CRAFTSMAN'S CRIBSHEET

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A Quick Guide to the Chemical Elements Found in Steel

This handy quick guide will give you the common chemical elements found in steel, how they affect steel properties and the machining process and a few tips on how to deal with them.

CHEMICAL ELEMENT	SYMBOL	WHAT DOES IT DO FOR THE STEEL PERFORMANCE	WHAT DOES IT DO FOR MACHINING	WHAT STEPS TO TAKE WHEN YOU ENCOUNTER THIS
Carbon	C	Strengthens, hardens, makes heat treatable.	Improves up to ~0.23%. Gives steel its hardness.	Anneal if over 0.40% and alloy steel; if carbon steel and over 0.50%.
Manganese	Mn	Strengthens, hardens, enhances heat treatment.	Improves surface and machinability.	No special techniques needed. Promotes machining.
Phosphorus	P	Ferrite strengthener. Lowers ductility.	Crisps up chip. Improves surface finish.	Be careful with subsequent cold work on rephosphorized steels.
Sulfur	S	Lowers ductility, toughness, weldability, surface quality.	Controls built up edge (BUE), improves machinability about 25%.	Increase speeds and feeds. Is machinist's friend.*
Silicon	Si	Deoxidizer, makes steel sound. May degrade surface quality.	Abrasive on tools.	Want 0.01-0.02 max silicon in 12XX steels; 0.10 max Si for 11XX for best machinability.
Copper	Cu	Negligible in our applications.	Usually it is a clue about how steel is made.	Higher coppers tend to indicate electric furnace steel.
Nickel	Ni	Ferrite strengthener. Aids heat treatment.	Usually makes chips tough to separate.	Avoid dwell. Sharpen tools. Secure workholding.
Chromium	Cr	Corrosion resistance, high temperature strength and heat treatability.	Higher strength makes machining more difficult.	Can be abrasive. Pay attention to tool edges and wear.
Molybdenum	Mo	Increases hardenability, raises tempering temperatures.	Not noticeable.	No special precautions.
Aluminum	Al	Develops fine austenitic grain size. Can combine with nitrogen.	Decreases tool life.	Pay attention to tool edges and wear.
Lead	Pb	No effect on mechanical properties.	Promotes machinability about 25%.	Run at higher productivity. Take advantage of this.
Columbium (Niobium)	Cb / Nb	Grain refiner up to 0.05% in bars. Microalloy strengthener. Similar to Al as grain refiner.	As microalloy, makes material harder and tougher to machine.	Pay attention to tools, understand condition if microalloy.
Vanadium	Va	Grain refiner and strengthener. Microalloy in forging steels.	Decreases tool life. Harder steels more difficult to cut.	Pay attention to tools, understand condition if microalloy.
Bismuth	Bi	No strengthening effects. Possible embrittlement.	Improves machining. Substitute for lead.	Run at higher productivity. Take advantage of this.
Nitrogen	N	Strengthener and lowers ductility (notch toughness). Improves surface finish and promotes chipbreaking.	Crisper chip and improved surface finish.	Does not like to be cold worked. Avoid dwell, avoid in crimping applications.

** Sulfur: Plain carbon and alloy steels with sulfur below 0.010 wt % are problematic for machining and surface finish. 0.02 wt % minimum sulfur is optimum in these steels for machining.*

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