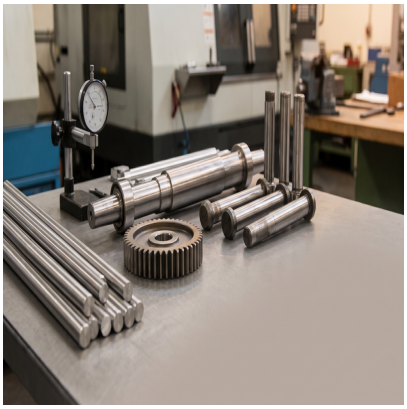


Case Hardening vs. Induction Hardening vs. Through Hardening: Steel Grade & Heat Treatment Guide

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

Description

When designing a shaft, gear, or heavy-duty wear pin, specifying â??58 HRC hardnessâ?• on an engineering drawing without defining the hardening route and base steel grade is an expensive mistake. Reaching 58 HRC by gas carburizing a low-carbon alloy bar produces a completely different stress profile, core toughness, and distortion pattern than induction hardening a medium-carbon bright bar or through-hardening an alloy steel.

Choosing the wrong combination leads to either **over-engineering** (paying for long furnace carburizing cycles when fast induction hardening would suffice) or **premature component failure** (sub-surface case crushing or brittle fracture under shock loads). Below is a practical engineering guide to matching **case hardening, induction hardening, and through hardening** to the right steel grades.



Selective surface induction hardening of

a medium-carbon steel shaft journal, delivering high wear resistance with minimal thermal distortion.

How the Three Hardening Methods Differ Metallurgically

Case hardening diffuses extra carbon into a low-carbon steel surface, induction hardening rapidly heats and quenches the existing carbon in a medium-carbon steel surface, and through hardening transforms the entire cross-section into tempered martensite.

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1. Case Hardening (Carburizing & Carbonitriding)

Case hardening starts with a low-carbon steel (typically **0.14% to 0.22% C**) that cannot harden deeply on its own. Components are heated to **900Â°C â?? 930Â°C** in a carbon-rich atmosphere so carbon diffuses into the outer layer (typically **0.5 mm to 2.0 mm** deep), followed by quenching and low-temperature tempering (150Â°C â?? 200Â°C).

- **Resulting Microstructure:** A high-carbon martensitic outer shell (**58 â?? 62 HRC**) backed by a ductile, tough low-carbon core (**28 â?? 42 HRC**) with beneficial compressive residual stresses at the surface.
- **Typical Steel Grades: 16MnCr5, 20MnCr5, SAE 8620, EN36C (832M13), EN32B (080M15), and SAE 1018** (for light-duty carbonitriding).

2. Induction Hardening (Surface Flame / Coil Hardening)

Induction hardening does not change the steelâ??s chemistry. Instead, it uses a medium-carbon or medium-carbon alloy steel (**0.38% to 0.50% C**) that already contains enough carbon to harden. A high-frequency copper coil heats only the outer skin (**1.0 mm to 5.0 mm** deep) above its austenitizing temperature in seconds, followed immediately by polymer or water spray quenching.

- **Resulting Microstructure:** A hard martensitic wear layer (**54 â?? 60 HRC**) over an untouched normalized or pre-toughened core, with minimal thermal distortion because the core stays cool and rigid.
- **Typical Steel Grades: EN8D (080A42), C45E (1.1191), EN9 (070M55), and EN19 / SAE 4140 (42CrMo4)**.

3. Through Hardening (Quenching & Tempering / +QT)

Through hardening heats the entire component uniformly to **820Â°C â?? 860Â°C**, quenches it in oil, polymer, or water, and tempers it at **450Â°C â?? 650Â°C** to balance hardness and impact toughness across the full cross-section.

- **Resulting Microstructure:** Uniform tempered martensite from surface to center (typically **28 â?? 45 HRC / 280 â?? 440 HB** for structural shafts, or up to **55 â?? 62 HRC** for high-carbon tool and bearing grades).
- **Typical Steel Grades: EN8 (080M40), C45, EN19 (SAE 4140), EN24 (SAE 4340), and EN31 (SAE 52100)**.

Comparison Table: Case Hardening vs. Induction Hardening vs. Through Hardening

Parameter	Case Hardening (Carburizing)	Induction Hardening	Through Hardening (+QT)
Base Carbon Content	Low Carbon (0.14% â?? 0.22% C)	Medium Carbon (0.38% â?? 0.50% C)	Medium to High Carbon (0.36% â?? 1.00% C)
Common Steel Grades	16MnCr5, 20MnCr5, SAE 8620, EN36C, EN32B	C45E, EN8D, EN9, EN19 (4140)	EN8, C45, EN19 (4140), EN24 (4340), EN31
Surface Hardness	58 â?? 62 HRC	54 â?? 60 HRC	28 â?? 45 HRC (up to 60 HRC in high-C grades)
Core Condition	Tough, ductile core (28 â?? 42 HRC)	Unchanged (As-rolled, normalized, or +QT core)	Hardened uniformly throughout section
Typical Case Depth	0.5 mm â?? 2.0 mm (follows complex gear teeth)	1.0 mm â?? 5.0 mm (deep wear & bending resistance)	Full cross-section (100% through)
Thermal Distortion Risk	**High:** Long soak at 920Â°C requires finish grinding	**Low:** Cold core supports shaft geometry	**Moderate to High:** Depends on quench severity & geometry
Selective Area Hardening	Difficult (requires copper plating or stop-off paint)	**Easy:** Hardens only journals, lobes, or teeth	Not possible (entire part is heated)

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Component-by-Component Selection: Shafts, Gears & Pins

1. Transmission Gears, Pinions & Splines

Best Choice: Case Hardening (16MnCr5, 20MnCr5, SAE 8620, EN36C)

Gear teeth experience two simultaneous stresses: severe sliding contact wear at the pitch line and high bending fatigue at the tooth root. Carburizing **20MnCr5** or **SAE 8620** provides a 60 HRC wear-resistant skin that follows every tooth profile uniformly, while compressive surface stresses prevent root bending fatigue cracks. For heavy mining or shock-loaded drivetrain gears, upgrade to nickel-chromium **EN36C** for maximum core impact toughness.

2. Long Motor Shafts, Pump Shafts & Hydraulic Piston Rods

Best Choice: Induction Hardening (C45E, EN8D, EN19)

Carburizing a 1,500 mm hydraulic piston rod or stepped motor shaft at 920Â°C causes severe warping and leaves the entire bar too hard to straighten easily. Instead, starting with peeled or ground **C45E (1.1191)** or pre-toughened **EN19 (+QT)** bright bars and induction hardening only the bearing journals or outer rod skin delivers 55 â?? 58 HRC wear resistance with minimal runout distortion. Note that for induction hardening, clean special-quality steels like **C45E** or peeled bars free from surface decarburization are essential to prevent soft spots and quench cracking.

3. High-Tensile Tie Bars, Axles, Bolts & Heavy Structural Shafts

Best Choice: Through Hardening (EN19 / 4140, EN24 / 4340, EN8)

When a component carries high torsional, tensile, or bending loads across its entire cross-section rather than localized sliding wear, through hardening is the right route. **EN19 (42CrMo4)** and **EN24 (34CrNiMo6)** quenched and tempered to 280 â?? 340 HB deliver high yield strength and fatigue endurance throughout thick diameters without requiring expensive post-heat-treatment cylindrical grinding.

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4. Pivot Pins, Bushings & Cam Rollers

Best Choice: Case Hardening (20MnCr5 / EN32B) or Through-Hardened Bearing Steel (EN31)

For heavy excavator and linkage pins subjected to high impact shock, case-hardened **20MnCr5** prevents brittle snapping. For small-to-medium precision rollers and bushings operating under pure rolling contact without shock bending, through-hardened high-carbon chromium steel (**EN31 / SAE 52100**) offers maximum compressive wear life.

Quick Decision Checklist Before Ordering Steel

- **Need 58 â?? 62 HRC surface hardness on complex shapes (gears, sprockets, dog clutches) with shock toughness?** Specify case-hardening alloy grades like **16MnCr5, 20MnCr5, or EN36C**.
- **Need 55 â?? 60 HRC wear resistance on specific journals or long shafts without furnace distortion?** Specify induction-hardening grades like **C45E (1.1191), EN8D, or EN19** in peeled or ground bright bar condition.
- **Need uniform core strength (800 â?? 1100 MPa tensile) across thick sections for shafts, studs, or axles?** Specify through-hardening alloy steels like **EN19 (SAE 4140) or EN24 (SAE 4340)**.
- **Want to eliminate in-house heat treatment distortion altogether?** Order pre-hardened and tempered (**+QT**) bright bars or peeled bars ready for finish machining.

Review international grade equivalents on our Steel Grade Cross-Reference page, or see how different heat-treated grades perform across industries on our Uses & Applications guide.

Source Heat-Treatable Bright & Black Steel Bars from Steelmet Industries

Steelmet Industries supplies tested Cold Drawn Bright Steel Bars, peeled and ground bars, and Hot Rolled Steel Bars across case-hardening, induction-hardening, and through-hardening grades including **16MnCr5, 20MnCr5, C45E, EN8D, EN19, and EN24**. Every dispatch includes full chemical and mechanical certification under our Quality Policy.

Consult Our Metallurgical & Sales Team:
Corporate Website: www.steelmet.in
Request a Quote: Contact Steelmet Industries

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Date
19/11/2026
Author
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