

INTRODUCING NAK80

40 HRC Pre-Hardened

*High Performance
High Precision
Mold Steel*

**PLASTIC MOLDS
RUBBER MOLDS
JIGS & FIXTURES
PRESS DIES**

KNOCK OUT

THE COMPETITION



Features:

- Machines up to 20 percent faster than 30 HRc P20
- Pre-hardened to 38-42 HRC
- Uniform microstructure & hardness (40 HRC between surface & interior)
- Never needs stress relieving, even after heavy machining
- Highly weldable, HAZ gets softer not harder (re-age harden to bring back to 40 HRC)
- EDM layer is easy to remove

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Recommended Reading:

Article: [Prehardened Mold Steels offer Machinability and Weldability](#)

UNIQUE CHARACTERISTICS

- Super clean, Vacuum-Arc Remelt manufacturing process.
- 40 HRc hardness.
- Age-hardened for uniformity of hardness throughout, even in heavy sections.
- When welded, NAK leaves no witness lines after re-aging.
- Uniform grain structure with no pin holes, inclusions or hard spots.
- Machines up to 20% faster than 30 HRc P20 mold steels.
- Never needs stress relieving, even after heavy machining.
- Polishes to a superior No. 1 finish, even over welded areas.

APPLICATIONS

- Clear lens molds
- Extremely critical diamond finish applications
- Molds requiring special EDM finish

BENEFITS

- **Welding**

As a result of low carbon content, age hardening, and the availability of NAK weld rod, hardness is lowered in the heat-affected zone during the welding process, NAK 80 can be re-aged to 40 HRc with no distortion or stress put into the mold. Polish, texture and wear in welded area are indistinguishable from adjoining "parent steel" on the finished product.

- **Machining**

Machines to a superior surface with negligible dimensional change up to 20% faster than P20. Positive rake cutters with concave, chip breaking inserts work best, and last up to twice as long as P20 mold steels.

- **EDM**

The soft recast layer (approximately 32 HRc) is much thinner and is easier to remove than steels with a recast layer that is equivalent to their "as quenched" hardness. With NAK80, no post EDM stress relieving is ever needed.

- **Stability**

Age hardening eliminates the stresses inherent in quenched and tempered steels. NAK80 is dimensionally stable and predictable over many years of heating and cooling cycles.

- **Surface Enhancements**

Super clean steel with uniform grain structure facilitates superior nickel, chrome, titanium, and other coatings. Unique chemistry responds extremely well to ion nitriding.

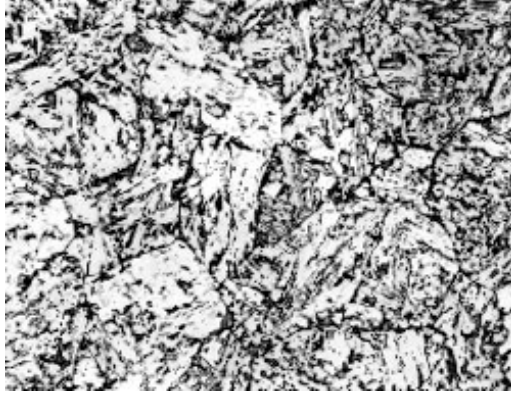
- **Texturing and Polishing**

Exceptionally clean steel with uniform grain structure polishes beautifully

allowing superior texturing and photo etching.

- **Wear**

Higher hardness ensures molds have a longer life than those made from P20, particularly in gate, runner, and parting line areas.



NAK80 x 400

TYPICAL CHEMISTRY

Carbon	0.15%	Copper	1.00%
Manganese	1.50%	Nickel	3.00%
Silicon	0.30%	Aluminum	1.00%

MECHANICAL PROPERTIES

Tensile Strength	183,400 psi
Yield Strength (.2% offset, 41 HRc)	147,600 psi
Reduction of Area	41.9%
Elongation in 2" (longitudinal)	16.1% psi
Modulus of Elasticity (room temp.)	30.0×10^{-6}
Charpy V-notch Impact Strength (toughness):	
Longitudinal	8.1 ft/lb
Transverse	8.5 ft/lb.
Hardness	40 HRc

PHYSICAL PROPERTIES

- **Coefficient of Thermal Expansion (x 10⁻⁶ in/in/F°)**

68°F to 212°F	6.3
68°F to 392°F	7.0
68°F to 572°F	7.5

- **Coefficient of Thermal Conductivity (BTU/ft·hr·F°)**

At 200°F	23.9
At 400°F	24.4

- **Magnetic Properties**

Maximum Magnetic Permeability	380
Saturated Magnetism (Gauss)	16,360
Residual Magnetism (Gauss)	8,500
Coercive Force (Oersted)	14.0

GENERAL DESIGN GUIDELINES

- **Compressive Strength**

NAK80 possesses excellent resistance to surface deformation by compressive force. Its resistance to surface deformation equals that of H-13 steel at like hardness.

- **Stability**

NAK80 is not quenched to achieve hardness. Therefore, it does not have the stresses inherent in quenched and tempered steels. **NAK80 never needs stress relieving due to heavy machining because of uniform hardness throughout!** It has excellent dimensional stability during mold construction and while in service. Even after long mold runs, cool-down, and subsequent re-heating, the material maintains dimensional stability.

- **Operating Temperature Ranges**

NAK80 is a precipitation hardening steel. The formation of the precipitates occurs at a temperature range between 932° and 968°F. Exposure to temperatures below the original precipitation hardening temperature has no effect on the grain structure of the steel. Therefore, even molds in service at high operating temperatures, maintain dimensional stability. Similarly, nitriding or Physical Vapor Deposition (PVD) treatments done below the precipitation hardening temperature range do not cause

distortion.

This is a tremendous advantage over typical mold steels that have been tempered at low temperatures to maintain hardness.

- **Hardness**

The precipitates, which account for the steel's hardness, begin to grow in size if the original hardening temperature range for NAK80 (932°-950°F) is exceeded for an extended period of time. This results in a loss of hardness and toughness, accompanied by dimensional change.

Re-solution heat-treating and subsequent precipitation hardening can recover hardness and toughness, but dimensional changes will have occurred.

- **Wear Properties**

NAK80 is a low carbon steel that acquires hardness by precipitation hardening. Very small carbide structures and precipitates are formed during the hardening process.

Care is required when NAK80 steel slides against itself in molding situations. The use of dissimilar metals with a 10 HRc point difference on the mating surfaces, is advisable in slide situations. Alternatively, you may change the hardness of the surface of similar metals by plating, nitriding, or applying other types of coatings.

- **Shut-Off Tolerances**

The tolerance between mating surfaces on angle shut-offs is very important, and proper setting of the mold is required. The recommended tolerance at molding temperature is .0008" per side for ABS, Polypropylene, Polyethylene, etc. A .0004" (.01mm) per side clearance is required for Polyacetals or nylons, due to their lesser viscosity.

- **Ejector Pin Tolerances**

Dia. of Ejector Pin	Recommended Clearance
.200" and below	.0008"
.201" to .500"	.0012"

Note: All clearance values are at molding temperature.

- **Sharp Corners**

Sharp or square corners serve as focal points for concentrating stresses that build up in molds and dies during operating conditions. A .100" - .120" radius to all corners is recommended, especially large box-type molds. To avoid these stresses, the thickness of the material backing up a sharp corner should be increased by 50% compared with softer steels.

- **Thin Sections**

Due to the toughness limitations of NAK80, it is suggested that other

types of steel be inserted at thin rising sections (4-to-1 ratio or more) **and** that a radius be put on the base of rising sections from the initial design

Cavity Depth

Cavity depth should be limited to no more than 50 - 55% of the block thickness in high-pressure injection molds.

Cooling/Heater Water Lines

Do not locate cooling or heater lines directly below the corner of a mold cavity. The **ideal** location for heating or cooling lines is located **three (3)** times the hole diameter from the molding surface. 1.5 times the hole diameter from the molding surface is the minimum. Example: a 1/4" diameter waterline should be **at least 3/8"** away from mold surface and **preferably 3/4"**. The distance between lines should be **five (5)** times the line diameter minimum.

PROCESSING GUIDELINES

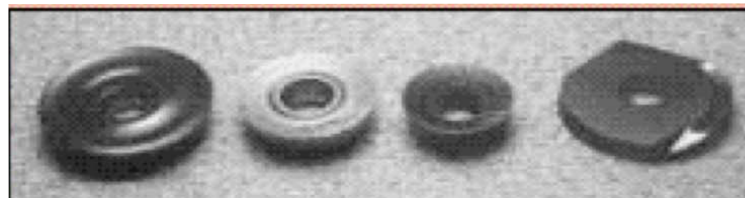
The optimum cutting conditions for NAK80 vary by machine tools. Cutting tools incorporating the recommended geometries will produce superb finish machined surfaces, often completely eliminating grinding. NAK80 does not work harden.

Milling

High-speed steel cutters give excellent results and very smooth machined surfaces. The best results are obtained with cutter geometries incorporating a positive rake angle of 15°-20° and a relief angle of less than 10°.

Carbide cutting tools (P40 grade) will yield excellent results if the effective, positive rake angle of the insert and holder is approximately 8°-15°, and the relief angle is less than 10°. When negative rake carbide is used, inserting grades with greater toughness than P40 gives better results. In general, a positive rake configuration is superior to a negative rake configuration for milling NAK80

Note: It is important that the inserts have a concave face with a sharp chip breaking edge. TiAlN coatings work well.



- **Grinding**

NAK80 grinds easily. It is recommended that it be ground wet.

- **Drilling**

NAK80 drills easily. The cutting speed should be lowered as the drill diameter increases. A smaller than standard twist angle and shorter length will reduce the danger of broken tools. Peck cycles are recommended, as NAK80 is a chip packing material.

- **Tapping**

NAK80 is a 40 HRc steel. The following is recommended to facilitate tapping:

1. Use a new, sharp premium grade of tap, TiN coated and spiral pointed.
2. Use a tapping oil or highly chlorinated sulfured oil. A mixture of 50% kerosene and 50% cutting oil also works well.

- **EDM**

Copper or graphite electrodes are suitable, or the steel may be used as an electrode when burning mating halves together to achieve a fit.

The recast layer for NAK80 is soft (approximately 32 HRc). Other low alloy grades, such as P20, or more highly alloyed steels, such as S7 and H13, have recast layers equivalent to their high, as-quenched hardness. Because the EDM white layer must be removed, the subsequent stoning or grinding of NAK80 is much easier than with other steels.

- **Polishing**

NAK80 is Vacuum-Arc Re-melted steel of exceptional cleanliness and as such, it polishes to a SPE/SPI #1 finish. Normal polishing techniques, with light pressure, will yield excellent results. ***It is also recommended to use light pressure during buffing.***

- **Texturing**

NAK80 is an ideal steel for photo etching or texturing. Vacuum-Arc Remelted processing employs a continuous ingot casting procedure that nearly eliminates chemical segregation of the alloying elements. This results in a clean, homogenous steel.

The low carbon content of NAK80 is also advantageous, since carbon is a potent alloying element and a major contributor to chemical segregation.

The uniform hardness of NAK80 assures even and uniformly textured patterns regardless of work-piece size or depth of cavity. Furthermore, the ability to easily restore a uniform hardness to welded areas is a tremendous advantage for texturing in comparison to other steels.

- **Nitriding**

NAK80 contains 1% aluminum and responds very well to nitriding. There are many forms of nitriding and each has advantages. However, for molding die applications, ion-nitriding, in particular, is very suitable for NAK80. When employing standard gas nitriding, do not exceed 950°F.

The ion-nitriding process is done in a controlled atmosphere. It is clean, with minimal distortion, and can be done at temperatures that do not damage NAK80.

Nitriding increases wear resistance and creates a hard surface ideal for slides or dies that mold abrasive or mineral-filled thermoplastics. The nitrided surface has a hardness over 60 HRc, improved corrosion resistance, and can be polished to a finer finish than possible at base metal hardness.

WELDING GUIDELINES

Welding of NAK80 should be performed employing only NAK-W Welding Rods. NAK-W Welding Rods are copper-coated for either TIG or Heli-Arc welding. Employ only recognized, safe shop welding practices.

- **General**

1. The die or mold should be free of all oil, rust, scale residue, or any other potential contaminants before attempting to weld.
2. All cracks and surface treatments should be completely removed before attempting to weld.
3. Sharp corners should be rounded to a minimum radius of .120".
4. To repair a crack, remove sufficient stock to eliminate the crack and insure only sound material remains. Dress the corners where stock was removed to eliminate any square corners by rounding to a minimum radius of .120".

- **Preheating**

Prior to making a welding repair, preheat the piece to be repaired by slowly heating in a furnace or with a gas burner to between **600° and 750°F**. Heating from the bottom is recommended if a gas burner is used. ***Uniform temperatures within the recommended range should be maintained during the entire period of time required to complete the repair.*** Ideally, the entire mold should be heated in a furnace to achieve uniform temperatures. This is easy to do for small molds, but may not be practical, or possible, for large molds. Localized preheating is the only option for large molds, and attention must be paid to the following:

1. Preheating temperature must be achieved to at least 2" away in all directions from area to be welded.
2. Use an oxygen-propane gas burner with a low flame temperature. **Heat the mold carefully and gradually, maintaining a distance of 18" between the flame and the**

mold surface.

3. Apply a temperature choke or a surface contact thermometer to accurately measure the preheating temperature.
4. Re-heat as necessary during welding to maintain the above **600°F** range.

• **Technique**

1. Use DC normal polarity
2. Use lowest possible amperage for the job
3. Use backhand welding - weld away
4. Use smallest diameter rod possible
5. Weld small beads
6. Peen weld as necessary
7. Upon completion of welding, proceed immediately to post-weld heating procedure

• **Post-Weld Heating**

It is imperative that the following procedure be carefully followed to assure the welded section is completely restored to a uniform hardness:

The weld-repaired piece should be heated to between **860°-940°F** and held at this range for a minimum of one (1) hour to re-age. This re-aging process should be conducted immediately after welding. Heating with a furnace is highly recommended, however a gas burner may be used as a last resort. ***If a gas burner is used, heating from the bottom is recommended, however the entire welded area, and as much as 2" surrounding the weld, must be kept in the post heat temperature range for a minimum of one (1) hour.*** Cool slowly to room temperature.

Note: Post-weld heating should be performed after every three layers of weld buildup in order to alleviate welding stress and avoid over-aging of adjacent parent metal.

• **Conditions**

Rod diameter	Electrode diameter	Current/Amps
.0310"	.0310"	40~70
.0630"	.0630"	70~150
.0946"	.0946"	150~250

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