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AISI S5

Silicon-Manganese-Moly-Vanadium Shock Resistant Steel

S5 was developed primarily for shock-resisting parts in which a combination of great ductility with hardness is required. Carbon tool steels with hardness under Rockwell C-60 cannot compare in shock-resisting properties with the alloy grades. S5 is primarily an oil hardening tool steel; intricate parts made of S5 are usually oil quenched. S5 may be quenched in water with satisfactory results, but care should be taken if the part has drastic sectional changes or sharp corners.

Uses - Hand and pneumatic chipping chisels, shear blades, caulking tools, beading tools, punches and all types of severe or unusual service, involving drastic and repeated impact at room temperatures.

Machinability - When annealed to Brinell 229 max, S5 machines without great difficulty. Where 1pct. carbon tool steel has a rating of 100, S5 is given a rating of 65.

Dimensional Stability - Although S5 is not classified as a non-deforming tool steel, it will hold size and shape reasonably well during heat-treatment, if normal precautions are used in its application and treatment. Where freedom from distortion is of primary importance, the tools should always be oil quenched rather than water quenched. S5 can be expected to expand 0.002 in./in.(+).

Impact Properties - To determine S5's resistance to impact, a series of tests were made with unnotched Charpy specimens 0.250 x 0.375 x 2 in. long. The specimens were rough-turned oversized, heat-treated and finished by grinding down to the standard size. Samples were oil quenched from 1600F and tempered at 100-degree intervals from 300 to 1000F. Although, S5 showed impact values above 40 ft-lb without tempering, all hardened tools made of this grade should be tempered.

Typical Analysis

Carbon 0.600	Manganese 0.700
Silicon 1.850	Molybdenum 0.450
Vanadium 0.200	

Annealing

Pack-annealing in sealed containers using inert materials is preferable because of the tendency of this steel to decarburize; otherwise controlled atmospheric furnaces may be used. Heat it slowly to a temperature of 1450°F, and hold one hour for each inch of greatest thickness.

To obtain best machining properties, the steel should be cooled slowly to 1000°F. Careful annealing should result in a hardness of Brinell 229 max.

Hardening

S5 is primarily an oil hardening grade; however, it hardens satisfactorily by water quenching when the design is not too intricate. Hardening temperature for both oil and water quenching is 1600°F. Holding time at hardening heat should be just sufficient for uniformity of temperature; holding time should not exceed a half-hour per inch of thickness because of the danger of excessive decarburization. After quenching, temper immediately.

Fracture grain size a Rockwell C hardness of S5 specimens 3/4-in. diameter by 5 in. long, quenched in oil and quenched in water at various temperatures, were as follow:

Oil Quench

Quenching Temperature - °F	Fracture rating	Rockwell C
1450	8	49
1500	9-1/2	55
1550	9-1/2	61
1600	9-1/2	64
1650	9	63

Water Quench

Quenching Temperature - °F	Fracture rating	Rockwell C
1450	8	51
1500	9	59
1550	9-1/2	64
1600	9-1/2	65
1650	9-1/2	65

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Tempering

Normal tempering procedure for S5 is to hold at temperature for at least two hours for each inch of greatest thickness. Tempering temperatures should be between 400 and 650°F, depending on the service desired. The resulting Rockwell C hardnesses for oil and water quenching and tempering from 300 to 1300°F by 100-degree intervals are as follows:

Tempering	1600°F	1600°F
Temperature	Oil quench	Water quench
°F	Rockwell C	Rockwell C
300	63	63
400	61	61
500	60.5	60
600	59	59
700	57.5	57.5
800	53	53.5
900	51	51
1000	49	48
1100	47	45
1200	40.5	40
1300	33.5	33

These results may be used as a guide in tempering tools to desired hardness. However, since 3/4-in.diameter specimens were used in this test, tools of heavy section or mass may be several points lower in Rockwell hardness for a given treatment.
