

O1 Oil Hardening Tool Steel – Technical Material Specification

1.0 Material Overview & Common Uses

O1 is a high-carbon, oil-hardening tool steel (AISI/SAE grade O1) known for its excellent dimensional stability during heat treatment, good wear resistance, and moderate toughness. It is a cold-work tool steel that hardens when quenched in oil, minimizing distortion and cracking compared to water-hardening grades.

Common industrial applications include: blanking dies, forming dies, punches, shear blades, gauges, jigs, fixtures, and woodworking tools. O1 is also used for master gauges and precision components where minimal size change after heat treatment is critical.

2.0 Core Technical Properties & Sizing

- Density: 7.85 g/cm³ (0.284 lb/in³)
- Hardness (annealed): 190–220 HB (Brinell)
- Hardness (hardened & tempered): 58–62 HRC (Rockwell C) typical
- Melting point: approximately 1425°C (2600°F)
- Thermal expansion coefficient: 11.5×10^{-6} /°C (20–200°C)
- Standard stock forms: round bar (diameter 1/8" to 12"), flat bar (thickness 1/16" to 6", width up to 24"), square bar, and plate
- Length tolerances: ±1/8" on standard 12' lengths; custom lengths per ASTM A681
- Diameter tolerance (ground finish): ±0.0005" for precision-ground stock; ±0.002" for hot-rolled annealed
- Flatness tolerance (plate): 0.005" per foot maximum deviation
- Chemical composition (nominal wt%): C 0.90, Mn 1.20, Cr 0.50, W 0.50, Si 0.30, V 0.20, balance Fe

3.0 Processing, Machinability & Application

O1 tool steel is readily machinable in the annealed condition (190–220 HB) using conventional high-speed steel (HSS) or carbide tooling. It responds well to grinding, turning, milling, and drilling. After heat treatment, grinding or EDM is required due to high hardness.

- Turning (annealed): Use HSS tools at 80–120 SFM with 0.010–0.020 IPR feed; carbide tools at 200–300 SFM with 0.005–0.015 IPR feed
- Milling (annealed): Use 4-flute carbide end mills at 150–250 SFM, chip load 0.002–0.005 inch per tooth, depth of cut up to 0.100"
- Drilling (annealed): Use HSS or cobalt drills at 50–80 SFM, peck cycle recommended for holes deeper than 3× diameter
- Grinding: Use aluminum oxide or CBN wheels; avoid overheating to prevent surface cracking
- Heat treatment: Preheat at 650°C (1200°F), austenitize at 790–815°C (1450–1500°F), quench in warm oil (50–70°C), temper at 175–260°C (350–500°F) for desired hardness
- Welding: Not recommended for hardened O1; if necessary, use preheat (300–400°C) and post-weld stress relief with low-hydrogen electrodes (e.g., AWS E7018)

- EDM: Suitable for hardened O1; use dielectric oil and avoid excessive current to prevent recast layer cracking

4.0 Common Defects & Quality Control

- Reject if surface decarburization depth exceeds 0.010" per side on precision-ground stock
- Reject if visible cracks or seams are present under 10× magnification after magnetic particle inspection
- Reject if hardness variation exceeds ± 5 HB across a single bar (annealed condition)
- Reject if out-of-round exceeds 0.003" for ground round bars
- Reject if flatness deviation exceeds 0.010" over 12" length for plate stock
- Reject if surface pitting or scale exceeds 0.005" depth on hot-rolled annealed stock
- Reject if chemical composition deviates from ASTM A681 limits (e.g., carbon below 0.85% or above 0.95%)
- Reject if non-metallic inclusions (Type A, B, C, D) exceed ASTM E45 rating of 2.0

5.0 Storage, Handling & WHMIS Guidelines

- Store in a dry, indoor environment with relative humidity below 60% to prevent rust; apply light oil or VCI paper for long-term storage
- Shelf life: indefinite if stored properly; inspect for corrosion every 6 months
- FIFO protocol: rotate stock by heat lot number to ensure traceability and consistent heat treatment response
- WHMIS classification: Not classified as hazardous under GHS in solid form; grinding dust and welding fumes may contain respirable particles (CAS 7439-89-6 iron, 7440-47-3 chromium)
- Mandatory PPE during machining/grinding: safety glasses with side shields, hearing protection, and dust mask (N95) for airborne particles; cut-resistant gloves when handling sharp edges
- Welding fume control: use local exhaust ventilation; avoid inhalation of chromium and manganese oxides (PEL 0.5 mg/m³ for Cr, 5 mg/m³ for Mn)
- Spill procedure: sweep up solid chips; do not wash into drains; dispose as scrap metal per local regulations
- First aid: for skin contact with cutting fluids, wash with soap and water; for eye contact, flush with water for 15 minutes

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