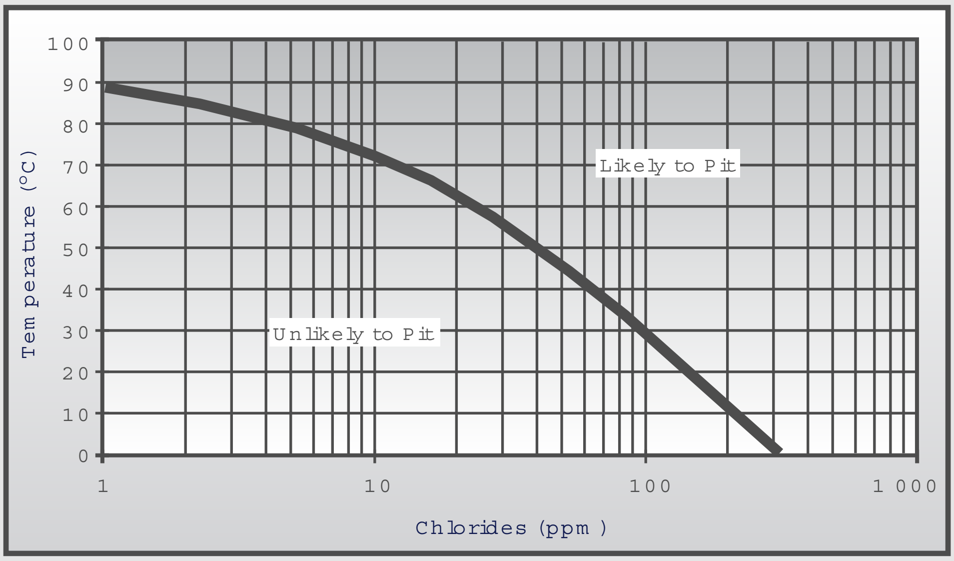
CORROSION RESISTANCE

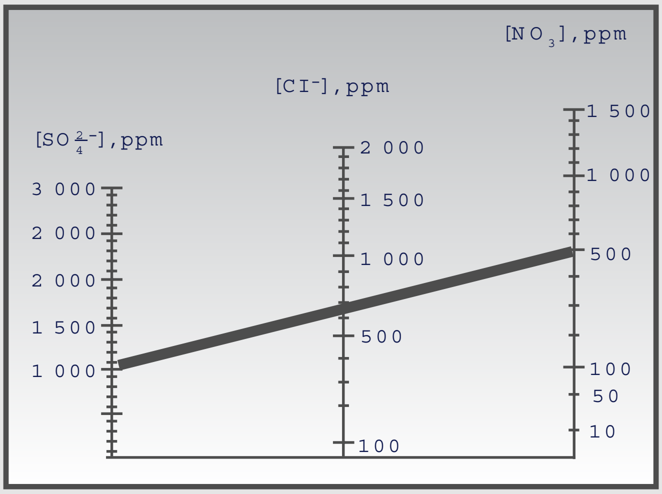
Whilst being significantly more corrosion resistant than mild or low alloy corrosion resistant steels, 3CR12 has a lower corrosion resistance than the higher chromium type 430. 3CR12 should only be used in mildly corrosive conditions where aesthetics is not a prime requirement. A light surface patina 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 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.

OXIDATION

3CR12 has good oxidation resistance in intermittent service up to 730°C and in continuous service to 620°C. In addition, 3CR12 has good resistance in sulphur bearing atmospheres and to many hot gases and fumes generated in industrial processes.

ATMOSPHERIC CORROSION

Atmospheric corrosion testing of 3CR12 has given corrosion rates as low as 0.001 - 0.002mm/year in moderate marine environments - an improvement of 250 times the life of unpainted mild steel under the same conditions. 3CR12 is not recommended for decorative purposes because in aggressive environments, it will tend to form a light surface rust coloured patina. This discolouration is superficial and does not affect the structural performance of the steel. Should aesthetic qualities be of prime importance, 3CR12 can be painted with a number of paint systems.

INTERGRANULAR CORROSION

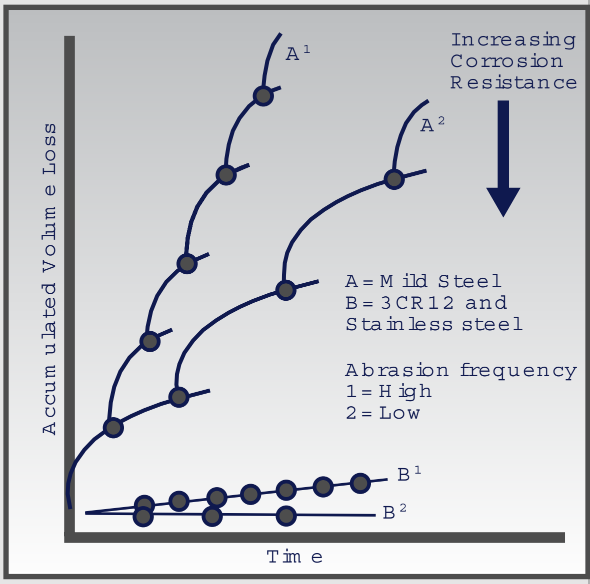
Sensitisation may occur when the Heat Affected Zones of welds in 12% chromium ferritic stainless steels are cooled through the sensitising temperature range of between 600°C and 700°C. At this temperature, a compositional change may occur at the grain boundaries. If a sensitised material is then exposed to a corrosive environment, intergranular attack may be experienced. In addition, operating and residual stresses can lead to intergranular stress corrosion cracking in these areas. 3CR12 (S41003, 410S and 1.4003) has reasonable resistance to sensitisation after welding. However, sensitisation can occur under specific corrosion conditions and where a very low or very high weld heat input has been used or occasionally with weld overlays (repair welds, stop/start, double fillet and multipass welds), depending on exact weld geometry.

3CR12 is titanium stabilised to be more resistant to sensitisation than 3CR12L (S41003, 410S and 1.4003). However, care should be taken to control the heat input of the weld to between 0.5kJ/mm and 1.5kJ/mm per pass in order to not only avoid sensitisation but to maximise the toughness of the Heat Affected Zone.

STRESS CORROSION CRACKING

SCC can occur in 3CR12 when stressed in tension in a sulphide environment. Sulphide SCC in 3CR12 pipelines can occur either internally, from transporting wet sour products or from water containing sulphate reducing bacteria (SRB), or externally, from SRB in the soil or water in contact with the pipe. Environmental variables such as low pH, high hydrogen sulphide partial pressure, and/or high sulphide concentration increase the likelihood of cracking. The use of uncoated 3CR12 pipelines is not recommended for transporting wet sour products or water with a high sulphide concentration.

CORROSION-ABRASION



The cycle of abrasive removal of a metal surface following surface corrosion, will rapidly erode carbon steels, even where costly coatings are applied. In wet or damp conditions where abrasion occurs, 3CR12 has demonstrated excellent performance by resisting corrosive attack and so maintaining better flow and slideability characteristics compared to non or low alloyed steels, including abrasion resistant grades. For materials handling applications, the superior slideability of 3CR12 can be exploited, not only to restore lost capabilities in existing plant, but also to save costs in new plant. Similarly, because of the improved slideability of 3CR12, it has found applications in the storage, handling and transportation of coal, allowing rapid throughput of material. In addition, the corrosion resistance of 3CR12 allows 3CR12 bins that have been out of service for a length of time to be brought back into immediate mass flow service.

In general, it can be shown that in dry abrasion, 3CR12 is no better than mild steel, but in real industrial situations, where corrosion is also present, 3CR12 is shown to be vastly superior to carbon and low alloy steels. When cost per unit volume loss is also taken into consideration, 3CR12 is superior to all types of steels that have been tested.

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