SINOXX 4542

PRECIPITATION HARDENING MARTENSITIC STAINLESS STEEL

SINOXX 4542 is a precipitation hardening (PH) martensitic stainless steel with Cu and Nb additions. In the solution-annealed (martensitic) condition, its yield strength is already above 110 ksi (750 MPa). Mechanical properties can be optimized with heat treatment. A yield strength of more than 170 ksi (1200 MPa) is obtained after aging treatment at 482 °C (900 °F). Higher aging temperatures coarsen the precipitates and reduce the strength.

The grade should not be used at temperatures above 300 °C or at very low temperatures. It has adequate resistance to atmospheric corrosion or in diluted acids or salts, where its corrosion resistance is equivalent to grade AISI 304 or 430.

APPLICATIONS

- offshore (foils, helicopter deck platforms …)
- food industry
- pulp and paper industry
- aerospace (turbine blades …)
- mechanical components
- nuclear waste casks

SPECIFICATIONS

ASTM A693	UNS S17400, type 630
AMS5604G	16.5Cr-4.0Ni-4.0Cu-0.30Cb
EN 10088-2	1.4542 X5CrNiCuNb16-4
DIN	1.4542

CHEMICAL COMPOSITION

Typical values in the range [wt. %]

	C	Mn	P	S	Si	Cr	Ni	Cu	Mo	Nb*
Min.	-	-	-	-	-	15.0	3.0	3.0	-	0.15
Max.	0.07	1.00	0.040	0.015	0.70	17.0	5.0	5.0	0.5	0.45

* Nb = C×5

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MECHANICAL PROPERTIES

SINOXX 4542 is provided in the solution-annealed condition. This is also called the solution heat treated condition or Condition A. Annealing is conducted by heat treating at approximately 1050 °C (1922 °F) and cooling to the room temperature. In this condition, the material possesses a martensitic structure. As a martensitic structure, SINOXX 4542 possesses a relatively high strength and hardness.

Minimum guaranteed values of the mechanical test requirements in solution-treated condition, following ASTM A693, AMS5604G are given in *Table 1*. The guaranteed values are valid for the plate thicknesses specified in *Table 1*.

Table 1

Solution treatment	Thickness	Tensile strength, max.		Yield strength, max.		Elongation, A_{50}, min.	Hardness – Brinell, max.
	[mm (in.)]	[ksi]	[MPa]	[ksi]	[MPa]	[%]	[HB]
1050 ± 25 °C (1922 ± 77 °F) (cooled as required)	8.0–101.6 (0.315–4.0)	-	-	-	-	-	363

The typical mechanical properties in the solution-annealed condition for the thickness range are given in *Table 2*.

Table 2

Solution treatment	Thickness	Tensile strength		Yield strength		Elongation, A_{50}	Hardness – Brinell	Impact Charpy – V, 20 °C (68 °F)
	[mm (in.)]	[ksi]	[MPa]	[ksi]	[MPa]	[%]	[HB]	[J]
1050 ± 25 °C (1922 ± 77 °F) (air cooling)	8.0–101.6 (0.315–4.0)	152–160	1050–1100	119–133	820–920	5–8	300–350	150–180

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The desired mechanical properties may be achieved by subsequent age hardening treatments.
Minimum guaranteed values of mechanical test requirements after precipitation hardening treatment for condition H900, H925, H1025, H1075, H1100, H1150, following ASTM A693 and AMS5604G are presented in *Table 3*. The guaranteed values are valid for the plate thicknesses specified in *Table 3*.

Table 3

Precipitation hardening condition, [H]	Hardening or Precipitation Treatment Temperature, [°C (°F)]	Thickness	Tensile strength		Yield strength		Elon-gation, A_{50}	Reduc-tion of area,	Hardness – Brinell		Impact Charpy – V, 20 °C (68 °F)
		[mm (in.)]	[ksi]	[MPa]	[ksi]	[MPa]	min. [%]	min. [%]	min. [HB]	max. [HB]	min.* [J]
H900	482 °C (900 °F) – 1 h – air cooling	10.0–15.88 (0.393701–0.625)	190	1310	170	1172	8	30	388	444	-
		15.90–101.6 (0.626–2.0)	190	1310	170	1172	10	35	388	444	-
H925	496 °C (925 °F) – 4 h – air cooling	10.0–15.88 (0.393701–0.625)	170	1172	155	1070	8	30	375	415	-
		15.90–101.6 (0.626–2.0)	170	1172	155	1070	10	35	375	415	-
H1025	552 °C (1025 °F) – 4 h – air cooling	10.0–15.88 (0.393701–0.625)	155	1069	145	1000	8	35	331	388	14
		15.90–101.6 (0.626–2.0)	155	1069	145	1000	12	40	331	388	20
H1075	579 °C (1075 °F) – 4 h – air cooling	10.0–15.88 (0.393701–0.625)	145	1000	125	862	9	35	311	363	20
		15.90–101.6 (0.626–2.0)	145	1000	125	862	13	45	311	363	27
H1100	593 °C (1100 °F) – 4 h – air cooling	10.0–15.88 (0.393701–0.625)	140	965	115	793	10	35	302	352	20
		15.90–101.6 (0.626–2.0)	140	965	115	793	14	45	302	352	27
H1150	621 °C (1150 °F) – 4 h – air cooling	10.0–15.88 (0.393701–0.625)	135	931	105	724	10	40	269	341	34
		15.90–101.6 (0.626–2.0)	135	931	105	724	16	50	269	341	41

** According to the ASTM A693 the impact test is not required unless specified on the purchase order.*

MICROSTRUCTURE

The microstructure of SINOXX 4542 PH steel in solution annealed condition (Condition A) is martensitic. Grain size according to ASTM E112 varies between 6 and 9, depending on plate thickness. The typical martensitic microstructure with grain size no. 6 for 70 mm thick plate is shown in *Figure 1*.

Figure 1: Martensitic microstructure

HOT FORMING

Hot forming should be carried out in a temperature range of 950–1200 °C (1742–2192 °F). After hot working, full heat treatment is required. This involves annealing and cooling to room temperature or lower. Then the components need to be precipitation hardened to achieve the required mechanical properties.

HEAT TREATMENT

Depending on the order:

- Solution annealing:
  1050 ± 25 °C (1922 ± 77 °F), air cooling below 25 °C (77 °F)
- Age hardening:
  H925 – 496 ± 6 °C (925 ± 10 °F) – 4 hours – air cooling
  H1025 – 552 ± 6 °C (1025 ± 10 °F) – 4 hours – air cooling
  H1075 – 579 ± 6 °C (1075 ± 10 °F) – 4 hours – air cooling
  H1100 – 593 ± 6 °C (1100 ± 10 °F) – 4 hours – air cooling
  H1150 – 621 ± 6 °C (1150 ± 10 °F) – 4 hours – air cooling
- Laboratory heat treatment:* (only for material response conformation)
  H900 – 482 ± 6 °C (900 ± 10 °F) – 1 hour – air cooling

**according to the AMS 5604G*

CUTTING

Thermal cutting operations, such as plasma cutting, should be avoided. Mechanical cutting operations, such as bandsaw, abrasive waterjet, shearing and machining, are preferred.

DELIVERY CONDITIONS

- Solution annealed – Condition A
- Age hardened conditions: H925, H1025, H1075, H1100, H1150

All blast cleaned quarto plates.

DIMENSIONS

SINOXX 4542	Thickness [mm]	Max. width [mm]	Max. length [mm]	Max. weight [kg]
Quarto plates	8–12.7 (0.31–0.5 in.)	2000 (78.74 in.)	12000 (472.44 in.)	9600 (21164 lbs)
Quarto plates	12.7–101.6 (0.5–4.0 in.)	2500 (98.42 in.)	12000 (472.44 in.)	9600 (21164 lbs)

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