Cincinnati Tool Steel Company
Phone #: (815) 226-8800 (800) 435-0717 Fax #: (815) 226-4388

AISI M2

Molybdenum-Tungsten High Speed

M-2 Is the most widely used type of high-speed steel and, in general, can be used for the same applications as T-1 high speed. Its higher carbon content and balanced analysis produce properties applicable to all general-purpose high-speed uses.

M-2 tool steel is used in practically all applications specified for T-1 high speed. These applications include lathe tools, planer tolls, drills, taps, reamers, breaches, milling cutters, form cutters, wood knives, gear cutters, and end mills.

Machinability - Like all highly alloyed steels, M-2 machines with somewhat more difficulfy than the lower alloyed steels. It is rated at 65 as compared to a 1-pct carbon tool steel, which is rated at 100.

Typical Analysis

Carbon 0.830	Chromium 4.150
Molybdenum 5.000	Vanadium 1.900
Tungsten 6.350	

Annealing

Annealing should always follow forging, preferably in controlled-atmosphere furnaces. If these are not available, pack-anneal in sealed containers using the protective material of your choice. Heat to 1600°F, thoroughly soak, then cool in the furnace at about 30 degrees per hour to 900°F and air-cool. Proper annealing should result in a hardness of Brinell 241 max.

Hardening

Harden M-2 by preheating slowly to 1550°F and holding until thoroughly soaked. Heat rapidly to 2250 to 2275°F Generally, total heating time in the furnace varies from a few minutes to a maximum of 15 minutes, depending on the size of the tool. Oil quenching from the hardening temperature is preferred for developing full hardness, although air quenching or quenching in hot salt or lead may be done.

When the tools have reached a temperature of 150 to 200°F in the quench, temper immediately. Precautions should be taken to prevent decarburization on tools which cannot be ground after hardening. For this purpose non-oxidizing furnace atmosphere or salt baths may be used.

Hardening – Cont.

Specimens 1 in. square x 2 in. long were held at various temperatures for three minutes and quenched in oil and in air with the following results:

Quenching	Oil-Quenched		Air-Quenched	
Temperature	Fracture	Rockwell	Fracture	Rockwell
(°F)	rating	C	rating	C
2000	9-1/2	62	9-1/2	61.5
2050	9-1/2	63.5	9-1/2	61.5
2100	9-1/2	64	9-1/2	63
2150	9-3/4	65.5	9-3/4	65
2200	9-3/4	66	9-3/4	65.5
2225	9-3/4	66	9-3/4	65.5
2250	9-3/4	66	9-3/4	65.5
2275	9-1/4	66	9-1/2	65
2300	8-1/2	66	9	64.5
2325	8-1/2	66	8-1/2	64.5
2350	7	65.5	8	64
2400	6	66	6	62

The effect of different holding times at a quenching temperature of 2250°F on 1-in. square specimens is shown in the following table. All pieces were oil-quenched.

	2250°F Oil-Quenched	
Holding time	Fracture	Rockwell
Minutes	rating	C
1	9-1/2	60.5
2	9-3/4	65.5
3	9-3/4	66
4	9-1/4	66.5
5	9	66.5
6	8-3/4	66.5
7	8-1/4	64.5
10	8	64.5
12	7-3/4	64.5
14	7-1/2	66.5

Tempering

The best tempering range for M-2 is 1000 to 1050°F. This results in the best combination of cutting ability, hardness, strength, and toughness. Tools are tempered by heating to the above temperature and holding for two hours per inch of greatest thickness, then cooling all the way to room temperature. It is customary to use a double-tempering operation on high-speed tool steels. This is carried out by a second heating to a temperature 25 to 50 degrees .below the first tempering operation. Tempering at higher temperatures will increase the toughness of tools at the expense of hardness. Therefore, hot-work and shock-resisting tools are usually tempered within a range of 1100 to 1200°F.

Test specimens 1 in. round x 2-1/2 in. long of M-2 steels were hardened in oil and still air at a temperature of 2250°F. After hardening, specimens were tempered for two hours at temperatures ranging from 300 to 1400°F. Specimens were then tested for Rockwell hardness. Treatment given the specimens and the hardnesses obtained are shown In the table below.

These results on 1-in. round specimens may be used as a guide in tempering tools to desired hardness. However, tools of heavy section or mass may be several points lower in Rockwell hardness for a given treatment.

Tempering	Oil-quenched	Air-quenched
temperature - °F	Rockwell C	Rockwell C
300	65	65
400	64	63
500	63	62.5
600	62.5	62.5
700	63	62.5
800	63.5	63.5
850	63.5	63.5
900	65	64
950	66	65
1000	66	65.5
1050	66	63.5
1100	64.5	61.5
1150	62	60
1200	53.5	53
1300	43	39.5
1400	33.5	34