Technical Datasheet

CarTech® Ferrium® M54® Alloy

Identification

U.S. Patent Number

- 9,051,635 B2

UNS Number

- K91973

Type Analysis

Single figures are nominal except where noted.

Carbon	0.30 %	**Chromium**	1.00 %
Nickel	10.00 %	**Molybdenum**	2.00 %
Cobalt	7.00 %	**Vanadium**	0.10 %
Tungsten	1.30 %	**Iron**	Balance

General Information

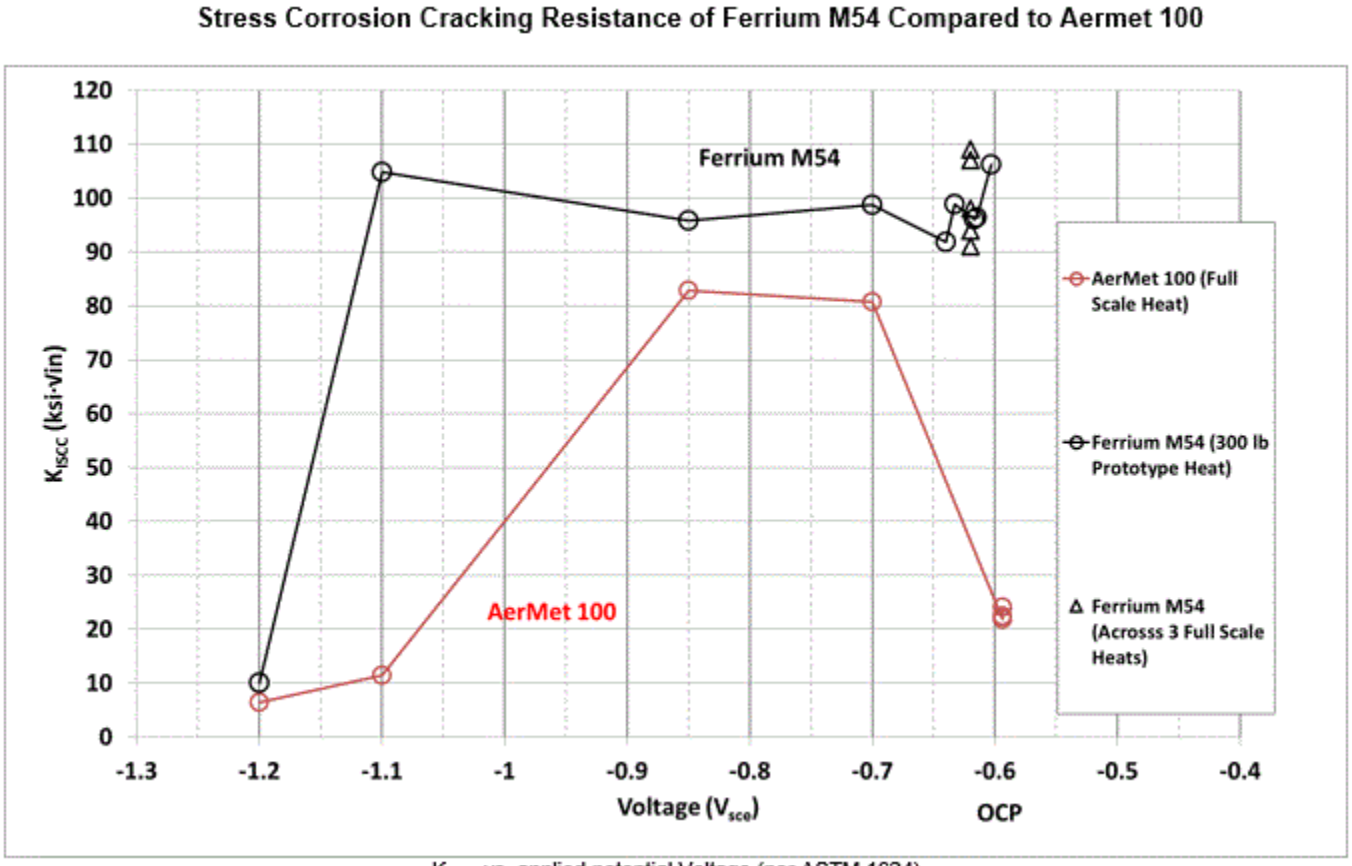
Description

Ferrium M54 is an ultra high-strength steel for structural aerospace and other applications where 300M, 4340, and AMS 6532 are typically used. Ferrium M54 has mechanical properties equivalent to the previously mentioned conventional alloys, but with the added benefit of very high toughness. This can be a major benefit in applications requiring high impact resistance or in flaw-tolerant designs. In addition, Ferrium M54 has greatly improved resistance to stress-corrosion cracking (SCC) compared to conventional ultra high-strength steels.

Applications

Typical applications can include aircraft landing gears, arresting tailhooks, blast-resistant or impact containment devices, armor, flap tracks, actuators, drive shafts, load bearing shafts for oil and gas, sporting goods, fasteners and other structural applications.

Corrosion Resistance



K_{ISCC} vs. applied potential Voltage (per ASTM 1624)

Properties

Physical Properties

Density	0.2880	lb/in³
Mean Specific Heat		
73°F	0.1070	Btu/lb/°F
392°F	0.1200	Btu/lb/°F
752°F	0.1360	Btu/lb/°F
1100°F	0.1700	Btu/lb/°F
Mean CTE		
75 to 212°F	5.65	x 10 $^{-6}$ in/in/°F
75 to 392°F	5.82	x 10 $^{-6}$ in/in/°F
75 to 572°F	5.99	x 10 $^{-6}$ in/in/°F
75 to 752°F	6.17	x 10 $^{-6}$ in/in/°F
75 to 932°F	6.37	x 10 $^{-6}$ in/in/°F
75 to 1004°F	6.47	x 10 $^{-6}$ in/in/°F
Thermal Conductivity		
73°F	182.5	BTU-in/hr/ft²/°F
212°F	193.6	BTU-in/hr/ft²/°F
392°F	206.8	BTU-in/hr/ft²/°F
572°F	216.5	BTU-in/hr/ft²/°F
752°F	223.4	BTU-in/hr/ft²/°F
932°F	229.0	BTU-in/hr/ft²/°F
1100°F	235.2	BTU-in/hr/ft²/°F

Modulus of Elasticity (E)	27.8	x 10 ³ ksi
Modulus of Rigidity (G)	10.7	x 10 ³ ksi
Critical Temperature (AC1)	1472	°F
Critical Temperature (AC3)	1616	°F
Martensite Start	400	°F

Typical Mechanical Properties

Typical Mechanical Properties								
Room Temperature Tensile Properties of CarTech Ferrium M54								
Test Temperature	Tensile Strength		Yield Strength		Elongation	R. of A.	Fracture Toughness	
	ksi	MPa	ksi	MPa	(% in 1")	(%)	ksi√in	MPa√m
Room Temperature	293	2020	250	1731	15	61	105	115

Heat Treatment

Decarburization

Solution treating in Vacuum has shown to result in small amounts of decarburization (0.001" or similar). Solution treating in air has been shown to result in an oxide/decarburization later of ~0.060", and will deepen with increasing furnace time. Solution treating in endothermic gas can result in a decarburization layer of up to 0.030", but has also been shown to result in 0.003"0.005" with an accurate carbon potential.

Normalizing

1965°F (1074°C) for 1 hour and air cool.

Annealing

Ferrium M54 alloy can be softened by subcritical annealing by heating to 1470°F (799°C) +/- 25°F (14°C), holding for 60 minutes, - 0 minutes, + 60 minutes, and then air cool to room temperature, followed by annealing by heating to 1205°F (652°C) +/- 50°F (28°C) for no less than 8 hours, and then air cool to room temperature.

Solution Treatment

1940°F (1060°C) 1 hour and oil quench or equivalent.

Quenching

Gas, Oil, or Equivalent.

Cold Treatment

Following 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. M54 achieves full mechanical strength after tempering, and thus trying to straighten parts after tempering will be more difficult.

If excessive distortion exists after the solution treatment, quench and sub-zero treatment, then it is recommended to heat the part to 392°F (200°C) in air for 1 hour, hot-straighten the part (temperature determined by amount of force required to straighten part; temperature should be maintained below 700F (371C) to avoid any tempering or decarburization; a small oxide layer may form at this temperature), and allow the component to air cool. The full temper cycle must then be applied.

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 960°F (516°C) for 8 to 12 hours and air cool.

Workability

Hot Working

1800 – 2050°F (982 – 1121°C).

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 M54 has machinability similar to AMS6532.

Preheating of Dies

None

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 6516

Forms Manufactured

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

References

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

Disclaimer:
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