M-4 High Speed Steel

(AISI M4)

M4 was developed to utilize to a greater extent abrasion resistance that results from higher carbon and higher vanadium contents in the molybdenum-tungsten family of high speed steels. Although the grade is somewhat more difficult to machine in the annealed condition, and more resistant to grinding in the hardened condition than lower alloyed types, there are many applications that justify its use. It is recommended for heavy duty cutting operations, and also for tools requiring sharp edges for fine cuts. **M4** should always be used at or near maximum hardness.

Chemical Composition

Carbon	**1.30**
Manganese	**0.30**
Silicon	**0.30**
Chromium	**4.50**
Molybdenum	**4.50**
Tungsten	**5.50**
Vanadium	**4.00**

Typical Applications

Broaches, reamers, milling cutters, chasers, form tools, lathe and planer tools, and checking tools.

Physical Properties

Critical temperature – (on heating) 1545°F

Specific Gravity – 7.97

Coefficient of Thermal Expansion

100 - 500°F	5.32 x 10^{-6} in/in/°F
100 - 800°F	6.24
100-1000°F	6.64
100-1200°F	6.82
100-1500°F	6.99

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Forging

Heating for forging must be done slowly and uniformly, with care being taken not to put cold steel into a hot furnace. Soak through at 1700-1800°F and then heat to 1900-2050°F for initial forging. Do not forge below 1600-1700°F, and when forging is completed, cool slowly in lime, mica, dry ashes or furnace.

Annealing

Heat slowly to 1550-1600°F, hold until the entire mass is heated through, and cool slowly in the furnace (30°F or hour) to about 1000°F, after which the cooling rate may be increased. Suitable precautions must be taken to prevent excessive carburization or decarburization.

Strain Relieving

When desirable to relieve the strains of machining, heat slowly to 1150-1250°F, allow to equalize, and then cool in still air.

Preheat for Hardening

Warm slightly before charging into preheat furnace, which should be operating at 1350-1550°F.

Hardening

After thorough preheating, transfer to the hardening furnace, operating at 2150-2250°F, depending upon the degree of hardening required for the application, and the size of the tool.

Quenching

Cool in air, oil, or molten salt bath operating at 1000-1100°F. In the case of oil quenching, it is usually good practice to interrupt the quench by removing the tool after it has reached about 1000°F, and allow the cooling to continue in still air. Where a salt bath is used, the tool should be held only long enough to equalize at the bath temperature, and then should removed and cooled in air. Any necessary straightening should be done while cooling in the range of 850-450°F. Tools should be allowed to cool to 150°F, or to where they can be held in the bare hand, and then tempered immediately.

Tempering

The tempering temperature may be varied according to the desired harness, but is usually in the range of 1000-1100*F. Triple tempering is always recommended. The response to tempering is shown in the following chart.

Hardening Temp. Triple Tempered	**2200°F**	**2225°F**
800°F	62.8 RC	62.5 RC
850°F	63.3	62.8
900°F	64.0	63.6
950°F	64.8	65.0
1000°F	66.0	66.3
1025°F	66.1	66.6
1050°F	65.6	66.1
1100°F	63.3	64.0
1150°F	59.5	60.3
1200°F	56.0	56.8

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