Alloy 200/Alloy 201 - Nickel Alloy: Corrosion Resistant

(UNS N02200/ UNS N02201)

GENERAL PROPERTIES

Alloy 200 (UNS Designation N02200) and Alloy 201 (UNS Designation N02201) are wrought commercially pure nickel. The alloys differ only in the maximum carbon level allowed by specification, 0.15 percent maximum for Alloy 200 alloy and 0.02 percent maximum for Alloy 201. Either alloy provides highly ductile mechanical properties across a wide temperature range. Either alloy provides corrosion resistance in neutral to moderately reducing environments. In the annealed condition, either alloy possesses the approximate strength of mild steel. As-rolled material is sometimes furnished to provide higher strength levels.

The nickel alloys are readily fabricated by standard fabrication practices. The materials are covered by a variety of specifications and are assigned maximum allowable stresses in the ASME Boiler and Pressure Vessel Code.

The Alloy 200 and Alloy 201 provide high thermal and electrical conductivity in comparison to nickel base alloys, stainless and low alloy steels. The Alloy 200 and Alloy 201 are ferromagnetic.

Because long-time exposures of Alloy 200 alloy in the 800 to 1200°F (427 to 649°C) range result in precipitation of a carbon containing phase and loss of ductility, the Alloy 200 alloy is not recommended for service above 600°F (316°C). In applications above 600°F (316°C), however, the low carbon Alloy 201 may be considered. As proposed service temperatures approach 800°F, (427°C), resistance to creep should be considered a design criterion.

FORMS AND CONDITIONS AVAILABLE

The Alloy 200 and Alloy 201 are produced in plate, sheet, and strip form. The Alloy 200 and Alloy 201 are furnished in the annealed condition.

SPECIFICATIONS

The Alloy 200 and Alloy 201 are covered by ASTM, ASME and AMS specifications, as shown in the following table.

Alloy 200 / Alloy 201

Product Form	Specification		
	ASTM	ASME	AMS
Plate, Sheet and Strip	B162	SB162	5553 (N02201 only)
Clad Plate	A265	SA265	
Rod and Bar	B160	SB160	
Seamless Tube and Pipe	B161 B163	SB161 SB163	
Fittings	B366		

TYPICAL COMPOSITION

Element	Percent
Nickel + Cobalt	Balance
Copper	0.02
Iron	0.05
Manganese	0.02
Carbon	0.15 maximum (AL 200 Alloy) 0.02 maximum (AL 201 Alloy)
Silicon	0.05
Sulfur	0.002

PHYSICAL PROPERTIES

Density 0.322 lb/in^3
8.90 g/cm^3

Specific Gravity 8.90

Alloy 200 / Alloy 201

Linear Coefficient of Thermal Expansion			
Temperature Range		Mean Coefficient of Thermal Expansion (Units of 10^{-6})	
°F	°C	/°F	/°C
(-300) - 80	(-184) - 27	5.8	10.4
(-100) - 80	(-73) - 27	6.3	11.2
80 - 200	27 - 93	7.4	13.3
80 - 400	27 - 204	7.7	13.9
80- 600	27 - 316	8.0	14.4

Thermal Conductivity			
Temperature Range		Average Thermal Conductivity	
°F	°C	Btu-ft/h-ft^2-° F	W/m•K
-200	-129	44.6	77.2
212	100	38.8	67.1
400	204	35.4	61.3
600	316	36.5	56.3

Electrical Resistivity		
Temperature		Resistivity microhm-cm
°F	°C	
-320	-196	1.7
-100	-73	4.8
80	27	8.5
200	93	11.8
600	315	26.6
1000	538	38.6

Specific Heat 0.106 BTU/lb°F
(Room Temperature) 456 J/kg·K

Magnetic Permeability Ferromagnetic

Curie Temperature 670 °F (357 °C)

Saturation Magnetization ~6400 Gauss

Temperature °F °C	Elastic Modulus (E) Units of 10^6psi GPa	Modulus of Rigidity (G) Units of 10^6 psi GPa	Poisson's Ratio (μ)
70 21	30.0 207	11.7 81	0.31

CORROSION RESISTANCE

The Alloy 200 and Alloy 201 are used principally in reducing or neutral environments. The alloys may also be used in oxidizing environments that cause formation of a passive oxide film.

Examples of environments in which Alloy 200 and Alloy 201 have been used are caustics, high temperature halogens and salts other than oxidizing halides. They are also used for food processing.

The nickel content of the alloys renders them virtually immune to chloride stress corrosion cracking. The Alloy 200 and Alloy 201 have been used in fresh and many other process waters.

The Alloy 200 and Alloy 201 have been used in caustic solutions such as those encountered in the production of caustic soda when chlorate level is low.

Nickel is not susceptible to caustic stress corrosion cracking. When chlorate is about 0.1%, as in diaphragm cell technology used in caustic soda production, an iron chromium alloy such as E-BRITE® alloy might be chosen.

Sulfurous atmospheres are corrosive to nickel alloys, especially above 600°F (316°C). Oxidizing mineral acids and oxidizing salts are also corrosive.

MECHANICAL PROPERTIES

Typical Short Time Tensile Properties as a Function of Temperature

The following tables illustrate the short time room and elevated temperature tensile properties of annealed Alloy 200 and Alloy 201. The tables indicate that Alloy 200 alloy is stronger than Alloy 201 in the annealed condition. Specifications generally recognize this difference by assigning lower minimum yield and tensile strength values to Alloy 201 than to Alloy 200 alloy.

Alloy 200

Temperature		Yield Strength 0.2% Offset		Ultimate Tensile Strength		Elongation
°F	° C	psi	MPa	psi	MPa	Percent in 2"
68	20	21,500	148	67,000	462	47
200	93	21,000	145	66,500	458	46
400	204	20,200	139	66,500	458	44
600	316	20,200	139	66,200	456	47

Alloy 201

Temperature		Yield Strength 0.2% Offset		Ultimate Tensile Strength		Elongation
°F	° C	psi	MPa	psi	MPa	Percent in 2"
68	20	15,000	103	58,500	403	50
200	93	15,000	103	56,100	387	45
400	204	14,800	102	54,000	372	44
600	315	14,300	98	52,500	362	42
800	427	13,500	93	41,200	284	58

The tensile properties of both alloys can be significantly enhanced by cold working. In plate products, this can be achieved by control of finishing temperature in hot rolling and elimination of the anneal that follows hot rolling. Sheet and strip can be cold rolled to higher strength. The typical range of enhancement of room temperature properties is shown in the next table. These properties depend on thermomechanical history and section size and cannot be developed in all gages.

Typical Property Ranges in Cold Worked Alloy 200 and Alloy 201

Product	Yield Strength 0.2% Offset		Ultimate Tensile Strength		Elongation
	psi	MPa	psi	MPa	Percent in 2"
Plate (As Hot Rolled)	20,000-80,000	138-552	55,000-100,000	379-690	55-35
Sheet (Hard Cold Rolled)	70,000-105,000	483-724	90,000-115,000	621-793	15-2
Strip (Spring Temper)	70,000-115,000	483-793	90,000-130,000	621-896	15- 2

IMPACT RESISTANCE

Material Condition	Charpy V-Notch Impact	
	Ft.-lbs	Joules
Hot Rolled	200	271
Annealed	200	271
Cold Rolled and Stress Relieved	228	309

HEAT TREATMENT

Considerable latitude exists in heat treating temperature for Alloy 200 and Alloy 201. Temperatures in the range of 1300°F (704°C) to 1700°F (927°C) may be employed. Batch anneal cycles which employ long furnace times should use lower temperatures. Continuous anneal cycles which employ short times should use higher temperatures. If heavy forming is required, anneal time may be increased to provide fully soft material.

Sulfur, phosphorus, lead, zinc and other low-melting metals are potential contaminants which must be avoided. Only clean materials should be exposed to heat treating operations.

Exposure of Alloy 200 and Alloy 201 to oxygen at heat treating temperature results in formation of a surface oxide. Reducing atmospheres such as dry hydrogen are preferred to maintain a scale-free surface.

FORMABILITY

Alloy 200 and Alloy 201 respond readily to commercial fabrication practices. Annealed mechanical properties are similar to those of mild steel but forming operations work-harden the material. Intermediate anneals should be considered for extensive cold forming.

WELDING

Alloy 200 and Alloy 201 may be joined by a wide variety of processes including inert gas welding processes, resistance welding, soldering and brazing. In all of these procedures, thorough cleaning of the joint area is necessary to avoid embrittlement from such sources as lubricants, paints and marking devices.

Welding procedures for Alloy 200 and Alloy 201 are similar to those used for austenitic stainless steels. Neither preheating, nor post-weld heat treatment are generally required. Joint design is similar to that used for austenitic stainless steels with two exceptions. The first is the need to accommodate the sluggish nature of the molten weld metal, necessitating a joint design sufficiently open to allow full filler wire access to fill the joint. The second is the high thermal conductivity and purity of the material which makes weld penetration lower than in austenitic stainless steels.

A variety of stabilized nickel base fillers such as Nickel Electrode 141, Nickel 61 or Inco-Weld A*, are available to join Alloy 200 or Alloy 201 sections. Materials such as Inconel* Electrode 182 or 141, Inco-Weld A or Inconel 82, or Filler Metal 61 are used for joining the Alloy 200 or Alloy 201 to a variety of dissimilar materials.

Special care should be taken in choice of filler metals for joining of Alloy 201. These materials should be low in carbon and stabilized to avoid introduction of free carbon to Alloy 201 with consequent potential for embrittlement at higher operating temperatures.

COMMON APPLICATIONS

- Food manufacturing such as handling of cooling brine, fatty acids and fruit juices due to the material’s resistance against acids, alkalis and neutral salt solutions and against organic acids.
- Tanks in which fluorine is produced and where it reacts with hydrocarbon (CFC) due to the material’s resistance against fluorine.
- Storage and transport of phenol Production and treatment of caustic soda Production of synthetic fibers and soaps.
- Production of hydrogen chloride and chlorination of hydrocarbons such as benzene, methane and ethane.
- Production of vinyl chloride monomer due to the material’s resistance against dry chlorine gas and hydrogen chloride in increased temperatures.
- Electrical and electronic components Electrode contacts and current conductors in batteries.
- Current conductors in alkali fuels Electrodes for hydrogen production by electrolysis temperatures.