Technical Datasheet

CarTech® Ferrium S53® Alloy

Identification

U.S. Patent Number

- 7,967,927 B2

UNS Number

- S10500

Type Analysis

Single figures are nominal except where noted.

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

General Information

Description

CarTech Ferrium S53* alloy is a corrosion resistant, ultrahigh-strength steel for structural aerospace applications. The alloy has provided mechanical properties equal to, or better than, conventional ultrahigh-strength steels such as CarTech 300M and SAE 4340 with the added benefit of modest corrosion resistance. Laboratory testing has shown CarTech Ferrium S53 alloy to possess improved resistance to stress-corrosion cracking (SCC) over CarTech 300M and SAE 4340.

CarTech Ferrium S53 alloy utilizes an efficient M2C strengthening dispersion precipitated through tempering while avoiding other carbides. This maximizes strength, wear resistance, and toughness resulting in a unique combination of mechanical properties for a corrosion-resistant steel. CarTech Ferrium S53 alloy uses a passive oxide film to provide corrosion resistance similar to CarTech 440C stainless steel. It also has high hardenability, permitting less severe quench conditions for a given section size and resulting in less distortion during heat treatment.

*Manufactured and sold under license from QuesTek Innovations LLC. Ferrium is a registered trademark of QuesTek Innovations LLC.

Applications

CarTech Ferrium S53 alloy can be considered as a candidate for use in applications such as:

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

Corrosion Resistance

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

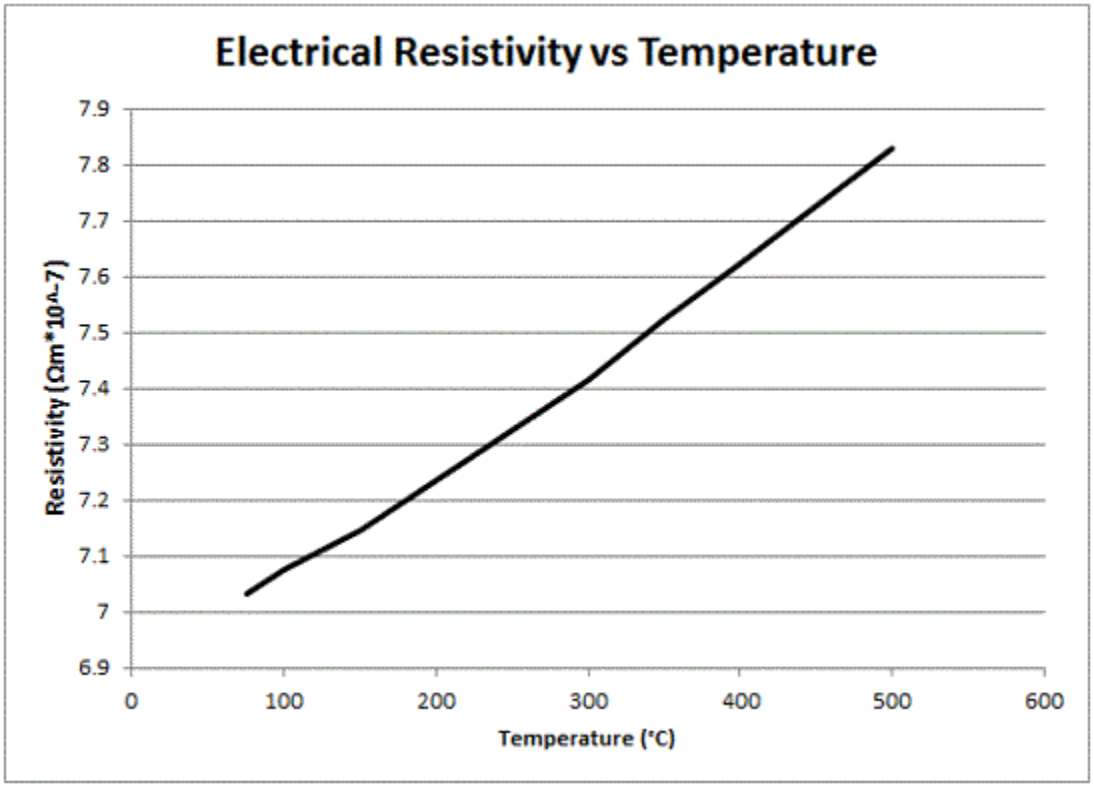
Nitric Acid	Excellent	Salt Spray (NaCl)	Good

Properties

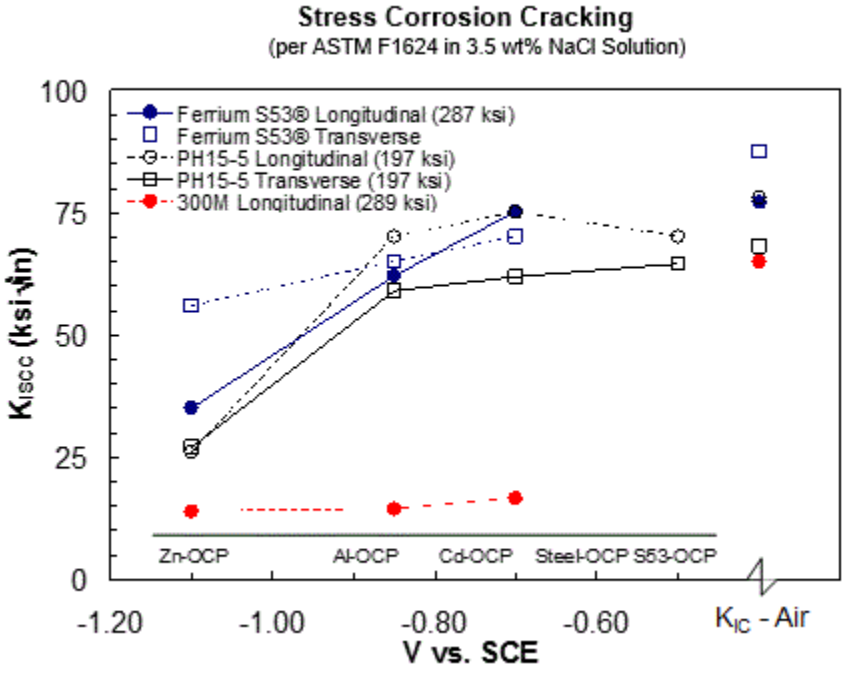
Physical Properties

Density	0.2880	lb/in³

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/ft²/°F
212°F	140.2	BTU-in/hr/ft²/°F
392°F	157.2	BTU-in/hr/ft²/°F
572°F	171.3	BTU-in/hr/ft²/°F
752°F	181.2	BTU-in/hr/ft²/°F
932°F	199.8	BTU-in/hr/ft²/°F
1100°F	243.9	BTU-in/hr/ft²/°F
Modulus of Elasticity (E)	29.6	x 10^{3} ksi
Critical Temperature (AC1)	1364	°F
Critical Temperature (AC3)	1436	°F
Martensite Start	212	°F



Typical Mechanical Properties



Typical Mechanical Properties											
Room Temperature Tensile Properties of *Ferrium S53*											
Orientation	Tensile Strength		Yield Strength		Elongation	R. of A.	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

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.

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 of S53 is uniform and approximately 0.002-0.003 inches per inch.

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. 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 392F (200C) for 1 hour following the first refrigeration operation should be conducted. Hot straightening should be conducted below 700F (371C) 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

Double 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 a third and final 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.

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 to 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

Metallurgical Requirements

Metallurgical Requirements

Per below material specifications.

Applicable Specifications

Note: While this material meets the following specifications, it may be capable of meeting or being manufactured to meet other general and customer-specific specifications.

- AMS 5922

Forms Manufactured

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

References

CINDAS ASMD/ASMH
MMPDS-09
AMS 2759/3 for thermal processing
AMS 2759/9 for hydrogen bake-out parameters
AMS 2759/11 for stress relieving parameters

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