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AISI S1

Chrome-Tungsten Shock Resistant Steel

AISI S1 is a versatile chrome-tungsten shock-resisting tool steel. Its properties provide excellent service in both cold and hot work shock applications. In addition, it is widely used for master hobs.

It's low carbon content provides toughness and its combination of alloying elements provides the carbide formation necessary for abrasion resistance, the hardenability necessary for shock tools, and improved hot work characteristics.

For additional wear resistance, tools of SI may be carburized during pack hardening.

Uses - Heavy duty blanking and forming dies, punches, chisels, shear blades, slitter knives, cold striking dies, cold extrusion tools, coining dies, master hobs.

Hot work applications with operating temperatures under 1050F such as headers, piercers, forming tools, shear blades, and drop forge die inserts.

Machinabilty - In the annealed condition S1 has a machinability rating of 75 as compared with a rating of 100 for a 1pct carbon tool steel.

Dimensional Stability - When oil-hardened, S1 can be expected to expand approximately 0.002 in./in. of greatest cross section.

Typical Analysis

Carbon 0.500	Chromium 1.250
Chromium 0.750	Tungsten 2.250
Vanadium 0.200	Manganese 0.300

Annealing

S1 can be softened to proper structure for machining by heating slowly to 1450 to 1500°F, holding at temperature for at least one hour per inch of greatest thickness, and cooling slowly to 1000°F, after which it may be air- cooled. Hardness resulting from this treatment will be Brinell 212 max. To prevent decarburization, pack or pipe-anneal in sealed containers, using inert material or use a controlled atmosphere furnace.

Hardening

Preheat to 1200°F. Then heat to 1750°F for quenching and hold at temperature for a half-hour for each inch of greatest thickness. Tungsten chisel steels are susceptible to decarburization on hardening and, therefore, precautions should be taken to minimize surface deterioration. It is advisable to protect the surface by using vacuum heating, neutral salt bath or atmosphere furnaces. If these are not available, pack hardening in spent pitch coke or similar material should prove adequate. Preheating at approximately 1200°F serves to minimize the subsequent time at hardening temperature, which also helps to reduce decarburization.

S1 is one of the most commonly used grades for master hob applications. Master hobs require a steel that has a very high toughness and at the same time a surface of almost file hardness. This can be achieved by carburizing and hardening from 1750°F. Use new carburizing compound to preserve the hob surface and to obtain maximum surface hardness. Aim for a case depth of .010 in. Avoid deep carburized cases (.015 or greater) which could cause brittle failures. Oil quenching can be conducted directly from the carburizing temperature. Temper at 350°F immediately after oil quenching. This carburizing treatment should result in a shallow file hard case of approximately HRC 61 and a tough core of approximately HRC 57.

Though primarily an oil-hardening grade, S1 can also be hardened by quenching In water from 1700°F, provided the section is not intricate. Water-quenching increases the hardness but likewise increases the amount of distortion.

The Rockwell C hardness and fracture grain-size of S1 specimens 1-in. square, quenched in oil after holding one hour at various temperatures, are as follows:

Oil Quench		
Quenching	**Fracture**	
Temperature - °F	**rating**	**Rockwell °C**
1550	9-1/2	56.5
1600	9-1/2	57.5
1650	9-1/2	58.5
1700	9-3/4	59.5
1750	9-3/4	61
1800	9	60
1850	7-3/4	59

Tempering - Next Page

Tempering

The tempering temperature of S1 varies with the intended use of the steel. For hot-work tools the range may be within 1000 to 1200°F, and for cold-work tools-the range may be between 300 and 500°F. Hold at temperature a minimum of one hour for each inch of thickness.

Specimens 1in. diameter by 5 in. long were quenched in oil from 1750°F and tempered at 100 degree intervals from 300 to 1200°F for one hour. Hardness results were as follows:

	1750°F
Tempering	**Oil-quench**
Temperature - °F	**Rockwell C**
None	61
300	57.5
400	56.5
500	54
600	53
700	52
800	50
900	48
1000	47
1100	47
1200	42

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.
