



Ferrium® C61™ Chemical Composition (nominal wt. %)

Fe	C	Co	Cr	Ni	Mo	V
Bal.	0.15	18	3.5	9.5	1.1	0.08

Overview of Ferrium® C61 Properties (typical)

YS (ksi)	UTS (ksi)	EI (%)	Core Hardness (HRC)	CVN (ft-lb)	K _{IC} (ksi√in)
225	240	15	48-50	50	130

Materials By Design® Objective

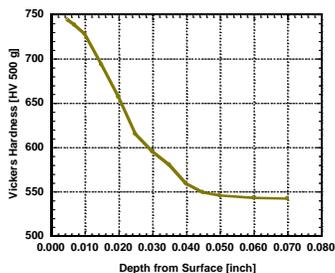
Advances in auto racing engine designs and increased engine power have caused an increase in the failure of dog rings, gears, camshafts, input shafts, racks and pinions. The design objective for *Ferrium*® C61 was to develop a high performance secondary-hardening gear and bearing steel with similar surface properties to conventional gear steels such as AISI 9310 and EN36C, but with the added benefits of an ultra high-strength core and excellent fracture toughness.

Description

Ferrium C61 is a member of a new class of martensitic secondary-hardening gear and bearing steels that utilize an efficient M₂C precipitate strengthening dispersion. Because of the efficiency of this strengthening dispersion, a superior combination of properties can be attained for a given application. *Ferrium* C61 was designed to provide carburized surface properties (60-62 HRC) similar to conventional gear steels such as AISI 9310 and EN36C with the added benefit of an ultra high-strength core along with excellent fracture toughness. A typical hardness profile of carburized *Ferrium* C61 is shown to the left.

Advantages

Ferrium C61 is targeted as a superior alternative to conventional gear materials such as AISI 9310 and EN36C for new smaller, lighter, high-temperature-resistant component designs, or to upgrade the material in an existing component where a re-design is not feasible. *Ferrium* C61 has surface-wear properties similar to those found in current commercial alloys, but provides an ultra high-strength, high-toughness, high-temperature-resistant core. Superior axial and STBF fatigue resistance data has also been demonstrated. *Ferrium* C61 can be particularly advantageous to reduce the size and weight of integrally-g geared driveshafts.





Alloy	Cycles to Failure
Ferrium C61	4.61×10^4
EN36C	4.00×10^4

Mean Coefficient of Thermal Expansion			
Temperature Range		Heat Treated Condition	
°C	°F	$10^{-6}/^{\circ}\text{C}$	$10^{-6}/^{\circ}\text{F}$
20-100	68-212	9.54	5.30
20-200	68-392	9.59	5.33
20-300	68-572	10.76	5.98
20-400	68-752	11.09	6.16
20-500	68-932	11.28	6.27

Processing

Ferrium C61 was designed for high-temperature carburizing. This allows solution heat treatment to be combined with the carburizing treatment and *Ferrium C61* is therefore quenched directly from the carburizing temperature. After quenching to room temperature *Ferrium C61* is subjected to liquid nitrogen immersion to assure a complete martensitic transformation. *Ferrium C61* is typically tempered at 900°F (482°C) and has excellent thermal resistance approaching this temperature. If desired, nitriding can be used in lieu of carburizing in order to achieve higher surface hardness. Using both nitriding and case carburizing may result in a brittle surface, resulting in sub-surface spalling initiation and significantly lower fatigue life; users should complete internal trials before considering this combination.

Case carburizing produces a gradient in the volume fraction of the M_2C carbides and results in an increase in hardness and surface residual compressive stress. The efficiency of the M_2C strengthening response allows this class of steels to achieve very high surface hardness with very low carbon content. Thus, this class of steels has the ability to achieve very high surface hardness without the formation of detrimental primary carbides. Final shot peening is recommended for superior fatigue performance.

Fatigue

Ferrium C61 alloy has the longest fatigue life of several materials evaluated and shows 15% enhancement over EN36C in a notch bending fatigue test. The sample is a Ford Research Lab design, incorporating 4-point loading and an approximately 0.050 inch notch root radius. All samples were finish ground and shot peened after heat treatment.

Product Forms

Ferrium C61 is manufactured in typical ingot, bar and billet forms.

Other

US Patent Number 6,176,946 B1.