Hastelloy C22/UNS N06022 Technical Data Sheet

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1. Alloy Overview

ALLOY C - 22 (UNS N06022; W.Nr. 2.4602; NiCr21Mo14W) stands as a fully austenitic advanced corrosion - resistant alloy. Hastelloy C-22® alloy is a versatile nickel-chromium-molybdenum-tungsten alloy with better overall corrosion resistance than other Ni-Cr-Mo alloys available, including C-276 and C-4 alloys and alloy 625. C-22 alloy has exceptional resistance to a wide variety of chemical process environments, including strong oxidizers such as ferric and cupric chlorides, chlorine, hot contaminated solutions (organic and inorganic), formic and acetic acids, acetic anhydride, and seawater and brine solutions.

1.1 Chemical Composition

As a nickel - base alloy, ALLOY C - 22 typically consists of 22% chromium, 14% molybdenum, and 3% tungsten. The iron content is strictly limited to less than 3%. The high chromium content endows the alloy with excellent resistance to wet corrosion induced by oxidizing media, such as nitric acid, ferric salts, and cupric salts. Meanwhile, the presence of molybdenum and tungsten contributes significantly to its resistance against wet reducing media, including sulfuric and hydrochloric acids.

Element	UNS N06022
Carbon, max	0.015
Manganese, max	0.50
Phosphorous, max	0.02
Sulphur, max	0.02
Silicon. max	0.08
Nickel	Remainder[A]
Chromium	20.0-22.5†
Molybdenum	12.5-14.5
Copper	...
Columbium (Nb) + tantalum	...
Nitrogen	...
Iron	2.0-6.0
Cobalt, max	2.5
Tungsten	2.5-3.5
Vanadium, max	0.35
Titanium, max	...
Zirconium, max	...
Columbium (Nb)	...
Tantalum	...
Nickel + Molybdenum	...
Aluminum, max	...

1.2 Corrosion Resistance in Different Environments

Seawater Resistance

ALLOY C - 22 exhibits outstanding resistance to corrosive attack by seawater, regardless of whether the seawater is in a stagnant or flowing state. This makes it highly reliable for marine - related applications.

High - temperature Resistance

At elevated temperatures, the elevated chromium level within ALLOY C - 22 plays a crucial role in resisting oxidation, carburization, and sulfidation. As a nickel - based alloy, it can effectively withstand high - temperature attacks from halides, such as chlorides and fluorides. These properties have led to its widespread use in protecting steel tubes and other components in coal - fired and waste - to - energy boilers.

1.3 Specifications and Approvals

ALLOY C - 22 products adhere to strict ASTM, ASME, and ISO specifications. It has been approved for the construction of pressure vessels and components under the ASME Boiler and Pressure Vessel Code Section VIII, Division 1, for service conditions reaching up to 1250°F (677°C). Additionally, it has received approval from VdTÜV under Werkstoffblatt 479. The limiting chemical composition ranges are detailed in Table 1. Table 2 provides a comparison of the combined alloying content (Cr + Mo + W + Nb) of ALLOY C - 22 with other similarly alloyed materials. Physical properties are presented in Table 3, mechanical properties at room temperature are shown in Table 4, thermal conductivity is detailed in Table 5, and mechanical properties at elevated temperatures can be found in Figure 1.

2. Corrosion Resistance Properties

2.1 General Corrosion Resistance

The most distinctive feature of ALLOY C - 22 is its outstanding resistance to a broad spectrum of corrosive media. It can effectively resist both oxidizing acids and reducing acids, such as sulfuric and hydrochloric acids. Moreover, it demonstrates high resistance to various other corrosive chemicals, including oxidizing acid chlorides, wet chlorine, formic and acetic acids, ferric and cupric chlorides, seawater, brines, and numerous mixed or contaminated chemical solutions, both organic and inorganic.

2.2 Localized Corrosion Resistance

Pitting and crevice corrosion are commonly evaluated by determining the minimum or critical temperature at which an attack initiates. Critical pitting temperatures (CPT) and critical crevice temperatures (CCT) were measured in a solution comprising 6 wt. % ferric chloride + 1 wt. % hydrochloric acid, with a maximum test temperature of 85°C (185°F), as illustrated in Table 7. The relatively high molybdenum and tungsten content, coupled with the low iron content of ALLOY C - 22, confers superior pitting resistance in this acid chloride environment.

2.3 Intergranular Corrosion

Intergranular attack (IGA) refers to a localized corrosive attack along the grain boundaries of an alloy product. While IGA can be triggered by multiple mechanisms, phase precipitation in the grain boundaries (sensitization) is the most prevalent cause, and the susceptibility to sensitization varies among different alloys.

ALLOY C - 22 has shown remarkable resistance to sensitization when compared to most other corrosion - resistant alloys. The ASTM G28 tests are commonly employed to verify an alloy product's resistance to IGA. Corrosion data generated by test methods A and B are presented in Table 9. Method A is the Streicher test, whereas method B utilizes a modified "Green Death" medium. The results indicate that ALLOY C - 22 offers resistance comparable to that of a competitive N06022 alloy.

3. Applications at Elevated Temperatures

Beyond its excellent resistance to aqueous corrosion, ALLOY C - 22 is also well - suited for numerous process environments at elevated temperatures of up to 1250°F (677°C).

It has proven particularly effective in safeguarding boiler tubes, waterwalls, and other components in coal - fired electric power generation boilers and has also delivered excellent performance in low NOx boilers. ALLOY C - 22 can withstand attacks from halides (especially chlorides) and sulfur at elevated temperatures, which are commonly present in the coal used for power generation. It also offers exceptional resistance to aggressive corrosion from metal chloride and sulfate salts in power generation boilers fired by municipal solid waste.

Alloy steel components are frequently overlaid with ALLOY C - 22 through welding. Weld deposits created using the Ni - Cr - Mo - W ALLOY C - 22 do not exhibit the segregation tendencies characteristic of Ni - Cr - Mo - Nb alloy systems. This results in significant enhancements in corrosion resistance and excellent resistance to corrosion fatigue cracking, which is commonly observed in low NOx boiler waterwall overlays made from Ni - Cr - Mo - Nb materials. In addition to welded overlays, solid components and ALLOY C - 22 clad steel tubes are also available.

To comply with stringent emission limits, fossil fuel and waste - fired power generation boilers are undergoing redesigns with the addition of burners to reduce the formation of nitrogen oxides (NOx). This calls for improved protection of boiler tubes and waterwalls in these more aggressive environments. ALLOY 625 Filler Metal weld overlays have long been used for protecting such boiler components. However, a recent study has revealed that these overlays can suffer from circumferential cracking due to stress - accelerated sulfidation of the dendrite centers of the weld overlays within as little as 18 months of service. The study also suggests that ALLOY 622 Filler Metal overlays should provide significantly better resistance to this attack, thereby extending the service life. This superior performance is attributed to the higher molybdenum content and the absence of niobium, which is responsible for elemental segregation issues in ALLOY 625 weld overlays. Consequently, ALLOY 622 welding products are preferred over ALLOY 625 products for overlaying boiler components.

4. Forming and Welding

ALLOY C - 22 can be fabricated with ease using standard procedures for nickel alloys. Its high ductility facilitates cold forming; however, work hardening may require intermediate annealing. Welding processes such as gas tungsten - arc, gas metal - arc, and shielded metal - arc can be employed for joining this alloy.

5,Production available

Standard Organization	Standard Number	Title / Description
ASTM (American Society for Testing and Materials)	**ASTM B575**	Standard Specification for Nickel Alloy Plate, Sheet, and Strip
	ASTM B574	Standard Specification for Nickel Alloy Rod, Bar, and Wire
	ASTM B619	Welded Pipe (annealed)
	ASTM B622	Seamless Pipe and Tube
	ASTM B626	Welded Pipe (non-annealed)
	ASTM B366	Wrought Nickel and Nickel Alloy Fittings
ASME (American Society of Mechanical Engineers)	**ASME SB-575**, **SB-622**, etc.	Boiler and Pressure Vessel Code approved versions of ASTM specs