CRAFTSMAN'S CRIBSHEET

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Miles Free – Director of Technology and Research

☒ Technical ☐ Regulatory ☐ Quality ☐ Management

THREE KEY FACTORS TO UNDERSTANDING THE MACHINABILITY OF CARBON AND ALLOY STEEL

The machinability of steel bars is determined by three primary factors: Cold work, Thermal treatment, and Chemical composition.

1. **Cold work improves the machinability** of low carbon steels by reducing the high-ductility of the hot-rolled product. Cold-working the steel by drawing through a die or cold-rolling results in chips that are harder, more brittle and curled, producing less build-up on the tool's cutting edge. The improved yield-to-tensile-strength ratio means that your tools and machines have less work to do to get the chip to separate.

2. **Thermal treatment improves the machinability** of steel by reducing stresses, controlling microstructure and lowering hardness and strength. While this is usually employed in higher carbon steels, sometimes a Spheroidize Anneal is employed in very low-carbon steels to improve their formability.

   Stress Relief Anneal, Lamellar Pearlitic Anneal and Spheroidize Anneals are the treatments applied to improve machinability in bar steels for machining.

3. **Chemical composition is a major factor that contributes to the steel's machinability or lack thereof.** Chemical factors that promote machinability include:

   Carbon. Low carbon steels are too ductile, resulting in gummy chips and the build-up of workpiece material on the tool edge (BUE). Between 0.15 and 0.30 wt. percent carbon, machinability is at its best. Machinability decreases as carbon content increases beyond 0.30.

Sulfur combines with Manganese to form Manganese Sulfides, which help the chip to break and improve surface finish. In non-resulfurized steels, higher levels of sulfur are best for machining. Lead is added to steel to reduce friction during cutting by providing an internal lubricant. Lead does not alter the mechanical properties of the steel.

Phosphorus increases the strength of the softer ferrite phase in the steel, resulting in a harder and stronger chip (less ductile), promoting breakage and improved finishes.

Nitrogen can promote a brittle chip as well, making it especially beneficial to internal machining operations like drilling and tapping, which constrain the chip's movement. (Nitrogen also can make the steel unsuitable for subsequent cold-working operations like thread rolling, crimping, swaging or staking.)

Sometimes Bismuth, Selenium or Tellurium may be encountered as machining enhancers.