Crucible Data Sheet

Crucible REX® M4 High Speed Steel

Issue #1

Carbon	**1.30%**
Manganese	**0.30%**
Silicon	**0.30%**
Chromium	**4.30%**
Vanadium	**4.00%**
Tungsten	**5.60%**
Molybdenum	**4.50%**

REX M4 is a special purpose high speed steel designed to give high wear resistance in tools. Its high vanadium and carbon content provide for high resistance to cratering and wear in cold work punches, die inserts, and cutting applications involving high speeds and light cuts. It is designed to give maximum performance working with abrasive materials, exhibiting better wear resistance than M2 or M3.

Typical Applications

- Punches
- Die Inserts
- Broaches
- Reamers
- Milling Cutters
- Chasers
- Lathe and Planer Tools
- Spade Drills
- Slitter Knives
- Shear Blades
- Roll Turning Tools
- Form Tools
- Taps

Note: The above are some *typical* applications. Your *specific* application should not be undertaken without independent study and evaluation for suitability.

Critical Temperature

Ac_1—1545F

Forging

Heat slowly and uniformly to 1900 to 2000F, soak long enough to insure thorough heat penetration. Reheat if temperature falls below 1700F. After forging, cool slowly in vermiculite or in a furnace.

Annealing

CRUCIBLE REX M4 must be annealed after forging and before rehardening. For full annealing heat uniformly to 1600F, hold at temperature for two hours, and cool slowly at 25F per hour maximum in the furnace to below 1000F. The steel may then be cooled in air if desired.

For cycle annealing*, heat to 1600F and hold at temperature for two hours, furnace cool to 1400F and hold at temperature for four to six hours. The steel may then be cooled in air if desired. Annealing in controlled atmosphere furnaces or with suitable protective media is recommended.

*Cycle (isothermal) annealing is most practical for applications in which full advantage may be taken of the rapid cooling to the transformation temperature, and from this temperature down to room temperature. Thus, for small parts which can be handled in salt or lead baths, or for light loads in batch type furnaces, cycle (isothermal) annealing makes possible large time savings as compared with the conventional slow furnace cooling. The method offers no particular advantage for applications such as batch annealing of large furnace loads in which the rate of cooling to the center of load may be so slow as to preclude any rapid cooling to the transformation temperatures. For such applications, the conventional full annealing method usually offers a better assurance of obtaining the desired microstructure and properties.

Hardening

In hardening REX M4 it is customary to use two furnaces. The first furnace is used to preheat to 1500F to 1550F, the second furnace

Note: Temperatures shown throughout this data sheet are metal temperatures.

is used to heat rapidly from the preheating temperature to the hardening temperature of 2150 to 2250F.

When a salt bath is used, the usual hardening temperature is 2125 to 2225F. The high temperature bath should not be overloaded (to the extent that cold charges cause a severe drop in bath temperature).

Vacuum hardening may be used for small sections, or when oil or pressure quench capabilities are available.

The high side of the hardening temperature range should be used for cutting tools. For cold work punch and die applications where increased toughness is required, the low side of the hardening temperature range should be used.

Quenching

Quench in oil, air or a salt bath maintained at 1000 to 1100F. When oil quenching is used, particularly for tools of large sections or complicated design, it is good practice to use an interrupted quench. The tools should be quenched in oil until they have reached approximately 1000 to 1100F (dull red). Then they should be removed from the oil and allowed to cool naturally in air.

When a salt bath is used, the tool is quenched into the bath and held just long enough to cool to the temperature of the bath It is then removed from the bath and allowed to cool naturally in air.

Salt bath quenching of large sections generally results in slightly lower hardness than an interrupted oil quench. No matter what method of quenching is used, the tool should be allowed to cool to a temperature below 150F or to a point where the tools can be held comfortably in bare hand.

Straightening

Any necessary straightening is best done from the quench at any temperature down to 400F.

Tempering

Temper immediately after quenching and cooling below 150F or as soon as the tool can be held comfortably in bare hands. The tempering temperature may be varied depending on the application and required hardness. Triple tempering is required. For example, heat to 1025F and hold for two hours, allow to cool to room temperature; reheat to 1025F, hold two hours, and again cool to room temperature; finally heat for a third time to 1025F, hold two hours, and cool to room temperature.

Hardness

Austenitized as shown below in a salt bath, held two minutes at heat, quenched in oil and tempered 2 + 2 + 2 hours at temperature indicated:

Tempering Temperature	Rc Hardness 2125F	Rc Hardness 2200F
As Quenched	64/66	64/66
1000F	63.5/65.5	64/66
1025F	63/65	64/66
1050F	62/64	63/65
1075F	61/63	62/64
1100F	59/61	61/63
1150F	56/58	58/60

Impact Toughness

REX M4

Hardening* Temperature	Temper**	Hardness	C-Notch Impact Strength
2200F	1025F	Rc65	8.5 Ft. lbs.
2125F	1050F	Rc63	11 Ft. lbs.

*Salt bath temperatures
**Triple tempered

Machining Data

Brinell 225/255
Approximately 30% of 1% Carbon Steel (W1)

Operation	Tool Width or Depth of Cut (in)	High Speed Tooling		Carbide Tooling	
		Speed (fpm)	Feed (in/rev)	Speed (fpm)	Feed (in/rev)
Turning—Single Point	.150	50	.015	250	.015
	.025	60	.007	310	.007
Drilling	1/4	30	.003		
	1/2	30	.005		
	1	30	.010		
	2	30	.013		
Broaching		5	.002		
Face Milling	.125	55	.007	240	.010
	.025	70	.005	320	.008
Cut Off	.062	35	.001	150	.002
	.125	35	.001	150	.003
	.250	35	.0015	150	.0045
Cutting Fluid		Sulfurized Oil—Light Duty		Water Soluble Oil	

Physical Properties

Modulus of elasticity in Tension (psi x 10^6) 31
Specific Gravity 7.97
Density (lbs./cu. in.) .... .286
Thermal Coefficient of Expansion (in/in/°F x 10^{-6})
100— 500F 5.32
100— 800F 6.24
100—1000F 6.64
100—1200F 6.82
100—1500F 6.99

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