**AISI H13**

**Hot Work Tool Steel**

**Typical Analysis**

Carbon 0.40; Chromium 5.00; Silicon 1.00; Molybdenum 1.25; Vanadium 1.00

**Advantages**

Superior red hardness

High resistance to heat checking

Excellent resistance to thermal shock

Good size stability

Excellent hardenability

**Applications**

Although AISI H13 originally was designed for aluminum die casting dies its well balanced mechanical properties make it suitable for a wide variety of hot work applications and also some cold work applications such as cold header die castings. This grade is especially suited to hot work requirements where drastic water cooling is used and both high red hardness and resistance to heat checking are crucial.

Typical applications for AISI H13 include aluminum and zinc die cast dies, hot extrusion tooling, forging die inserts, hot gripper and header dies, shear blades, and plastic molds.

**Thermal Treatment Summary**

**Critical Points**

 Heating (Ac) - 100⁰F/Hr. – begins 1544⁰F, ends 1634⁰F

 Cooling (Ar) - 50⁰F/Hr. – begins 1472⁰F, ends 1418⁰F

**Forging** – 2000 to 2100⁰F, stop at 1600⁰F, cool slowly

**Annealing** – 1525 to 1625⁰F, furnace cool to 1000⁰F, air cool, BHN 229 max

**Stress Relieving** – 1100 to 1250⁰F, furnace cool to 1000⁰F, air cool

**Preheating** – 1400 to 1500⁰F prior to hardening

**Hardening** – 1825 to 1850⁰F, air quench to 150⁰F

**Tempering** – 1050 to 1150⁰F, Rc 46-52

**FABRICATION**

**Forging**

Heat slowly to about 1500⁰F and more rapidly to the forging range of 1900-2100⁰F. Do not hot work below 1500-1600⁰F. After forging, allow to cool slowly, preferably buried in lime, or other insulating material. It is desirable to anneal soon after forging.

**Annealing**

Heat slowly to 1525-1625⁰F, hold until uniformly soaked, then furnace cool to about 1000⁰F at a rate not exceeding 30⁰F per hour. Then air cool. The use of a controlled atmosphere or vacuum furnace or pack annealing in a sealed container with neutral packing compound is advisable to prevent detrimental surface condition. Annealed hardness range from the above cycle should be Brinell 201-229.

**Stress Relieving**

To achieve better size stability during hardening, it is advisable to stress relieve AISI H13 after rough machining (to within about 1/8” of final dimensions). Heat slowly to 1100-1250⁰F, allow to equalize, furnace to cool to 1000⁰F and then air cool. Finish machining to near final dimension should then be conducted prior to hardening.

**Machinability**

The machinability of AISI H13 is rated at 70 as compared to 1% carbon tool steel which is rated at 100.

**HEAT TREATMENT**

**Hardening**

For most AISI H13 requirements an austenitizing temperature of 1825-1850⁰F followed by a still air quench is recommended to accomplish optimum dimensional stability as well as safety in hardening. Soaking time at high heat should be a minimum of 30 minutes time at temperature for the first inch plus 20 minutes for each additional inch of maximum block thickness. Preheating should be performed in the range of 1400-1500⁰F making certain that the tooling is uniformly soaked at preheat temperature. (With large and/or more intricate tooling an initial preheat in the range of 1100-1250⁰F is suggested in addition to the 1400-1500⁰F preheat). Following austenitizing the parts should be air cooled below 150⁰F or to hand warmth prior to tempering.

Die casting dies or other critical tooling should be hardened in a controlled atmosphere or vacuum furnace to insure clean surface within the die impression as well as minimum decarburization. If such facilities are not available pack hardening in a sealed container with a neutral packing compound can be used.

**Tempering**

Tempering of AISI H13 is usually performed within the range of maximum secondary hardness or higher. Reference to the accompanying tempering series chart gives approximate hardness to be obtained from relatively small specimens. Consideration should be given to the somewhat lower hardness expected from larger sections as shown in the 4” cube tempering series for this grade.

All hot work steel should be tempered at a minimum of 50⁰F above the maximum operating temperature of the tooling. Double tempering of AISI H13 is considered mandatory and the second temper should always be performed at about 25⁰F lower than first temper. Holding times at tempering temperature should vary from 2 hours at temperature for small tools (not over 1 inch in cross section) to several hours (at least 1 additional hour per additional inch of cross section) on larger sections. On the initial temper blocks should not be charged into a tempering furnace held higher than 500⁰F max. to allow for equalization in the furnace and gradual coming up to the tempering temperature. Such practice will avoid excessive thermal shock accompanied by possible cracking and distortion.

**Hardening Series**

Test pieces 1 inch round by 2 inches long cut from annealed bars were held 6 minutes at the indicated hardening temperatures and cooled in still air. Hardnesses were noted and grain size determined according to the Shepherd standards.

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| **Air Quenched** |
| 1750 | 48.5 | 8 |
| 1800 | 50.5 | 8 ½ |
| 1850 | 52.5 | 8 ½ |
| 1900 | 54.0 | 9 |
| 1950 | 54.5 | 9 |
| 2000 | 55.0 | 8 ½ |
| 2050 | 56.0 | 8 |
| 2100 | 57.0 | 8 |

|  |  |
| --- | --- |
| **Single Tempered 2 hours** | **Air cooled from** |
| **1800⁰F** | **1850⁰F** | **1900⁰F** | **1950⁰F** |
| As Quenched | 50.5 Rc | 52.5 Rc | 54.0 Rc | 54.5 Rc |
| 600⁰F | 50.0 | 52.0 | 52.5 | 53.5 |
| 700 | 50.0 | 52.0 | 53.0 | 53.5 |
| 800 | 50.5 | 52.0 | 53.5 | 54.0 |
| 900 | 52.0 | 53.0 | 54.5 | 55.0 |
| 1000 | 53.0 | 54.5 | 55.5 | 56.5 |
| 1100 | 50.5 | 53.5 | 54.5 | 55.5 |
| 1200 | 40.0 | 42.5 | 44.0 | 46.0 |

**Hardening Large Sections**

|  |  |
| --- | --- |
| **Temperature Tempering ⁰F** | **Hardness Rockwell C** |
| **Air Cooled** | **Oil Quenched** |
| None | 53.5 | 53.5 |
| 1000 | 55.0 | 55.0 |
| 1100 | 47.5 | 48.5 |
| 1125 | 43.0 | 44.0 |
| 1150 | 39.5 | 40.5 |
| 1175 | 37.5 | 38.5 |
| 1200 | 36.5 | 38.5 |
| 1300 | 26.5 | 26.5 |

Samples 4 by 4 by 4 inches were ground on two saw-cut ends and preheated at 1500⁰F for 1 hour. They were then hardened in a controlled atmosphere furnace at 1850⁰F for 1 hour. After 1 block was air cooled and the other oil quenched, they were tempered consecutively for 3 hours at each of the indicated temperatures.

**DIMENSIONAL STABILITY**

Since AISI H13 is a strong air hardening steel it is capable of exceptionally good size stability. When properly hardened (at 1850⁰F) and tempered, this material normally will show slight growth, not exceeding .001” per inch of cross section. As mentioned earlier stress relieving AISI H13 after rough machining is recommended to avoid distortion during heat treatment.