Carbon. Carbon. Carbon. — The Secret to Understanding Steel

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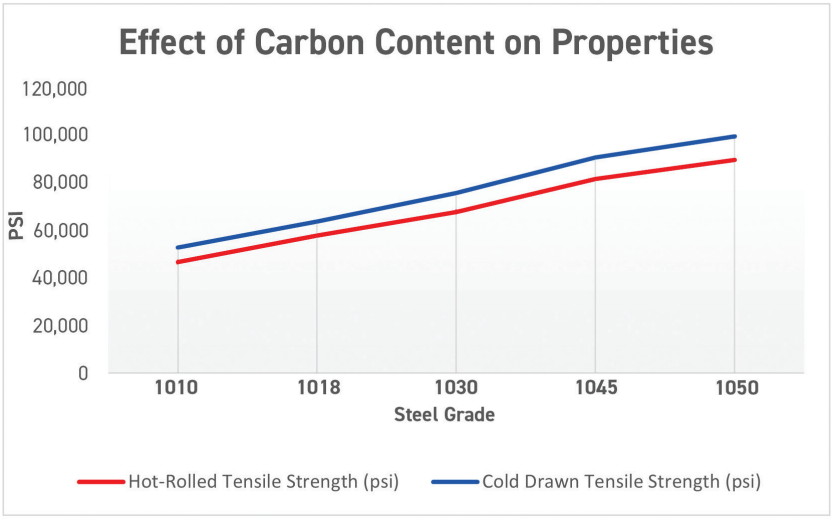
In the real estate industry, the secret to understanding how any property transaction will be priced is "Location. Location. Location." In order to understand steel, it is Carbon. Carbon. Carbon.

Carbon is, quite frankly, what makes iron "steel." Carbon is present in all steels and is the principal element responsible for the properties that can be developed by cold work and thermal treatment in particular hardness. The strength and hardness of hot-rolled steels increases as carbon content increases, especially in hypoeutectoid (medium and low carbon) steels. Just as the amount of carbon explains the increase in strength and hardness in these steels, the ductility and ease of welding declines as the amount of carbon increases in these grades. Carbon is the primary predictor of a steel's performance.



It's In The Grade

Carbon is so important an ingredient, its level is in the very name of the grade. Because carbon is the primary predictor or determinant of a steel's properties, it is no surprise that in the United States' traditional steel nomenclature system (AIS/SAE) the last two digits of a steel grade's 4-digit designation is the "mean carbon content" of that grade's permissible carbon range. For AISI/SAE grade 1010, the range is from 0.08-0.13 weight % (wt.%) and the nominal average carbon content is 0.10 wt. %. Thus the second "10" in grade 1010 is the expected center point of expected carbon content of 0.10 wt.% .

In 1045, the range of carbon permitted when melting the steel is 0.43-0.50 and the 0.45 wt.% is the nominal average of that range. Thus, the last two digits in grade designation 1045, "45" indicate the average carbon to be expected in that product.

In 1090, the range of carbon permitted when melting the steel is 0.85-0.98 and 0.90 is the nominal mean or average of that range. The last two digits in the AISI/SAE grade 1090 therefore, identify this steel as averaging 0.90 wt% carbon in the final product.

Having carbon in the grade descriptor of the steel makes it easy for us to understand, just by looking at the grades, that steels can be divided into groupings of similar expectations by carbon content. We classify the groupings as low (hypoeuctectoid), medium (eutectoid) and high (hypereutectioid) carbon steels. Including the average carbon content in the grade identifier is helpful for selecting steels as carbon is chiefly responsible for the differences in the performance of the grades.

Carbon provides the basis for microstructure, and microstructure provides the properties of the steel in use. In the plain carbon and alloy bar steels that are typical in our shops, the carbon makes up several different constituents —Martensite, a constituent

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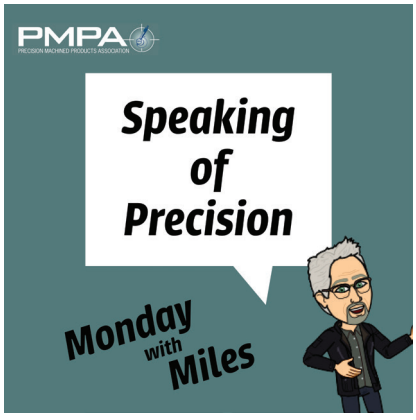

Industry expert, Miles Free III, talks precision machining. All episodes may be found on major platforms.

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that is supersaturated by carbon formed during rapid quenching from high temperatures and tempering treatments. Austenite is a solid solution of carbon in gamma phase iron; Cementite is an iron carbon compound- Fe3C. Pearlite is a structure that is a mixture of ferrite (almost pure iron) and the carbon containing constituent of cementite.

List of Steel Aspects Affected by Carbon

Hardness. Increases as carbon increases.
Hardenability. Increases as carbon increases.
Heat treat response. Increases as carbon increases.
Tensile strength. Increases as carbon increases.
Yield strength. Increases as carbon increases.
Microstructure. Increases of carbon increases volume fraction of carbon containing constituents.
Ductility. Decreases as carbon increases .
Weldability. Decreases as carbon increases.
Work hardening. Increases in carbon result in increased ability to work harden. PMPA

Miles Free III is the PMPA Director of Industry Affairs with over 40 years of experience in the areas of manufacturing, quality, and steelmaking. He helps answer "How?", "With what?" and "Really?" Miles' blog is at pmpaspeakingofprecision.com; email: mfree@pmpa.org; website: pmpa.org.