FERRIUM® M54

Applicable specifications: AMS 6516

Associated specifications: U.S. Patent 9,051,635 B2, UNS K91973

Type analysis

Single figures are nominal except where noted.

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

Forms manufactured

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

Description

Ferrium M54 is an ultra high-strength steel for structural aerospace and other applications where 300M, 4340, and AMS 6532 are typically used. The alloy 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.

Key Properties:

- Ultra high strength
- High toughness
- Resistance to stress-corrosion cracking

Markets:

- Aerospace
- Consumer
- Defense
- Energy

Applications:

- Landing gear, tailhooks
- Drive and load-bearing shafts
- Sporting goods
- Fasteners
- Blast-resistant or impact containment devices
- Armor

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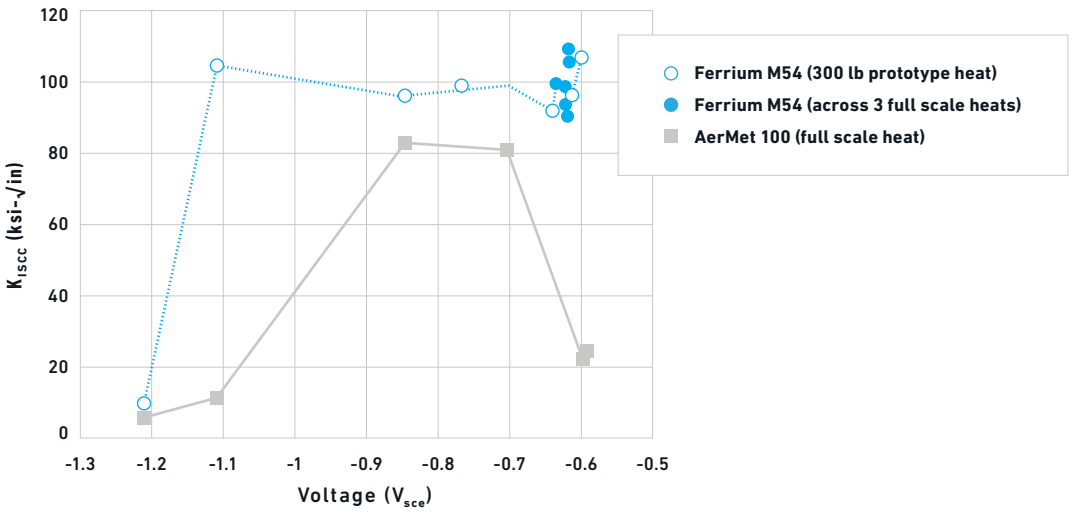
Corrosion resistance

STRESS CORROSION CRACKING RESISTANCE VS AERMET 100

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



Physical properties

PROPERTY	At or From	English Units
DENSITY	—	0.2880 lb/in^3
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

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THERMAL CONDUCTIVITY	73°F	182.5 Btu-in/hr/ft^2/°F
	212°F	193.6 Btu-in/hr/ft^2/°F
	392°F	206.8 Btu-in/hr/ft^2/°F
	572°F	216.5 Btu-in/hr/ft^2/°F
	752°F	223.4 Btu-in/hr/ft^2/°F
	932°F	229.0 Btu-in/hr/ft^2/°F
	1100°F	235.2 Btu-in/hr/ft^2/°F
ELASTIC MODULUS (E)	—	27.8 x 10^3 ksi
RIGIDITY MODULUS (G)	—	10.7 x 10^3 ksi
CRITICAL TEMPERATURE (AC1)	1472°F	—
CRITICAL TEMPERATURE (AC3)	1616°F	—
MARTENSITE START	400°F	—

Typical mechanical properties

ROOM TEMPERATURE TENSILE PROPERTIES

TEST TEMPERATURE	TENSILE STRENGTH		YIELD STRENGTH		ELONGATION	REDUCTION OF AREA	FRACTURE TOUGHNESS	
	ksi	MPa	ksi	MPa	% IN 1 INCH	%	ksi√in	MPa√m
Room Temperature	293	2020	250	1731	15	61	105	115

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Heat treatment

Decarburization	Solution treating in vacuum has shown to result in small amounts of decarburization (0.001 in. or similar). Solution treating in air has been shown to result in an oxide/decarburization later of ~0.060 in., and will deepen with increasing furnace time. Solution treating in endothermic gas can result in a decarburization layer of up to 0.030 in., but has also been shown to result in 0.003–0.005 in. with an accurate carbon potential.
Normalizing	1965°F (1074°C) for 1 hour and air cool.
Annealing	Ferrium M54 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. Ferrium 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 700°F (371°C) 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.

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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 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.

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Other Information

Descaling (cleaning)	Bar peeling.

For additional information, please contact your nearest sales office:
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