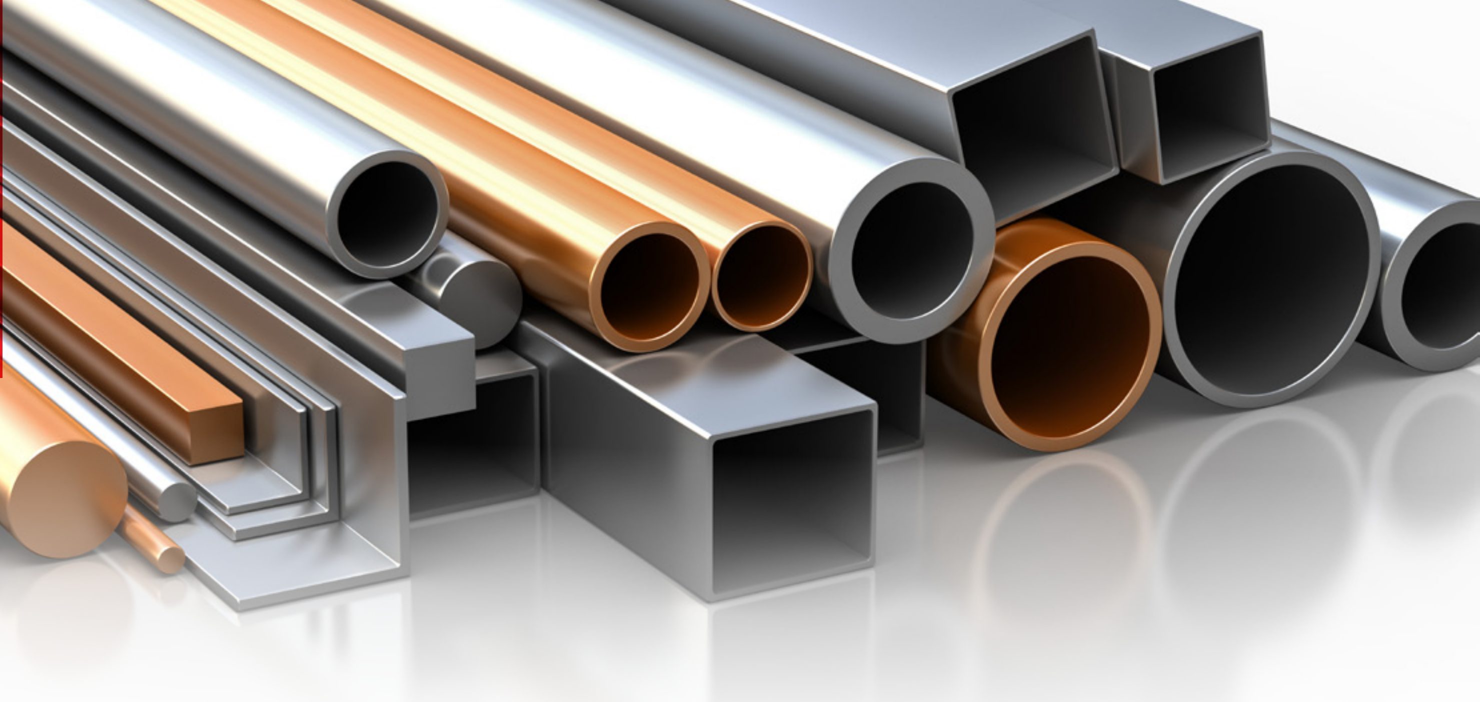
DATA SHEET



MONEL® 400
UNS No - N04400

Other common names: Alloy 400

It is a nickel-copper alloy (around 67% Ni – 23% Cu) that is resistant to sea water and steam at high temperatures and in addition to salt and caustic solutions. Monel 400 is solid solution alloys that must be harden by cold working. These nickel alloys displays qualities like good corrosion resistance, great weldability and high strength. A low corrosion rate in quickly streaming brackish or seawater joined with incredible imperviousness to stretch corrosion breaking in many freshwaters and its resistance to an assortment of corrosive conditions prompted its wide use in other non-oxidizing chloride solutions and marine applications. This nickel alloy is especially resistant to hydrofluoric acids and hydrochloric when they are de-aerated. As would be normal from its high copper content, alloy 400 is quickly assaulted by nitric acid and ammonia systems. Monel 400 has incredible mechanical properties at below zero temperatures, can be utilized as a part of temperatures up to 1000° F and its melting point is 2370-2460° F. In any case, alloy 400 is low in strength in the annealed condition along these lines; an assortment of tempers might be utilized to increase the strength.

Applications

- Marine engineering
- Chemical and hydrocarbon processing equipment
- Gasoline and freshwater tanks
- Crude petroleum stills
- De-aerating heaters
- Boiler feed water heaters and other heat exchangers
- Valves, pumps, shafts, fittings, and fasteners
- Industrial heat exchangers
- Chlorinated solvents
- Crude oil distillation towers

Characteristics

- Resistant to seawater and steam at high temperatures
- Excellent resistance to rapidly flowing brackish water or seawater
- Excellent resistance to stress corrosion cracking in most freshwaters
- Particularly resistant to hydrochloric and hydrofluoric acids when they are de-aerated
- Offers some resistance to hydrochloric and sulfuric acids at modest temperatures and concentrations, but is seldom the material of choice for these acids
- Excellent resistance to neutral and alkaline salt
- Resistance to chloride induced stress corrosion cracking
- Good mechanical properties from sub-zero temperatures up to 1020° F
- High resistance to alkalis

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Corrosion Resistant

Alloy 400 is for all intents and purposes insusceptible to chloride ion stress corrosion cracking in ordinary situations. Usually, its corrosion resistance is better in decreasing situations, however poor in oxidizing conditions. It is not valuable in oxidizing acids, for example, nitric acid and nitrous. So, it is resistant to most alkalis, salts, waters, food items, natural substances and environmental conditions at typical and high temperatures. This nickel alloy is attacked in sulfur-bearing gases above approximately 700° F and molten sulfur attacks the alloy at temperatures over around 500°F. Monel 400 offers about the same corrosion resistance as nickel yet with higher maximum working pressure and temperatures and at a lower expense because of its better capacity than be machined.

Fabrication

Alloy 400 can without much of a stretch be welded by the gas-tungsten arc, gas metal arc or shielded metal arc forms utilizing suitable filler metals. There is no requirement for post weld heat treatment; in any case, careful cleaning after welding is basic for ideal corrosion resistance and generally there is the risk of contamination and embrittlement. Completed fabrication can be delivered to an extensive variety of mechanical properties when legitimate control of the measure of hot or cold working and the determination of suitable thermal treatment is finished. Like most other nickel alloys, Monel 400 is usually difficult to machine and will work harden. Be that as it may, great results can be acquired on the off chance that you settle on the right decisions for tooling and machining.

Machining

Standard machining methods utilized for iron based alloys might be utilized. This alloy works harden during machining and has higher strength and “gumminess” not typical of steels. Heavy duty machining equipment as well as tooling should be utilized to minimize chatter or work-hardening of the alloy in front of the cutting. Most any business coolant might be utilized as a part of the machining operations. Water-base coolants are favored for high speed operations, for example, turning, grinding or milling. Heavy lubricants work best for tapping, drilling, broaching or boring. Turning: Carbide tool is recommended for turning with a nonstop cut. High speed steel tools should be utilized for interfering with slices and for smooth completing to close resilience. Tools should have a positive rake angle. Cutting speeds and feeds are in the accompanying reaches: For High-Speed Steel Tools For Carbide Tooling Depth Surface Feed Depth Surface Feed of cut pace in inches of cut rate in inches feet/min. per rev. Inches feet/min. per rev. 0.250” 60-70 0.030 0.250” 250-300 0.020 0.050” 90-100 0.010 0.050” 300-350 0.008 Drilling: Steady sustain rates must be utilized to maintain a strategic distance from work hard because of harping of the drill on the metal. Rigid setups are crucial with as short a stub drill as practical. Standard high speed steel drills work well. Sustains fluctuate from 0.0007 inches for each rev. for openings of under 1/16” measurement, 0.003 inches for each rev. for 1/4” dia., to 0.010 inches for each rev. for openings of 7/8”diameter. Surface speed of 45-55 feet/minute, are best to drill. Processing: To acquire great exactness and a smooth completion, it is fundamental to have unbending machines and fixtures and sharp cutting devices. High speed steel cutters, for example, M-2 or M-10 work best with cutting speeds of 60 to 80 feet per minute and feed of 0.005”- 0.008” per cutting tooth. Grinding: The alloy should be wet ground and aluminium oxide wheels or belts are favored.

Forming

This alloy has good ductility and might be promptly formed by every standard technique. Since the alloy is more powerful than consistent steel it need more power to perform forming. Heavy-duty lubricants should be utilized during cold forming. It is crucial to altogether clean the part of all traces of lubricant to shaping as embrittlement of the alloy might occur at high temperatures if lubricant is left on.

Welding

The usually utilized welding strategies work well with this alloy. The coordinating alloy filler metal should be utilized. In the event that coordinating alloy is not available, then the closest alloy richer in the essential chemistry (Ni, Co, Cr and Mo) should be utilized. All welds dots should be marginally curved. It is not important to utilize preheating. Surfaces to be welded must be perfect and free from oil, paint or crayon marking. The cleaned area should stretch out no less than 2” past either side of a welded joint. Gas-Tungsten Arc Welding: DC straight polarity (electrode negative) is recommended. Keep as short an arc length as could be expected under the circumstances and use consideration to keep the hot end of filler metal dependably inside of the protected environment. Shielded Metal-Arc Welding: Electrodes should be kept in dry storage and if dampness has been grabbing the electrodes should be prepared at 600 F for one hour to safeguard dryness. Current settings shift from 50 amps for material (0.062” thick) up to 190 amps for material of 1/2” and thicker. It is best to weave the electrode marginally as this alloy weld metal does not tend to spread. Cleaning of slag is finished with a wire brush (hand or powered). Complete evacuation of all slag is essential before progressive weld passes furthermore after final welding. Gas Metal-Arc Welding: Reverse-polarity DC should be utilized and best results are acquired with the welding weapon at 90 degrees to the joint.

For Short-Circuiting-Transfer GMAW a typical voltage is 19-25 with a current of 100-175 amps and a wire feed of 225-400 inches per minute. For Spray-Transfer GMAW voltage of 26 to 33 and current in the scope of 200-350 amps with wire feed rate of 200-500 inches per minute, relying on filler wire diameter. Submerged-Arc Welding: Matching filler metal, the same concerning GMAW, should be utilized. DC current with either turn around or straight polarity might be utilized. Convex weld globules are favored.

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Heat Treatment
Not heat treatable, but rather might be annealed after cool working.

Forging
No data, but the alloy might be hot forged.

Hot Working
Regarding its resistance to hot deformation, MONEL alloy 400 is softer than numerous steels. It can, along these lines, be hot-formed into any shape. The utilization of appropriate temperature during hot forming is very important. The scope of hot-shaping temperatures is 1200°F to 2150°F. For heavy reduction, recommended metal temperature is 1700° to 2150°F. Light decreases might be brought down to 1200°F. Working at the lower temperatures produces higher mechanical properties and small grain size. Drawn out soaking in the hot-working temperatures are adverse. In the event that a delay happens during processing, the furnace should be reduced to 1900°F and not conveyed to temperature until operations are continuing. In no situation should the alloy be heated above 2150°F; changeless harm might come about. Substantial manufacturing ought not to be done so quickly that the metal gets to be overheated from working. The utilization of an optical pyrometer is recommended. In hot-bending operations the metal should be functioning at the earliest opportunity after expulsion from the furnace. Preheating tools and dies to around 500°F are useful to forestall cooling the material while working. A controlled forging method is important to meet the necessities of a few particulars for produced, hot-completed parts. Both the measures of reducing and the completing temperature must be controlled with a specific end goal to add to the desired properties. One strategy for creating forgings to such particulars comprises of taking 30-35% decrease after the last reheat. This is proficient as takes after: 1. Reheat. 2. Forge to a section having around 5% bigger area than the last shape (take no less than 25% reduction). 3. Cool to 1300°F. 4. Completion to measure (5% reduction). High-tensile forgings, as described in certain military particulars, additionally require at least 30-35% decrease taking after the last reheat. This is taken in the accompanying way: 1. Reheat. 2. Forge to a section having a territory around 25% bigger than the last shape (take around 5% reductions). 3. Cool to 1300°F. 4. Completion to estimate (25% reduction). Grain refinement is accomplished by utilizing a temperature of 2000°F for the last reheat and by expanding the measure of reduction taken after the last reheat.

Cold Working
Cold forming might be done utilizing standard tooling albeit plain carbon tool steels are not recommended for shaping as they tend to produce galling. Soft die materials (bronze, zinc alloy, and so forth.) minimize galling and deliver great completions, yet the die life is to some degree short. For long production runs the alloy tool steels (D-2, D-3) and high speed steels (T-1, M-2, M-10) give great results particularly if hard chromium plated to decrease galling. Tooling should be, for example, to take into consideration liberal clearances and radii. Heavy duty lubricants should be utilized to minimize galling in all forming operations. Twisting of sheet or plate through 180 degrees is for the most part constrained to a twist sweep of 1 T for material up to 1/8" thick and 2 T for material thicker than 1/8".

Annealing
Annealing might be done at 1700 F. A stress-relief anneal might be done at 1050 F for 1 to 2 hours, followed by slow cooling.

Hardening
Hardens are due to cold work only.

Chemical Properties

C	Si	S	Cu	Mn	Fe	Ni
0.3 max	0.5 max	0.024 max	28.0 - 34.0	2.0 max	2.5 max	63.0 min

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Mechanical Properties

Tensile Strength (ksi)	0.2% Yield Strength (ksi)	Elongation% in 2 inches
87	60	20

*The ranges shown are composites for various product sizes and therefore are not suitable for specification purposes. Hardness values are suitable for specification purposes provided tensile properties are not also specified.

Alloy 400 Trivia - *Alloy 400 is slightly magnetic at room temperature. *This alloy has a long history of use as a corrosion resistant material, dating back to the early 20th century when it was developed as an attempt to use a high copper content nickel ore. The nickel and copper contents of the ore were in the approximate ratio which is now formally specified for the alloy.

Physical Properties

Properties	Units	Temperature in °C
Density	8.8 g/cm^3	Room
Specific Heat	0.102 Kcal/kg.C	21°
Melting Range	1300-1350 °C	-
Modulus of Elasticity	179 KN/mm^2	Room
Electrical Resistivity	51 µΩ.cm	21°
Coefficient of Expansion	14.2 µm/m °C	20 - 100°
Thermal Conductivity	22 W/m -°K	21°

ASTM Specifications

Pipe (SMLS)	Pipe Welded	Tube (SMLS)	Sheet / Plate	Bar	Forging	Fitting
B 165	B 725	B 163	B 127	B 164	B 564	B 366

Availability

MANUFACTURING
Fasteners
Custom Machining
Custom Fabrication
Piping / Spools
Stamped Parts
B/W Fittings
S/W Fittings
Flanges
Compression Fittings

RAW MATERIALS
Pipes
Tubes
Bars
Sheets
Plates
-
-
-
-