NAK80 Mold Steel Explained Properties, Machining & Pitfall Checklist

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What Is NAK80 Mold Steel?

NAK80 is a pre-hardened mirror-finish plastic mold steel produced by Daido Steel (Japan). It is typically supplied at about **38–42 HRC**, designed for **no overall heat treatment**, lower risk of machining distortion, and strong suitability for **mirror polishing** and **precision machining**.

Key Features of NAK80

1. **High hardness & wear resistance:** Pre-hardened at **37–43 HRC**, offering more stable wear resistance and polish retention for production plastic molds.
2. **Good machinability:** Uniform hardness; complex geometries remain machinable even around **40 HRC**.
3. **Convenient weld repair:** Uniform aging response after welding; no full heat treatment required,

reducing repair cost.

4. **Excellent texturing/etching performance:** Uniform texture quality, suitable for high-end requirements.

5. **Outstanding mirror-polishing potential:** Can reach a high mirror-finish level (often referenced as **#4000–#8000** in polishing-grit terminology) with a clean surface.

6. **Pre-hardened delivery:** Ready for machining without overall heat treatment, reducing deformation risk and shortening lead time.

***SPI gradesRa/Rz**Note: "#4000–#8000" refers to polishing system grit/industry wording and is not a universal acceptance standard. Actual acceptance should follow , , or customer-approved samples.*

NAK80 Property Tables (Daido Steel Official)

1) Chemical Composition

Element	Daido Official (Brochure)	Engineering Typical (Common Reference)
C	0.15	0.15
Si	0.30	0.30
Mn	Proper amount	~1.50
Ni	3.00	3.00
Mo	0.30	0.30
Cu	1.00	1.00
Al	1.00	1.00

2) Physical Properties

Property	Test Temperature Range	Value & Unit
Coefficient of Thermal Expansion	20–100°C	11.3×10^{-6}/°C
Coefficient of Thermal Expansion	20–200°C	12.5×10^{-6}/°C
Coefficient of Thermal Expansion	20–300°C	13.4×10^{-6}/°C
Thermal Conductivity	25°C	29.5 W/(m・K)
Thermal Conductivity	100°C	31.4 W/(m・K)
Thermal Conductivity	200°C	33.0 W/(m・K)
Thermal Conductivity	300°C	32.8 W/(m・K)
Thermal Conductivity	400°C	32.1 W/(m・K)

3) Mechanical Properties

Property	Value (SI / Metric)	Value (JIS / Imperial)
Tensile Strength	1255 MPa	128 kgf/mm^2 (183 ksi)
Yield Strength (0.2% Offset)	1010 MPa	103 kgf/mm^2 (147 ksi)
Elongation	15.60%	-

Reduction of Area	39.80%	-
Charpy Impact Value	20 J/cm²	2.0 kgf・m/cm² (2mm U-notch)
Hardness	38–42 HRC	372–421 HBW

Typical Applications of NAK80 Mold Steel

- High mirror-finish / high-gloss appearance requirements
- Transparent parts or optical-grade appearance requirements
- High clarity requirements for micro-textures / micro-structures
- EDM-intensive cavities/inserts requiring high surface quality
- Large-area surfaces requiring consistent polishing appearance

Applications Not Recommended for NAK80

- High impact / high shear/edge or cutting areas with high stress
- Ultra-long service life targets (> 1,000,000 cycles)
- High-abrasion materials (glass fiber / mineral-filled resins)
- Strongly corrosive plastics (e.g., PVC)
- Long-term high-temperature operation (> 150°C)
- Cost-sensitive projects without high surface requirements

NAK80 Selection Decision Comparison Table

Dimension	Recommended Use Cases for	Not Recommended Use Cases

	NAK80	
Core Goal & Industry	Extreme appearance & precision: optical lenses, high-gloss 3C housings, cosmetic packaging, light guide plates.	Extreme durability & robustness: continuous stamping, cold-work die edges, ultra-long-life high-volume tooling.
Surface Quality Requirement	High-grade mirror finish & fine textures: #4000–#8000 polishing-grit wording (reference), 0.1 mm-class micro-structures, high texture consistency.	General surface requirement: matte, standard fine texture, or highly cost-sensitive plastic parts.
Resin & Processing Environment	Common transparent/engineering plastics: ABS, PC, PMMA. Mold temperature typically < 120°C.	High abrasion/high corrosion: glass fiber/mineral-filled resins, corrosive PVC. Mold temperature long-term > 150°C.
Mechanical Load & Tool Life	Uniform loading: stable injection pressure, low stress concentration; suitable for medium-to-large production runs.	High-stress loading: high impact, high shear; target life above 1,000,000 cycles.
Machining & Compliance Notes	Shorter lead time: avoid overall heat treatment to reduce distortion. EDM-intensive parts require high surface quality.	Special constraints: huge molds (high rigidity sensitivity) or export projects with stringent compliance/testing needs.
Economics	1) Lower total cost: no overall heat treatment, shorter cycle, less polishing labor.2) Higher value-add: suitable for higher	1) Higher unit cost: over-spec for ordinary parts.2) Higher maintenance cost for huge molds or ultra-long-life tooling.

	budgets and fast payback projects.	

Recommended Cutting Tools for CNC Machining NAK80

Machining Stage	Recommended Tool Type	Material / Coating / Geometry Suggestions	Typical Model / Brand Reference
Roughing	Indexable inserts / end mills	WC-Co (8–10%) substrate; tough coatings	Mitsubishi VP15TF, ZCC YB205
Semi-finishing	Corn roughing cutter / ball nose	AlCrN coating; 3–4 flutes with variable helix (anti-chatter)	Kennametal, Kyocera series
Finishing	Solid carbide ball nose	Ultrafine grain + positive rake; keep cutting edge sharp	Sandvik GC1030, Sumitomo AC530U
High-gloss / Mirror	CBN / single-crystal diamond (PCD)	Very high hardness, strong chemical wear resistance; use with high-pressure coolant	Dedicated CBN tools, PCD diamond tools

Logic for Selecting CNC Cutting Parameters (NAK80)

Key Factor	Selection Logic	Practical Reference
Spindle Speed (S) / Cutting Speed (v)	High speed to reduce the built-up edge. NAK80 is tough; a low cutting speed can lead to a built-up edge. For	Roughing: 2500–3500 rpmFinishing: 5000–10000 rpm

	carbide tools, v is often suggested at **120–180 m/min**.	
Feed (F) / Feed per tooth (f)	Lower feed to reduce chatter and surface waviness. Suggested f: **0.05–0.15 mm/tooth**.	Roughing: 150–200 mm/minFinishing: 60–100 mm/min
Depth of Cut (a) & Stepover (a)	Shallow cuts to release stress. NAK80 may deform from internal stress; use “thin layers, multiple passes”.	Roughing: 0.5–2.0 mmFinishing: 0.05–0.1 mm
Cooling Method	High-pressure cooling to control heat. Prefer oil-based cutting fluid or high-pressure through-coolant.	Pressure reference: 0.3–0.5 MPa

NAK80 Machining Notes (Pitfall Checklist)

- **Pre-hardened delivery:** Supplied at ~38–42 HRC; typically machinable without overall heat treatment. Plan finishing allowance by process needs to avoid unnecessary extra work.
- **Toolpath sensitivity in deep cavities:** Deep-cavity machining can be more sensitive to toolpath direction. Evaluate the rolling direction and deflection risk; adjust the toolpath strategy and tool support as needed.
- **Surface quality improvement:** With adequate machine rigidity, tooling, and coolant, higher RPM / reasonable cutting speed can reduce built-up edge and drag marks, helping reduce polishing workload.
- **Anti built-up edge:** Due to Ni/Cu alloying, a lower cutting speed is more likely to cause built-up edge. Keep cutting speed in a reasonable range and tune by tool and cooling method.
- **Rust prevention:** Rust prevention management is important. Water-based emulsions should be evaluated carefully; clean, dry, and apply rust preventive protection after machining to avoid long exposure.

- **Weld repair note:** Weld repair has crack risk. Typically, preheating to around 200°C and controlled, slow cooling are recommended to reduce the risk of cracking (depending on the filler, repair area, and heat input).

Typical Problems & Solutions

Q1: What if haze, pinholes, and scratches appear during NAK80 polishing, making it hard to reach "Mirror Level 3"?

Try the following approaches:

1. Refine the polishing process into **8 steps**, progressing sandpaper grit as: **180# → 320# → 400# → 600# → 800# → 1000# → 1500# → 2000#.**
2. Check hardness and consistency. If hardness is uneven, perform **two stabilization treatments** before entering the mirror-polishing stage.
3. Use imported mirror polishing fluid or **diamond polishing paste** (W5 → W1.5). Finish with a wool wheel and **chromium oxide** compound for final luster.
4. Control pressure and direction: reduce pneumatic polishing pressure to about **0.25 MPa** and maintain a consistent polishing direction to prevent repeated cross-scratches.

Q2: What if local "white haze" appears after polishing (especially at corners), affecting appearance?

Try the following approaches:

1. Add cold-air cooling for the polishing area to avoid local overheating (keep temperature below about **60°C**).
2. Use smaller polishing tools at corners and reduce pressure.

3. After polishing, clean with alcohol to remove polishing compound residue.

Q3: What if pinholes cause dimples on molded plastic parts after polishing?

Try the following approaches:

1. Select higher-purity NAK80 with **S ⩽ 0.005%.**
2. Perform fluorescent penetrant inspection before polishing.
3. Use a compatible mold repair compound to fill existing pinholes, then re-polish.

Q4: How to improve efficiency and reduce cost for mirror polishing of NAK80 molds?

Try the following approaches:

1. Introduce robotic polishing for rough and mid polishing, keeping only final mirror finishing as manual work.
2. Use dedicated NAK80 polishing wheels to improve cutting efficiency.
3. Build a polishing parameter database to standardize operations.

Q5: What if cracks appear after weld repair on NAK80?

Try the following approaches:

1. Preheat to **200–250°C** using ceramic heaters or induction heating for uniform temperature rise.
2. Use low-hydrogen / crack-resistant consumables such as **WE600** special alloy steel electrodes or **ERNiCrMo-3** nickel-based filler wire.
3. Use low current with multi-layer multi-pass welding or segmented back-step technique; control interpass temperature at **200–220°C**.

4. Immediately cover with asbestos cloth for slow cooling, then stress-relief at **280–300°C × 1.5–2 hours**.

Q6: What if hardness/strength is not acceptable after weld repair?

Try the following approaches:

1. If hardness is insufficient: use "base layer + WC-reinforced top layer" overlay welding, then temper at **250°C for 1 hour**.
2. If hardness is too high and machining is difficult: use low-carbon filler, temper at **350°C × 2 hours**, and machine with carbide tools at high speed and low feed.
3. If strength is insufficient: increase groove angle to **60°**, use three-layer welding to ensure penetration, choose **ER110S-G** high-strength wire, preheat to **280°C**, then temper at **320°C × 2 hours**.

Q7: What if porosity, color difference, or mirror finish is not achieved after weld repair?

Try the following approaches:

1. **Remove porosity:** clean the area with acetone; bake electrodes at **350°C for 1 hour**; use 2–3 mm short-arc uphill welding and increase travel speed to reduce molten pool residence time.
2. **Reduce color difference:** use filler with similar composition; control heat input to reduce oxidation; apply local heat treatment and tone-matching polishing.
3. **Meet mirror finish:** use pulsed TIG and dedicated filler wire; leave **0.1 mm** stock after precision grinding; polish progressively with diamond paste **800#–8000#**, then finish with wool wheel for mirror appearance.

Q8: What if hardness is insufficient after heat treatment?

Try the following approaches:

1. **Low-temperature aging strengthening:** 500–530°C staged holding for 2–3 hours; strictly control heating rate ⩽ 100°C/hour; furnace cooling.
2. **Double aging:** 500°C × 2 hours air cool, then 530°C × 3 hours furnace cool; use polymer quench fluid to increase cooling rate when applicable.
3. **Local/overall re-hardening:** for machined parts, local induction heating (850°C × 30 s + spray cooling + 200°C temper). For unmachined parts, re-austenitize at 840–870°C for 1.5–2.5 hours, then isothermal quench and age at 520–540°C.
4. **Surface nitriding:** gas nitriding at 500°C for 3 hours; 180°C low-temperature temper; control case depth at 0.1–0.2 mm.

Q9: What if hardness is uneven after heat treatment?

Try the following approaches:

1. **Vacuum quenching + aging:** 840°C vacuum heating for 1.5 hours; oil cool to 150°C then temper at 200°C; age at 520°C for 3 hours; maintain temperature uniformity ±3°C.
2. **Stress relief + overall aging:** 550°C × 2 hours anneal, then 530°C overall aging for 3 hours.
3. **Local heating + overall aging:** locally induction heat low-hardness areas to 840°C, then age overall at 530°C; repeat local treatment if still not acceptable.
4. **Adjust process parameters:** increase quench temperature (860–870°C), extend holding time, and use two-stage tempering to optimize precipitate distribution.

Q10: What if hardness is abnormal (too high/brittle)?

Try the following approaches:

1. **High-temperature temper to reduce hardness:** 600°C × 2 hours to relieve stress, then age at 520°C for 3 hours; heating rate ⩽ 50°C/hour to reduce cracking risk.
2. **Vacuum slow-cooling aging:** hold at 520°C for 3 hours, cool slowly at 20°C/hour to reduce thermal

stress.

3. **Targeted adjustments:** confirm alloy composition first, then fine-tune austenitizing temperature, cooling rate (control at 50–60°C/s), and tempering process to balance hardness and toughness.

4. **Low-temperature pre-treatment:** add 150°C × 1 hour pre-treatment before aging to reduce deformation and stabilize hardness.