

Cold Heading & Cold Forging Steel Selection: Low-Carbon, Medium-Carbon, Alloy & Boron Steels Compared

Steelmet Industries - Bright Bars, Alloy Steels, Free Cutting Steels, Stainless Steels

Description

In high-speed cold heading and cold forging, the wrong steel grade does not just produce a weak fastenerâ??it cracks bolt heads on the first blow, destroys tungsten carbide dies prematurely, or distorts beyond tolerance during post-forging heat treatment. Yet many buyers still specify wire rods or cold-drawn bars purely by target tensile strength without accounting for **work-hardening rate, spheroidize annealing requirements, or boron hardenability**.

Whether you are manufacturing automotive wheel bolts, socket head cap screws, structural anchor studs, or cold-extruded pins, selecting between **low-carbon CHQ (Cold Heading Quality) steels, medium-carbon steels, alloy steels, and boron steels** determines both your die life and your final component cost.

At **Steelmet Industries**, we supply precision cold-drawn bright bars, wire rods, and spheroidize-annealed bars tailored for cold forming and fastener production. Below is a practical metallurgical comparison to help you match the right grade to your forming severity and fastener property class.

Why Cold Heading Demands Specialized Steel Metallurgy

Unlike hot forging, cold heading deforms steel at room temperature under extreme compressive and shear stressesâ??often achieving cross-sectional area reductions of **50% to 75%** in multi-station progressive headers. To survive this without shear cracking, the steel requires:

- **Low Yield-to-Tensile Ratio & Low Work-Hardening Exponent (*n*-value):** Minimizes forming tonnage and keeps die cavity pressures within safe limits.
- **Aluminum-Killed Fine Grain Structure:** Prevents strain aging and ensures uniform plastic flow across upset heads and extruded shanks.
- **Surface Seam & Decarburization Control:** Even a 0.05 mm surface seam on a hot-rolled rod opens into a visible split during head upsetting.

- **Spheroidized Carbide Microstructure (for Medium-Carbon & Alloy Grades):** Breaks up hard lamellar pearlite into soft globular carbides before heading.

The 4 Steel Families Used in Cold Heading & Cold Forging

1. Low-Carbon Steels (SAE 1006, SAE 1008, SAE 1010, SAE 1018)

Low-carbon CHQ steels (0.06% to 0.20% C) are the baseline choice for rivets, machine screws, sheet-metal fasteners, and ISO Property Class **4.6, 4.8, and 5.8** bolts. Because ferrite dominates their microstructure, they cold-head easily in the as-drawn or annealed condition without spheroidizing.

- **Strengths:** Lowest forming force, longest punch and die life, excellent cold extrudability, and easy weldability.
- **Limitations:** Cannot be through-hardened by quenching and tempering. For wear-resistant pins or self-tapping screws, parts must be case-carburized or carbonitrided after forming.

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2. Medium-Carbon Steels (SAE 1035, SAE 1038, SAE 1045 / EN8 / C45)

Medium-carbon steels (0.32% to 0.50% C) are the traditional workhorses for **ISO Property Class 8.8** and **SAE Grade 5** high-tensile bolts, studs, and automotive suspension fasteners.

- **Strengths:** Achieves 800 to 1000 MPa tensile strength after oil or polymer quenching and tempering, with reliable fatigue resistance.
- **Pain Points & Limitations:** In the as-rolled state, hard pearlite colonies cause high heading loads and rapid die wear. Complex head geometries (such as flange bolts or hex-socket heads) require expensive **spheroidize annealing** before cold drawing, plus higher austenitizing temperatures and aggressive quenching that increase distortion risk.

3. Boron Steels (SAE 10B21, SAE 15B25, 19MnB4, 20MnB4, 27MnB4)

Boron steels have transformed modern automotive fastener manufacturing. By adding just **0.0005% to 0.003% (5 to 30 ppm) of soluble boron**â??protected by titaniumâ??to a low-carbon manganese base (0.18% to 0.28% C), metallurgists achieve the hardenability of a 0.40% carbon steel while retaining the soft cold-formability of a low-carbon steel.

- **Strengths:** Forms with 15% to 25% lower heading tonnage than SAE 1035/1038, frequently eliminates pre-heading spheroidize annealing, reduces quench cracking, and delivers uniform core hardness for **ISO Class 8.8 and 10.9** bolts.
- **Pain Points & Limitations:** Requires strict steelmaking control (titanium or aluminum must tie up free nitrogen, otherwise boron forms inactive boron nitride and fails to harden). Also susceptible to temper embrittlement if tempered between 250Â°C and 400Â°C.

4. Alloy Steels (SAE 4135, SAE 4140 / EN19, SAE 8620, 34CrMo4, 42CrMo4)

Chromium-molybdenum and nickel-chromium-molybdenum alloy steels are mandatory for critical safety fastenersâ??**ISO Property Class 10.9 and 12.9**, **ASTM A193 B7** studs, connecting rod bolts, and heavy-section bolts above M20 where boron steels lack deep hardenability.

- **Strengths:** Deep hardenability across thick cross-sections, superior resistance to hydrogen-induced delayed fracture (critical for Class 12.9), and high elevated-temperature creep strength.
- **Pain Points & Limitations:** Highest raw material cost and highest flow stress. Virtually always requires full spheroidize annealing before cold heading and careful atmosphere control during heat treatment to prevent surface decarburization.

Head-to-Head Comparison for Cold Heading & Fastener Production

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Parameter	Low-Carbon Steels (SAE 1010 / 1018)	Boron Steels (10B21 / 20MnB4)	Medium-Carbon Steels (SAE 1035 / EN8)	Alloy Steels (4135 / 4140 / EN19)
Nominal Carbon %	0.08% â?? 0.20%	0.18% â?? 0.28%	0.32% â?? 0.45%	0.33% â?? 0.44%
Cold Formability / Upsetting	Excellent (Up to 75% area reduction)	Very Good (60% â?? 70% reduction)	Moderate (Requires annealing for severe heads)	Fair to Moderate (Spheroidized anneal mandatory)
Die Wear & Heading Tonnage	Lowest	Low to Moderate	Moderate to High	Highest
Pre-Heading Spheroidize Anneal	Not Required	Often Not Required (Simple/medium heads)	Required for complex heads	Mandatory
Target Fastener Property Class	ISO 4.6, 4.8, 5.8 (or Case-Hardened)	ISO 8.8, 10.9 (Up to ~M20)	ISO 8.8, SAE Grade 5	ISO 10.9, 12.9, ASTM A193 B7 (>M20)
Quench Distortion & Cracking Risk	N/A (Not through-hardened)	Low (Lower carbon martensite)	Moderate to High (Water/polymer quench)	Low to Moderate (Oil quench)

Common Cold Heading Shop-Floor Pain Points & How to Prevent Them

1. Shear Cracking at 45Â° on Bolt Heads

Root Cause: Exceeding the steelâ??s maximum reduction ratio in a single blow, or using unannealed medium-carbon/alloy bar where lamellar pearlite cannot flow around tight die radii.

Fix: Switch from as-drawn SAE 1038 to spheroidize-annealed stock, or transition to a boron grade like **10B21 / 20MnB4** to lower flow stress.

2. Longitudinal Splits Along the Shank

Root Cause: Rolling laps, seams, or non-metallic inclusions present in commercial hot-rolled rod.
Fix: Specify certified **Cold Heading Quality (CHQ)** or peeled/shaved bright bar feedstock with eddy-current or ultrasonic surface defect testing.

3. Soft Core After Quenching Large-Diameter Bolts

Root Cause: Using boron steel (e.g., 10B21) on diameters above 20â??24 mm. Boron increases surface and shallow hardenability, but lacks the deep core hardenability of chromium and molybdenum.
Fix: Upgrade to **SAE 4135 or 4140 (EN19)** for larger diameters and heavy structural fasteners.

4. Thread Rolling Die Chipping

Root Cause: Excessive work hardening after head upsetting or decarburized/irregular surface hardness on cold-drawn bars.
Fix: Control the final cold-drawing skin pass reduction (typically 5% to 12% after annealing) to maintain consistent surface hardness and tight ISO h9/h10 diameter tolerance.

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How to Choose the Right Grade for Your Component

- **Choose Low-Carbon (SAE 1008 / 1010 / 1018):** For rivets, pins, low-tensile bolts (Class 4.8/5.8), and case-hardened self-drilling screws where maximum die life is priority #1.
- **Choose Boron Steel (10B21 / 15B25 / 20MnB4):** For high-volume Class 8.8 and 10.9 automotive bolts (up to M20) where eliminating spheroidize annealing and reducing die wear cuts per-part cost.
- **Choose Medium-Carbon Steel (SAE 1035 / EN8 / C45):** When customer drawings explicitly prohibit boron additives (common in certain oil & gas, railway, and welded stud specifications) or when induction hardening is required.
- **Choose Alloy Steel (4135 / 4140 / EN19):** For Class 12.9 fasteners, large-diameter bolts (>M20), high-temperature studs, and safety-critical drivetrain bolts.

Explore how our precision bars support fastener, automotive, and engineering manufacturing on our Uses & Applications page, or review cross-standard equivalents on our Steel Grade Cross-Reference guide.

Source Cold Heading & Fastener-Grade Steel from Steelmet Industries

Steelmet Industries supplies tested Cold Drawn Bright Steel Bars, annealed bars, and hot-rolled rounds across low-carbon, medium-carbon, alloy, and boron steel specifications. Every lot is backed by full chemical and mechanical certification under our Quality Policy.

Discuss Your Fastener or Cold-Forging Requirement:
Corporate Website: www.steelmet.in
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