**AISI D2**

**High Carbon High Chromium Die Steel**

**Typical Analysis**

Carbon 1.50; Manganese 0.40; Silicon 0.30; Chromium 12.00; Molybdenum 0.80; Vanadium 0.90

**Advantages**

Very high wear resistance

Excellent size stability in heat treatment

Deep hardening in air

**Applications**

Use for cold work assignments requiring very long runs and close tolerances. Ontario is especially suited for tooling calling for high compression strength along with optimum dimensional control during hardening. Typical uses include blanking, stamping and cold forming dies where emphasis is not on toughness, slitters, punches, thread rolling dies and trim dies.

**Thermal Treatment Summary**

**Critical Points**

 Heating (Ac) - 100⁰F/Hr. – begins 1499⁰F, ends 1553⁰F

 Cooling (Ar) - 50⁰F/Hr. – begins 1418⁰F, ends 1373⁰F

**Forging** – Heat slowly to 1900/2000⁰F, stop at 1650⁰F, cool slowly

**Annealing** – 1600 to 1650⁰F, furnace cool, BHN 248 max

**Stress Relieving** – 1100 to 1200⁰F, air cool

**Preheating** – 1200 to 1300⁰F, prior to hardening

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

**Tempering** – 350 to 450⁰F Rc 60-62

 900 to 1000⁰F Rc 57-59

**FABRICATION**

**Forging**

Preheat very slowly and allow ample time for bringing up to temperature of about 1200-1300⁰F. Hold at this temperature until uniformly heated; then bring up to a temperature of 1900-2000⁰F. Hold only long enough to heat the steel through before the forging operation is started. Discontinue forging and reheat the steel before it cools to a temperature of 1600-1650⁰F. After forging, allow to cool very slowly, preferably burying in ashes, mica, lime or some similar material. In all cases, annealing is recommended after the forging operation and before hardening.

**Annealing**

The annealing temperature range is 1600-1650⁰F. For most reliable surface protection, annealing should be performed in an atmosphere or vacuum furnace. If such facilities are not available, the parts should be packed in a tight container with a neutral compound such as spent pitch coke or sand/charcoal mixture surrounding the work. The container should then be slowly heated to the annealing temperature and its contents soaked for several hours. Cooling should follow at a rate not to exceed 50⁰F per hour to about 1000⁰F before increasing the cooling rate.

The fully annealed hardness of Ontario should be approximately 212-248 Brinell.

**Machinability**

Ontario can be machined readily in the fully annealed condition. Its machinability rating is about 50% of annealed 1% carbon tool steel.

**Grindability**

As would be expected from its high wear resistance, Ontario D2 is not as easy to grind as lower alloyed tool steels. It has a grindability index of 3.0\* when hardened and tempered to full working hardness.

\* courtesy of Norton Company

**HEAT TREATMENT**

**Hardening**

In order to prevent decarburization, Ontario should be hardened in a neutral furnace environment, preferably in a controlled atmospheric or vacuum furnace, or salt bath. After preheating at 1200-1300⁰F, the work should be brought to 1800-1850⁰F and be allowed to soak thoroughly at high heat. Parts should be cooled in still air to 150⁰F or lower. If he above hardening furnaces are not available, pack hardening in spent pitch coke or other carbonaceous material may be used to provide surface protection.

**Tempering**

Do not temper until the steel is cool enough to hold comfortably in hand. Tools not subject to any appreciable shock or for working on thin gage material can be tempered as low as 300-450⁰F to hardness of 61-63 Rockwell C. Tools subject to considerable shock or for working on heavy material should be tempered at 900-1000⁰F to 56-58 Rockwell C. In the latter case, double tempering is essential. Allow at least 1 hour per inch of thickness, and preferably not less than 1 hour even if very thin. Longer tempering may be beneficial.

When applied to limited hot work applications, Ontario should be double tempered within the secondary hardening range (900-1000⁰F) or at a temperature at least 100⁰F above the operational temperature.

**Hardening and Tempering Series**

Samples 1” round by 2” long were preheated 10 minutes at 1200⁰F, transferred to the hardening surface, held 20 minutes at temperature, and air cooled. Samples were tempered cumulatively at the indicated temperature and quenched in air.