CARPENTER TECHNOLOGY

DATASHEET

FERRIUM® S53

Applicable specifications: AMS 5922

Associated specifications: U.S. Patent 7,967,927 B2, UNS S10500

Type analysis

Single figures are nominal except where noted.

Iron	Balance	**Cobalt**	14.00 %	**Chromium**	10.00 %
Nickel	5.50 %	**Molybdenum**	2.00 %	**Tungsten**	1.00%
Vanadium	0.30 %	**Carbon**	0.21 %		

Forms manufactured

Bar-Flats	**Bar-Rectangles**	**Bar-Rounds**	**Billet**

Description

Ferrium S53 is a corrosion-resistant, ultra high-strength steel for structural aerospace applications. The alloy has provided mechanical properties equal to, or better than, conventional ultra high-strength steels such as 300M and SAE 4340, with the added benefit of resistance to corrosion and stress-corrosion cracking (SCC). Ferrium S53 uses an efficient M_2C strengthening dispersion precipitated through tempering, while avoiding other carbides. This maximizes strength, wear resistance, and toughness. It uses a passive oxide film to provide corrosion resistance similar to 440C stainless steel, and it has high hardenability, permitting less severe quench conditions and resulting in less distortion during heat treatment.

Ferrium S53 is manufactured and sold under license from QuesTek Innovations LLC.

Key Properties:

- Ultra high strength
- Corrosion resistance
- SCC resistance
- High hardenability

Market:

- Aerospace

Applications:

- Fasteners
- Landing gear
- Actuators
- Structural members
- Drive shafts

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Corrosion resistance

IMPORTANT NOTE:
The following 4-level rating scale is intended for comparative purposes only. Corrosion testing is recommended; factors that affect corrosion resistance include temperature, concentration, pH, impurities, aeration, velocity, crevices, deposits, metallurgical condition, stress, surface finish, and dissimilar metal contact.

Nitric Acid	Excellent	**Salt Spray (NaCl)**	Good

Physical properties

PROPERTY	At or From	English Units
DENSITY	—	0.2880 lb/in^3
MEAN SPECIFIC HEAT	73°F	0.1080 Btu/lb/°F
	392°F	0.1200 Btu/lb/°F
	752°F	0.1340 Btu/lb/°F
	1076°F	0.2330 Btu/lb/°F
MEAN CTE	75 to 220°F	5.86 x 10^{-6} in/in/°F
	75 to 400°F	5.89 x 10^{-6} in/in/°F
	75 to 600°F	6.00 x 10^{-6} in/in/°F
	75 to 800°F	6.13 x 10^{-6} in/in/°F
	75 to 1000°F	6.22 x 10^{-6} in/in/°F
	75 to 1100°F	6.19 x 10^{-6} in/in/°F
THERMAL CONDUCTIVITY	73°F	124.6 Btu-in/hr/ft^2/°F
	212°F	140.2 Btu-in/hr/ft^2/°F
	392°F	157.2 Btu-in/hr/ft^2/°F
	572°F	171.3 Btu-in/hr/ft^2/°F
	752°F	181.2 Btu-in/hr/ft^2/°F
	932°F	199.8 Btu-in/hr/ft^2/°F
	1100°F	243.9 Btu-in/hr/ft^2/°F
ELASTIC MODULUS (E)	—	29.6 x 10^3 ksi
CRITICAL TEMPERATURE (AC1)	1364°F	—
CRITICAL TEMPERATURE (AC3)	1436°F	—
MARTENSITE START	212°F	—

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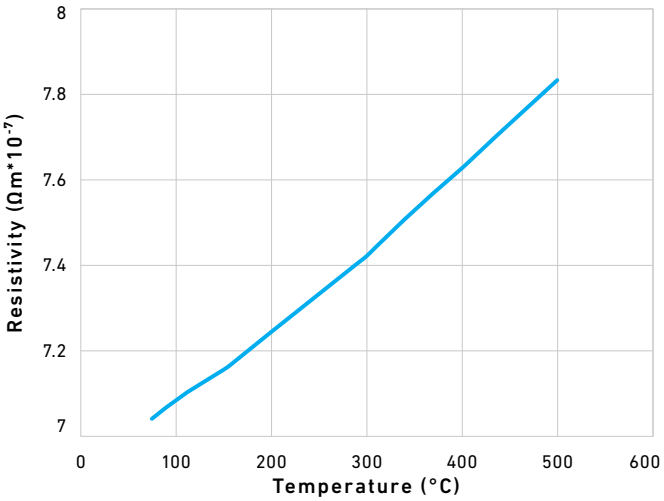
ELECTRICAL RESISTIVITY VS TEMPERATURE



Typical mechanical properties

ROOM TEMPERATURE TENSILE PROPERTIES

ORIENTATION	TENSILE STRENGTH		YIELD STRENGTH		ELONGATION	REDUCTION OF AREA	FRACTURE TOUGHNESS		IMPACT ENERGY		HRC
	ksi	MPa	ksi	MPa	% IN 4D	%	ksi√in	MPa√m	ft-lbs	J	
Longitudinal	288	1986	225	1551	15	57	65	71	18	24	54
Transverse	288	1986	225	1551	15	55	65	71	18	24	54

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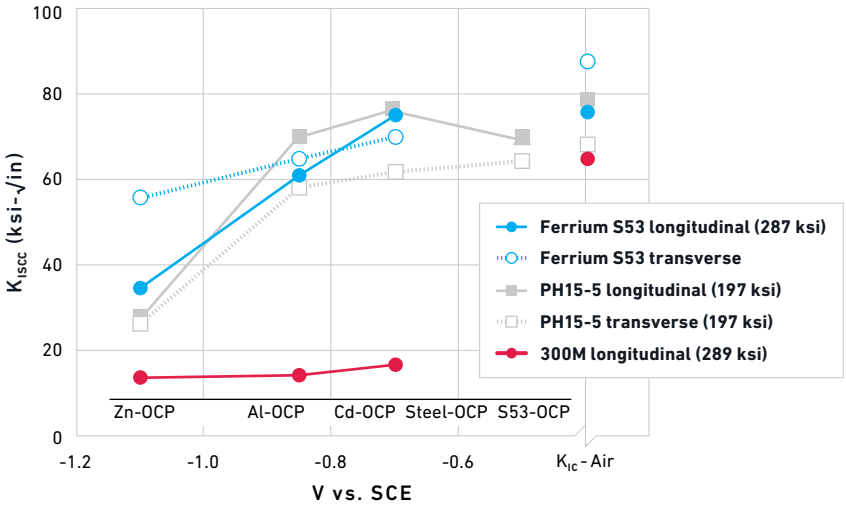
STRESS CORROSION CRACKING PER ASTM F1624 IN 3.5 WT% NaCl SOLUTION



Heat treatment

Ferrium S53 can be solution treated and tempered in either vacuum, air, or other media as described below, and selection of the process can depend on factors such as: industry application; ability and desire to final-machine a part after tempering; size or weight of part; achievable quench rates, etc.

Decarburization	Ferrium S53 is subject to decarburization during hardening. To mitigate decarburization, heat treatment should take place in a neutral atmosphere furnace, salt bath, or vacuum. The extent of decarburization can be determined by comparing the surface and internal hardness of a small test coupon.
Normalizing	1975°F (1080°C) for 1 hour and air cool.
Annealing	1255°F (680°C) for 8 hours and air cool. An annealed hardness of 327 HB or lower is obtained following annealing.

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Solution treatment	1985°F (1085°C) 1 hour and oil quench or equivalent.
Deformation (size change) in hardening	Heat treatment growth of Ferrium S53 is dependent upon the thermal history and machining path (e.g., machining stresses) of the parts being produced. Typical growth is uniform and approximately 0.002–0.003 in. per in.
Quenching	Gas, oil, or equivalent.
Cold treatment	Following normalization and/or solution treatment, -100°F (-73°C) for 1 hour and air warm.
Straightening	Operations such as shaft straightening (if required) should preferably be done after the sub-zero treatment but prior to the temper. Ferrium S53 achieves full mechanical strength after tempering, and thus trying to straighten parts after tempering will be more difficult. For some parts, mechanical straightening may be desired to compensate for possible distortion during heat treatment. Prior to straightening, a low temperature stress relief at 392°F (200°C) for 1 hour following the first refrigeration operation should be conducted. Hot straightening should be conducted below 700°F (371°C) to avoid tempering, oxidation, or decarburization.
Stress relieving	If it is desired to stress-relieve a machined part in the mill-annealed condition as a means to help prevent distortion during further processing (e.g., if significant forces were imposed on the part during machining), then either of two options are recommended: i. Produce the part in a rough-machined state with adequate stock material on all surfaces so that oxide scale can be removed, and then stress-relieve the part at ~1200°F (649°C) for 2 hours, followed by cooling in air. Then complete all final machining operations prior to solution treatment, quench, sub-zero treatment, and temper, in order to remove the oxide scale formed at 1200°F (649°C). ii. Produce the part in a fully or nearly fully machined state prior to solution treatment, sub-zero treatment quench and temper, and then stress-relieve the part at 700°F (371°C) for 2 hours or 525°F (274°C) for 4 hours, followed by cooling in air.
Tempering	Temper at 934°F (501°C) for 3 hours and oil quench or equivalent, followed by -100°F (-73°C) for 1 hour and air warm, then temper at 900°F (482°C) for 12 hours and air cool.
Preheating	A preheat temperature of no higher than 600°F (315°C) is recommended.

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Workability

Hot working	1800–2050°F (982–1121°C). Recommended reduction ratio of 4:1.
Forging	Standard forging of billet and bar stock should be conducted at 1800–2050°F (982–1121°C). If higher forging temperatures are preferred, hot fire temperatures of 2300–2350°F (1260–1288°C) may be used, provided a minimum of 4:1 forging reduction ratio is achieved. Following forging, the parts should be air cooled to room temperature, followed by normalization, cold treatment, and annealing to improve machinability.
Machinability	Annealed Ferrium S53 has machinability similar to 300M at 35 HRC. Tools used for cutting and drilling are typically those used for other 400 series stainless steels. Recommended speeds are 225–260 SFM for milling, 250–300 SFM for drilling.
Preheating of dies	None.
Plating	Ferrium S53 can be electroplated with surface protection options such as: Cr; Ni; duplex Ni+Cr; Zn-Ni; Cd; Al, including Alumiplate and Ion Vapor Deposition (IVD) aluminum; and WC-Co powder by HVOF thermal spray.
Passivation	Passivation in a 50% nitric acid solution is recommended for maximum corrosion resistance per AMS 2700B, Method 1.

Other Information

Descaling (cleaning)	Bar peeling.

For additional information, please contact your nearest sales office:
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