

Focused on designing and deploying best-in-class novel materials

QuesTek *Materials by Design*[®] methodology is based on Integrated Computational Materials Engineering (ICME) technologies that benefit producers, processors, OEMs and end-users by minimizing risks associated with alloy development, reducing research costs, and cutting in half the time to market with least overall life cycle cost. We design higher performance materials to meet specific property goals, such as:

- Tensile Strength
- Fracture Toughness
- Corrosion Resistance
- Stress Corrosion Cracking Resistance
- Wear Resistance
- Fatigue Strength
- Creep Resistance
- Thermal Conductivity

These materials are designed to yield benefits such as lower operating & maintenance costs, smaller/lighter/reliable components, and patent-protected competitive advantages.

New Economical High-Toughness UHS Steel

Ferrium[®] M54[®] (AMS 6516; MMPDS-09)

is a 293 ksi UTS, 115 ksi-√in K_{IC} , fatigue- and SCC-resistant steel for more economical, durable and SCC-resistant landing gear, tailhooks, driveshafts, etc.

- ✓ Upgrade from 300M, 4340 or Maraging 250
- ✓ Qualified for T-45 Hook Shanks (60 in production)
- ✓ Rig testing showed <2x life versus incumbent Hy-Tuf
- ✓ Lower cost and far greater SCC resistance than AMS 6532
- ✓ Less sensitive to time or temperature variances during tempering than AMS 6532



Ferrium M54 T-45 Hook Shank

New Corrosion-Resistant UHS Steel

Ferrium S53[®] (AMS 5922; MMPDS-05)

is a 288 ksi UTS steel for more durable, corrosion- and SCC-resistant landing gear, rotor/drive shafts, actuators, droop stops, blade folds, etc.

- ✓ Upgrade from 300M, 4340 or 440C
- ✓ Sikorsky evaluating for Navy helicopter rotor shafts
- ✓ In landing gear service without toxic cadmium plating
- ✓ Flying on T-38, C-5, KC-135 & A-10 platforms
- ✓ Good general corrosion & SCC resistance
- ✓ Excellent fatigue & corrosion fatigue resistance



Sikorsky's MH-60S Helicopter Mast produced from *Ferrium S53*

Alloy Typical Properties	UTS (ksi)	YS (ksi)	Elong (%)	RA (%)	K_{IC} Fracture Toughness (ksi-√in)	K_{ISCC} (ksi-√in)	Temper Temp (°F)
Ferrium S53	288	225	15	57	65	18-40	900
Ferrium M54	293	251	15	61	115	100	960
300M	287	242	11	37	50	15	575
AMS 6532	285	250	13	65	115	20	900

New High-Performance Carburizing-Grade Steels

- ✓ **Stronger/Tougher than 9310 and Alloy X53:** Smaller, Lighter Transmissions
- ✓ **High Fatigue Resistance:** Greater Operational Durability
- ✓ **High Temperature Resistance:** Greater Oil-Out Survivability
- ✓ **High Hardenability:** Less Heat Treatment Distortion
- ✓ **Greater Corrosion Resistance:** Greater Operational Durability

Ferrium C61™ (AMS 6517)

is a 240 ksi UTS, 130 ksi-√in K_{IC} steel that can be case-hardened to 61 HRC for integrally-geared driveshafts, gears, etc.

- ✓ **Being qualified by Boeing for the CH-47 Chinook forward rotorshaft, achieving ~20% increase in power at same geometry**



Completed *Ferrium C61*
CH-47 Chinook Forward Rotor Shaft

Ferrium C64® (AMS 6509)

is a 229 ksi UTS, 85 ksi-√in K_{IC} steel that can be case-hardened to ~64 HRC for gears, driveshafts, actuators, etc.

- ✓ **Being evaluated by Bell Helicopter/U.S. Army** in Future Advanced Rotorcraft Drive System (FARDS) Program for transmission gears
- ✓ **Increased resistance to Single Tooth Bending Fatigue**
- ✓ **Race-proven, reducing pitting observed vs. 9310 components**



Ferrium C61
Ring and Pinion Set

Alloy Typical Properties	UTS (ksi)	YS (ksi)	Core Hardness (HRC)	Case Hardness (HRC)	Elong (%)	RA (%)	K _{IC} Fracture Toughness (ksi-√in)	Tempering Temp. (°F)
<i>Ferrium C61</i>	240	225	48-50	60-62	16	70	130	900
<i>Ferrium C64</i>	229	199	48-50	62-64	18	75	85	925
AISI 9310	175	155	34-42	58-62	16	53	85	300
Alloy X53	170	140	36-44	59-63	16	67	115	400

Commercially Available from Carpenter Technology  CARPENTER

Other New Alloys Under Ongoing Development:

- Nitridable stainless gear & bearing steel as upgrade from AMS 5930
- Low-cost, castable, high-strength Ti-6-4 mod
- Low-cost, defect-free single crystal Ni alloy for industrial gas turbine blades
- Thermally-stable Cobalt alloy (Be-free Copper Alternative) for bushings
- Wrought/castable high-strength, high toughness stainless steel (*Ferrium PH48S™*)
- Be-free, high strength Copper alloy (*Cuprium®* Alloy)
- Ductile, oxidation-resistant, high-temperature Molybdenum alloy
- Oxidation-resistant Niobium alloy
- Ductile Tungsten alloy