JACQUET

ALLOY 200/201 DATA SHEET

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 % maximum for **Alloy 200** and 0.02 % maximum for **Alloy 201**. Both alloys provide highly ductile mechanical properties over a wide temperature range. Both alloys provide 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.

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

////Because long-time exposures of **Alloy 200** in the 800 to 1 200 °F (427-649 °C) range result in precipitation of a carbon phase and loss of ductility, it is not recommended for service above 600 °F (316 °C). For applications above 600 °F (316 °C), the low carbon **Alloy 201** should be considered.

////For proposed service temperatures approaching 800 °F (427 °C), resistance to creep should be considered as a design factor.

APPLICATIONS///

////INDUSTRIES

////Food production;

////Fluroine generation;

////Storing and transportation of phenol;

////Manufacture and handling of sodium hydroxide;

////Production of hydrochloric acid and chlorination of hydro-carbons such as benzene, methane and ethane;

////Manufacture of vinyl choloride monomer;

////FABRICATIONS

////Heat exchangers;

////Tube sheets;

////Piping;

////Shell plate;

////Tank heads;

////Tanks;

////Storage vessels;

////Mixers;

////Valves.

ALLOY 200/201

STANDARDS //

Product form	Specifications					
	ASTM	ASME	AMS	DIN	VdTÜV	UK
Plate sheet and Strip	B162	SB162	5553 (N02201 only)	17750	345	3072
Rod and Bar	B160	SB160	–	17752	345	3076
Smls Pipe and tubind	B161/B163	SB161/SB163	–	17751	345	3074

CHEMICAL COMPOSITION (%) //

Alloy	C	Mn	S	Si	Cu	Ni+Co	Fe
200	0.15 max	0.35 max	0.01 max	0.35 max	0.25 max	99.00 min	0.40 max
201	0.02 max	0.35 max	0.01 max	0.35 max	0.25 max	99.00 min	0.40 max

MECHANICAL PROPERTIES //

////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** 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 200

Temperature		Yield Strength 0.2 % Offset				Elongation
°F	°C	psi	MPa	psi	MPa	% 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				Elongation
°F	°C	psi	MPa	psi	MPa	% 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	316	14 300	98	52 500	362	42
800	427	13 500	93	41 200	284	58

////THE EFFECTS OF COLD WORKING

////The tensile properties of both **Alloy 200** and **Alloy 201** can be significantly enhanced by cold working. In plate products, this can be achieved by control of the finishing temperature in hot rolling and the 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 the thermomechanical history and section size and cannot be developed in all gages

////TYPICAL PROPERTY RANGES IN COLD WORKED ALLOY 200

Form	**Tensile Strength**		**Yield Strength 0.2 % Offset**		**Elongation**	**Hardness**	
	ksi	**MPa**	**ksi**	**MPa**	**% in 2"**	**Birnell (3 000 kg)**	**Rockwell B**
Rod and Bar							
Hot Fin	60–85	415–585	15–45	105–310	55–35	90–150	45–80
Cold drawn	65–110	450–760	40–100	275–690	35–10	140–230	75–98
CD or HR Ann	55–75	380–520	15–30	105–210	55–40	90–120	45–70
Plate							
Hot Rolled	55–100	380–690	20–80	140–550	55–35	100–150	55–80
HR Ann	55–80	380–550	15–40	105–275	60–40	90–140	45–75
Sheet							
Cold Rolled	90–115	620–795	70–105	480–725	15–2	–	90 **min**
CR Ann	55–75	380–520	15–30	105–210	55–40	–	70 **max**
Tube							
Stress Rel	65–110	450–760	40–90	275–620	35–15	–	75–98
Annealed	55–75	380–520	12–30	85–210	60–40	–	70 **max**
Condenser Tube							
Annealed	55–75	380–520	15–30	105–210	60–40	–	65 **max**
Stress Rel	65–110	450–760	40–90	275–620	35–20	–	75–98

////TYPICAL PROPERTY RANGES IN COLD WORKED ALLOY 200

Form	**Tensile Strength**		**Yield Strength 0.2 % Offset**		**Elongation**	**Hardness**	
	ksi	**MPa**	**ksi**	**MPa**	**% in 2"**	**Birnell (3 000 kg)**	**Rockwell B**
Rod and Bar							
HF, HF Ann	50–60	345–415	10–25	70–170	60–40	75–100	–
Cold drawn	60–100	415–690	35–90	240–620	35–10	125–200	–
CD Ann	50–60	345–416	10–25	70–170	60–40	75–100	–
Plate							
Hot Rolled	50–70	345–485	12–35	83–240	60–35	–	–
HR Ann	50–70	345–485	12–35	83–240	60–40	–	–
Tube, Pipe							
CD Ann	50–70	345–485	10–28	70–195	60–40	–	62 **max**
Stress Rel	60–105	415–725	30–85	205–585	35–15	–	75–98

////IMPACT STRENGTH

////As measured by Charpy impact tests, **Alloy 200** is one of the toughest metals. Both hot rolled and annealed samples have higher impact strength than cold-worked material.

////IMPACT PROPERTIES FOR ALLOY 200

Condition	Hardness Birnell (3 000 kg)	Charpy-V		Charpy Torsion			Charpy Tension			
		Ft-lb	J	ft-lb	J	Twist°	Ft-lb	J	Elong. in 3.54 in. (89.9 mm), %	Reduction of area (%)
Hot Rolled	**107**	200	271	29	39	103.5	98	132	20	83.1
Cold Drawn-24 **% reduction, stress-relieved**	177	204	277	35	47	102	88	119	19.5	71.2
Cold Drawn-Annealed at 1 350 **°F (**732 **°C)/**3 **hrs**	109	228	309	29	39	103	113	153	33	75.1

////TYPICAL PROPERTY RANGES IN COLD WORKED ALLOY 200

Condition	Temperature		Tensile Strength		Yield Strength 0.2 % Offset		Elongation	Reduction	Hardness
	°F	°C	ksi	MPa	ksi	MPa	% in 2"	of Area (%)	Rockwell C
Hot Rolled	−310	−190	103	710	–	–	51	–	–
	−292	−180	98	676	28	193	–	–	–
	−112	−80	76.4	527	27.5	190	–	–	–
	room	**room**	65.6	452	24.6	169	50	–	–
Cold Drawn	−110	−79	112.3	774	101.8	702	21.5	60.9	22
	room	**room**	103.4	713	97.4	672	16.3	66.9	19

PHYSICAL PROPERTIES//

Density

0.322 **lb/in**^{3}

8.90 **g/cm**^{3}

Specific Gravity

8.90

Magnetic Permeability

Ferromagnetic
Saturation Magnetization
App. 6 400 **Gauss**

Melting Range

°F = 2615–2635

°C = 1435–1446

Specific Heat

0.109 **Btu/lb-°F**

456 **J/kg-°K**

ALLOY 200/201

THERMAL PROPERTIES

Temperature		Specific Heat		Thermal Conductivity				Electrical Resistivity		Modulus of Elasticity		Coefficient
				Alloy 200		Alloy 201						of Thermal Expansion	
°C	°F	J/kg K	Btu/lb °F	W/m K	Btu in.μ/ft^2 h °F	W/m K	Btu in.μ/ft^2 h °F	μΩ cm	Ω circ mil/ft	kN/mm^2	10^3 ksi	10^{-6}/K	10^{-6}/°F
−200	−328	150	–	78.5	–	93	–	2	–	–	–	10.1	–
−184	−300	–	0.045	–	540	–	640	–	15	–	–	–	5.8
−129	−200	–	0.076	–	530	–	630	–	21	–	–	–	6.8
-100	−148	355	–	75	–	87	–	4.5	–	–	–	11.3	–
-73	−100	–	0.091	–	505	–	590	–	33	–	–	–	6.3
0	32	426	0.102	71.5	500	81	560	8.5	51	207	30	–	–
20	68	456	0.109	70.5	490	79	550	9	54	205	29.7	–	–
93	200	–	0.113	–	465	–	510	–	75	–	29.1	–	7.4
100	212	475	–	66.5	–	73	–	13	–	200	–	13.3	–
200	392	500	–	61.5	–	67	–	19	–	196	–	13.9	–
204	400	–	0.132	–	425	–	460	–	114	–	28.4	–	7.7
300	572	570	–	57	–	60	–	26	–	190	–	14.3	–
316	600	–	0.139	–	390	–	410	–	162	–	27.3	–	8
400	752	530	–	56	–	57	–	33	–	182	–	14.8	–
427	800	–	0.124	–	390	–	390	–	207	–	26.1	–	8.3
500	932	525	–	57.5	–	58.5	–	37	–	175	–	15.2	–
538	1000	–	0.128	–	405	–	410	–	229	–	24.7	–	8.5
600	1112	535	–	60	–	61	–	40	–	165	–	15.6	–
649	1200	–	0.130	–	420	–	430	–	250	–	23.2	–	8.7
700	1292	550	–	62	–	63	–	43	–	153	–	15.8	–
760	1400	–	0.133	–	435	–	445	–	265	–	21	–	8.9
800	1472	565	–	64	–	65.5	–	45	–	140	–	16.2	–
871	1600	–	0.137	–	455	–	465	–	285	–	19.6	–	9.1
900	1652	580	–	66.5	–	68	–	48	–	134	–	16.5	–
982	1800	–	0.144	–	470	–	480	–	305	–	–	–	9.3
1000	1832	590	–	69	–	70.5	–	51	–	–	–	16.7	–

CORROSION RESISTANCE//

////**Alloy 200** and **Alloy 201** are used primarily in reducing or neutral environments. The alloys may also be used in oxidizing environments that cause the 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 in the food processing industry.

////The nickel content of these alloys renders them virtually immune to chloride stress corrosion cracking. The alloys have been used in fresh and many other process waters with superior results.

////**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 might be preferred.

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

////AQUEOUS CORROSION DATA

Test Environment		Temperature		Corrosion Rate
Name	Media & Concentration	°F	°C	mpy
Acetic Acid	5 % CH_3CO_2H w/ air	70	21	40
Acetic Acid	10 % CH_3CO_2H	86	30	3.4
Acetic Acid	56 % CH_3CO_2H	176	80	66
Acetic Acid	85 % CH_3CO_2H w/ air	70	21	400
Acetic Acid	98 % CH_3CO_2H	241	116	12
Caustic Soda	50 % NaOH	195	90	0.55
Caustic Soda	50 % NaOH	310	155	0.5
Caustic Soda	75 % NaOH	250	120	1
Formic Acid (liquid)	90 % CH_2O_2	70	21	4
Formic Acid (vapor)	90 % CH_2O_2	70	21	7
Hydrochloric Acid	1 % HCl	214	101	680
Hydrochloric Acid	10 % HCl	86	30	80
Hydrochloric Acid	10 % HCl	221	105	8 000
Nitric Acid	10 % H_3PO_4	216	102	12 000
Phosphoric Acid	10 % H_3PO_4	75	24	0.6
Phosphoric Acid	10 % H_3PO_4	214	101	154
Phosphoric Acid	40 % H_3PO_4	75	24	1
Sodium Hypochlorite	500 ppm NaClO	77	25	0.8
Sulfuric Acid	2 % H_2SO_4	70	21	2
Sulfuric Acid	5 % H_2SO_4	140	60	10
Sulfuric Acid	5 % H_2SO_4 w/ air	86	30	61
Sulfuric Acid	19 % H_2SO_4	223	106	110
Sulfuric Acid	20 % H_2SO_4	70	21	4
Sulfuric Acid	50 % H_2SO_4 w/ air	86	30	16
Sulfuric Acid	50 % H_2SO_4	255	124	1 000
Sulfuric Acid	96 % H_2SO_4 w/ air	86	30	10

HEAT TREATMENT//

////Considerable latitude exists in heat treating temperatures for **Alloy 200** and **Alloy 201**. Temperatures in the range of 1 300 °F (704 °C) to 1 700 °F (927 °C) may be employed.
Car or box anneal cycles which employ long furnace times should use the 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.

////Exosure of **Alloy 200** and **Alloy 201** to oxygen at heat treating temperatures 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** can be formed by most common 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.

////COLD FORMING

////**Alloy 200** and **Alloy 201** can be worked by all conventional cold-forming methods. In general, the alloys will behave similarly to mild steel with the exception that because of the higher elastic limit of these alloys, greater force will be required to perform the operations (with **Alloy 201** requiring slightly less force due to its slightly lower range of mechanical properties). As such, manual operations such as spinning and hand hammering are limited to simple shapes. Severe work can be done manually only with the assistance of frequent anneals to restore softness.

////HOT FORMING

////**Alloy 200** and **Alloy 201** can be easily formed to practically any shape. Making sure that the material is at the optimum temperature during deformation is the most important factor in achieving hot malleability. The recommended temperature range for hot forming is 1 200-2 250 °F (650-1 230 °C). Heavy forging should be done above 1600°F (870°C) as the metal stiffens rapidly below this temperature. Light forging below 1200°F (650°C) will produce higher mechanical properties.
In any forming process, care should be exercised to avoid heating above the upper limit of 2 250 °F (1 230 °C).

////MACHINING

////**Alloy 200** and **Alloy 201** can be machined at common commercial rates. The material tends to flow under pressure of the tool cutting edge and form long stringy chips. To avoid a built-up edge, tools should be ground with very high positive rake angles (angles of 40°-45° have been used in some instances). High-speed or cast-ally tools should be used.

////Chip action is substantially better with material in the harder tempers. Cold drawn bar in the as-drawn or stress-relieved condition will machine easier than material in the annealed condition.

WELDING //

////**Alloy 200** and **Alloy 201** can 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 material, 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 are available to join **Alloy 200** or **Alloy 201** sections. Other materials are available for joining **Alloy 200** and **Alloy 201** to dissimilar materials.

Special care should be taken in choosing filler metals to join **Alloy 201**. These materials should be low in carbon and stabilized to avoid the introduction of free carbon to **Alloy 201** with the subsequent potential for embrittlement at higher operating temperatures.