

HASTELLOY® C-22HS® alloy

Oil & Gas Applications

The C-22HS® alloy has a composition of Ni-21Cr-17Mo and was introduced for applications requiring both corrosion resistance and high strength. Being a C-type alloy (Ni-Cr-Mo), the new material has excellent resistance to stress corrosion cracking, uniform and localized corrosion. The alloy can be age-hardened or be cold worked plus age hardened to provide two to four times the yield strength of other C-type alloys. The C-22HS alloy can achieve yield strengths well above those of cold worked C-276 alloy while maintaining toughness and corrosion resistance. The alloy is of interest in the oil & gas industry due to the very high strength capabilities, its toughness, and its resistance to sour gas environments. To determine the usefulness of the alloy in oil and gas applications, an extensive sour gas test program was initiated. The program was undertaken to develop an understanding of the alloy in sour gas environments and to produce the data necessary to apply for NACE MR0175 coverage. Testing has been performed including the NACE standard room temperature tests for sulfide stress cracking, as well as slow strain rate and autoclave testing at elevated temperatures (Level VII) both with and without the presence of elemental sulfur. The alloy has shown excellent resistance in all test conditions.

The high strength of Ni-21Cr-17Mo is imparted through the formation of long-range ordered (LRO) domains of the Ni₂(Cr,Mo) phase which develop during a two-step age-hardening treatment given to the alloy in the annealed condition. The LRO domains result in just over doubling of the room temperature (RT) yield strength up to values around 115 ksi (794 MPa). The two-step age-hardening treatment is 1300°F (704°C)/16 h/furnace cool (FC) to 1125°F (607°C)/32 h/air cool (AC). A simpler single step age is done on cold worked material at 1125°F (607° C) for 10 hours.

Mechanical Properties of Various Product Forms and Conditions:

Average Room Temperature Tensile Properties-Bar					
Material Condition	Yield Strength (ksi)	UTS (ksi)	Elongation (%)	R.A. (%)	-75°F Impact Energy (ft-lbf)
Cold-Worked	198.0	203.5	16.7	64.2	153
Cold-Worked +Age-Hardened	202.4	230.7	19.9	48.7	125
Annealed + Age-Hardened	117.8	194.1	32.9	45.7	67

Cold-Worked Condition: cold work levels ranged from 43 to 47%

Cold-Worked + Age-Hardened Condition: cold work levels same as above, age-hardening treatment- 1125°F/10h

Annealed + Age Hardened: Annealing temperature 1850°F, age-hardening treatment- 1300°F/16h/FC to 1125°F/32h

HASTELLOY® C-22HS® Alloy

Average Room Temperature Tensile Properties-Tube

Material Condition	Yield Strength (ksi)	UTS (ksi)	Elongation (%)
Cold-Worked	187.3	195.0	15.1
Cold-Worked + Age-Hardened	198.7	222.6	19.2
Annealed + Age-Hardened	120.8	191.3	33.4

Cold-Worked Condition: cold work levels ranged from 52 to 53%

Cold-Worked + Age-Hardened Condition: cold work levels same as above, age-hardening treatment- 1125°F/10h

Annealed + Age Hardened: Annealing temperature -1850°F, age-hardening treatment- 1300°F/16h/FC to 1125°F/32h/AC

Room and Elevated Temperature Tensile Properties-Bar

Material Condition	Test Temperature °F	Yield Strength (ksi)	UTS (ksi)	Elongation (%)	R.A. (%)
43% CW	RT	195.1	200.4	18.0	65.2
43% CW	400	181.8	182.6	14.6	63.1
43% CW	500	181.0	181.1	14.1	60.8
43% CW + 1125°F/10 h/AC	RT	203.1	233.6	21.4	57.5
43% CW + 1125°F/10 h/AC	400	185.9	208.9	20.9	58.7
43% CW + 1125°F/10 h/AC	500	183.1	207.3	20.9	57.5

For more information please email pmanning@haynesintl.com or visit www.haynesintl.com.