Cromgard C22-5

CROMPION INTERNATIONAL

Introduction

Cromgard C22-5 is a nitrogen-enhanced stainless steel alloy. The nitrogen serves to significantly improve the corrosion resistance of the alloy, especially in the welded condition. Earlier duplex type alloys have had moderate resistance to general corrosion and chloride stress corrosion cracking but suffered a substantial loss of properties when used in the as-welded condition. The increased nitrogen content found in Cromgard C22-5 maintains the significant improvement of corrosion resistance performance while maintaining the overall great properties even in the "as-welded" condition.

When heat-treated properly the composition of Cromgard C22-5 produces a microstructure that consists of a nearly equal mixture of austenite and ferrite. The microstructure and composition of the Cromgard C22-5 alloy provide corrosion resistance to many environments that is superior to Types 316 or 317, and a minimum yield strength that is more than double that of conventional austenitic stainless steels.

Because Cromgard C22-5 has a greater than 166% advantage in minimum yield strength over traditional austenitic stainless steels such as grades 304L and 316L there are many opportunities for down gauging in the design, depending on Young's Modulus and buckling limitations.

Impact Properites

Cromgard C22-5 may undergo a transition from a ductile mode of fracture at higher temperatures to a brittle mode of fracture at lower temperatures when subjected to impact loading. The ductile-to-brittle transition temperature can be substantially increased by exposing the alloy for extended periods of time at temperatures in the range from 650 to 1000°F (343-530°C). Consequently, this temperature range must be avoided in fabrication and service. Improper welding procedures, such as welding with straight chromium stainless steel filler metals, will increase the susceptibility of the weld to brittle impact behavior.

Cromgard C22-5 will (for full size specimens) exhibit Charpy impact energies far greater than the 40 ft-lb (54 J) at -40°F (-40°C) minimum specified by ASTM A 923.

Cromgard C22-5 also passes the NORSOK minimum impact energy requirement at -50°F (-46°C) of 45J average and 35J single specimen minimum. If specified, this toughness will be demonstrated by test prior to shipment.

Elevated Temperature Properties

Effect of Elevated Temperature on Mechanical Properties

An upper temperature limit of 600°F (316°C) has been placed on the use of Cromgard C22-5 in the ASME Boiler and Pressure Vessel Code due to what is known as "885°F (475°C) Embrittlement." This means that the ferrite phase of Cromgard C22-5 may be embrittled after exposure to temperatures from 650 to 1000°F (343-538°C). The 885°F (475°C) embrittlement is reversible by heat treating the alloy at a temperature above 1100°F (590°C). However, another embrittling range exists from about 1200°F (649°C) to 1830°F (1000°C) due to the precipitation of excess phases that are detrimental to both impact and corrosion properties. A full anneal and rapid cooling treatment is required to eliminate the latter form of embrittlement and is also the preferred manner of relieving forming stresses and 885°F (475°C) embrittlement.

Fatigue Resistance

Cromgard C22-5 shows high resistance to fatigue. Its endurance limit at room temperature is about 45% of its tensile strength.

Cromgard C22-5 has a ductile to brittle transition temperature of about -40°C or lower. Thus, application temperatures are generally limited from -50°C to 300°C.

Applications

Due to the higher Chromium, Molybdenum and Nitrogen content Cromgard C22-5 offers significantly improved pitting and crevice corrosion resistance in the presence of chlorides. Its excellent strength, toughness, corrosion resistance and resistance to stress corrosion cracking (SCC) make Cromgard C22-5 suitable for applications such as:

- Subsea Flow Lines
- Bridge Decking
- Desalinization
- Water Heaters
- Pipes & Tubes
- Water Treatment
- Potable Water Systems
- Power Generation
- Chemical Processing
- Transport Tanks
- Home Appliances
- Heat Exchangers
- Pressure Vessels
- Architectural Structures
- Pulp & Paper Production

Specifications Coverage

Cromgard C22-5 is covered in ASTM under the following specifications: A182, A276 & A479 (Bar), A240 (Plate, Sheet and Strip), A270 & A789 (Tube; Welded and Seamless), A790 & A928 (Pipe; Welded and Seamless) and ASTM A815 (Pipe Fittings)

Cromgard C22-5 has been approved for use under Section VIII, Division 1 of the ASME Boiler and Pressure Vessel to a maximum temperature of 600°F (316°C).

Use of Cromgard C22-5 is approved for nuclear construction by Code Case N-741. The strength of Cromgard C22-5 is indicated by the maximum allowable stress values given in the ASME Boiler and Pressure Vessel Code reproduced below and compared to values for Type 316L stainless steel.

Corrosion Resistance

General Corrosion
Cromgard C22-5 is resistant to dilute reducing acids and moderate to high concentrations of oxidizing acids. The alloy is resistant to low concentrations of organic acids, but should be used with caution in higher concentrations at elevated temperatures.

Intergranular Corrosion
Tests of Cromgard C22-5 in the welded condition indicate that it resists intergranular corrosion as measured by the 16% sulfuric acid-copper sulfate (ASTM A 262 Practice E) test.

Chloride Stress Corrosion Cracking Resistance
The nickel-free ferritic steels are essentially immune to chloride stress corrosion cracking even in the extremely severe boiling 42% magnesium chloride test. Nickel-containing austenitic stainless steels, on the other hand, are highly susceptible to stress corrosion cracking (SCC). The resistance of austenitic and ferritic stainless steels to chloride stress corrosion cracking has been correlated to the nickel content of the alloys.

Chloride Stress Corrosion Cracking Resistance
Cromgard C22-5 and other similar Cromgard alloys behave in a manner that is a combination of the characteristics of the austenitic and ferritic phases that make up the alloy. Certain elements tend to partition into one of the two primary phases in duplex alloys. For example, the nickel content of the ferrite phase will be lower than that of the austenite phase relative to the bulk composition. Consequently, the ferrite phase in Cromgard C22-5 will provide resistance to chloride stress corrosion cracking, making it substantially better than the standard 300 series austenitic stainless steels. Therefore, Cromgard C22-5 and other Cromgard stainless steels are often preferred over austenitic stainless steels in applications where chloride SCC is a problem.

Pitting and Crevice Corrosion Resistance

Crevice Corrosion Resistance:
A relative ranking of the resistance to chloride-ion pitting and crevice corrosion can be made by using the procedure described in ASTM Standard G 48 Method B (10% $FeCl_3 \cdot 6H_2O$) and increasing the test temperature until the onset of crevice corrosion attack is observed. The temperature at which attack is first observed is called the critical crevice corrosion temperature and can be used as a relative measure of crevice corrosion resistance. The critical crevice corrosion temperature criterion is useful for ranking alloys, but does not necessarily indicate an absolute limiting temperature for the use of a particular alloy in chloride-bearing solutions.

Crevice Corrosion Resistance:
Testing data indicates that Cromgard C22-5 offers superior resistance to chloride-ion crevice corrosion compared to Type 316 and Type 317 stainless steels.

Pitting Corrosion Resistance:
According to ASTM G 150 using standard and modified test solutions the critical pitting temperature of Cromgard C22-5 was measured to be similar to that of Type 904L and much higher than that of Type 316.

Where pitting corrosion is anticipated, steel with high pitting resistance equivalents (PRE), such as Cromgard C22-5, should be considered. The PRE number for Cromgard C22-5 is 36.

Atmospheric Corrosion

The atmospheric corrosion resistance of Cromgard C22-5 is very good. Cromgard C22-5 is more than sufficient in urban and industrial environments and is normally well suited for most marine environments .

Welding

Cromgard C22-5 can be welded by most methods used to weld stainless steels. Autogenous welding will increase the amount of ferrite present in the weldment and adjacent areas of the base metal. If Cromgard C22-5 is autogenously welded, the fabrication should be solution annealed to restore the desirable microstructure and hence the toughness. A nitrogen addition is recommended to preserve corrosion resistance and strength.

Commercially available overmatched filler metals are suggested for welding Cromgard C22-5. Such filler metals, like AWS E2209, contain more nickel than the base metal in order to produce a phase balance within the weld that is approximately the same as the base metal.

Cromgard C22-5 has good weldability in most applications provided that the recommended procedures are adopted. It can be welded with most standard welding methods (MMA/SMAW, MIG/TIG, FCAW, SAW and PAW). If Cromgard C22-5 is autogenously welded the fabrication should be solution annealed to restore the desirable microstructure and hence the toughness. Only welding consumables specifically specified for Cromgard C22-5 should be used to ensure that the deposited metal has the correctly balanced microstructure. Type 2209 is the filler welding electrode recommended for optimum properties. Nitrogen, when added to the shielding gas, will also assist in ensuring adequate austenite in the microstructure.

Cromgard C22-5 should be welded with a heat input controlled to between 1 and 2kJ/mm in order to keep the Heat Affected Zone (HAZ) narrow and to ensure there is at least 20% austenite in the HAZ. The interpass temperatures should not exceed 150°C. The lower coefficient of thermal expansion of Cromgard C22-5, compared to austenitic stainless steels, reduces distortion and the associated stresses.

Preheating, although not essential, is beneficial on thicker gauge sections. Typical preheat temperatures are between 100°C and 250°C. Post weld heat treatment is not normally required but solution annealing will restore the toughness and confer the optimum stress corrosion cracking resistance to the fabrication.

Chemical Composition

Element	Range
Carbon	0.030 max
Silicon	1.000 max
Manganese	2.000 max
Phosphorus	0.035 max
Sulfur	0.015 max
Chromium	22.00 - 23.00
Nickel	4.500 - 6.500
Nitrogen	0.140 - 0.200
Molybdenum	2.500 - 3.500
Iron	Balance

Per ASTM A240
Values are maximum values or ranges

Mechanical Properties

Property	Value
Tensile Strenght (ksi)	95
0.2% Proof Strength (ksi)	65
Elongation*	25%
Hardness (HRc)	31

Per ASTM A240
Values are minimum unless stated
* Elongation over a length of 50.8mm

Physical Properties

Property		Value
Density (lb/in^3)		0.28
Modulus of Elasticity	Tension (GPa)	200
Specific Heat Capacity (J/kg K)		470
Thermal Conductivity	100°C (W/m K)	17.0
	500°C (W/m K)	21.1
Resistivity (x10-9 Ωm)		610
Coefficient of Thermal Expansion	0 - 100°C (x10^{-6} K^{-1})	13.0
	0 - 300°C (x10^{-6} K^{-1})	14.0
	0 - 500°C (x10^{-6} K^{-1})	14.5
	0 - 700°C (x10^{-6} K^{-1})	15.0
Melting Point (°C)		1410 - 1460
Magnetic		Yes

Per ASTM A240
Values are minimum unless stated

CROMPION
INTERNATIONAL

CROMMCAUS10252010

Please visit us at crompion.com