JACQUET

ALLOY 800/800H/800AT DATA SHEET

UNS N08800/UNS N08801/UNS N08811

GENERAL PROPERTIES

//// **Alloy 800** (UNS N08800), **Alloy 800H** (UNS N08810) and **Alloy 800AT** (UNS N08811) are nickel-iron-chromium alloys designed to resist oxidation and carburization at elevated temperatures through 1 900 °F. The nickel content, 32 %, makes the alloys highly resistant both to chloride stress corrosion cracking and to embrittlement from precipitation of sigma phase. The general corrosion resistance is excellent. In the solution annealed condition, **Alloys 800H** and **800AT** have superior creep and stress rupture properties. All three versions of the basic **Alloy 800** have been approved as materials of construction under ASME Boiler and Pressure Valve Code, Section I-Power Boilers, Section III-Nuclear Vessels, and Section VIII-Unfired Pressure Vessels.

Alloys 800, **Alloy 800H** and **Alloy 800AT** are identical except for the higher level of carbon (0.05 to 0.1 %) in **Alloy 800H**, and the addition of up to 1 % aluminum + titanium in **Alloy 800AT**. The **Alloy 800** is normally used in this service at temperatures to approximately 1 100 °F (593 °C). **Alloy 800H** and **Alloy 800AT** are normally used above approximately 1 100 °F (593 °C) where resistance to creep and rupture is required.

APPLICATIONS

//// Industrial Heating Industry radiant tubes, return bends, muffles, retorts and furnace fixtures

//// Petrochemical furnace cracker tubes

//// Hydrocarbon Processing Industry catalyst tubing, convection tubing, outlet manifolds and quenching system piping

//// Power Generation Industry steam superheating tubing, high temperature heat exchangers

STANDARDS

Product form	Specifications			
	ASTM	ASME	AMS	EN/Werkstoff
Plate sheet and Strip	B409	SB409	5871	1.4958/1.4958
Smls Pipe and tubing	B163/B407	SB166/SB409	–	1.4958/1.4958
Welded Pipe and tubing	B514	–	–	1.4958/1.4958
Rod and Bar	B408	SB408	–	1.4958/1.4958
Forgings	B564	SB564	–	1.4958/1.4958

////**Alloy 800**, **Alloy 800H** and **Alloy 800AT** alloys are assigned maximum allowable stresses in the ASME Boiler and Pressure Vessel Code, Section VIII, Division 1, Table UNF 23.2 up to 1 500 °F (816 °C). These alloys are assigned maximum allowable stresses to higher temperatures than almost all other alloys covered in the ASME Code. Comparing the three alloys, **Alloy 800H** and **Alloy 800AT** are assigned higher maximum allowable stresses above 1 200 °F (649 °C), and **Alloy 800** is assigned higher maximum allowable stresses below 1 100 °F (593 °C). This corresponds to the temperature range where short time tensile properties become less important design criteria than resistance to creep and stress rupture

ALLOY 800/800H/800AT

CHEMICAL COMPOSITION (%)

Alloy	C	Mn	P	S	Si	Cr	Ni	Ti	Al	Al + Ti	Cu	Fe	ASTM Grain size
800	0.02	1	0.02	0.01	0.35	21	32	0.4	0.4	–	0.3	39.5	**Not Specified**
800**H**	0.02	1	0.02	0.01	0.35	21	32	0.4	0.4	–	0.3	39.5	5 **or coarsef**
800**AT**	0.02	1	0.02	0.01	0.35	21	32	–	–	1	0.3	39.5	5 **or coarsef**

MECHANICAL PROPERTIES

////TYPICAL PROPERTIES OF ALLOY 800 WHICH WAS ANNEALED AT 1800 °F (928 °C)

Temperature		Yield Strength 0.2 % Offset		Ultimate Tensile Strength		Elongation
°F	°C	psi	MPa	psi	MPa	% in 2"
70	21	43 000	295	87 700	600	44
200	93	39 700	274	81 700	563	43
500	260	34 000	234	76 200	525	39
800	427	33 300	230	74 600	514	40
1 000	538	31 700	219	72 000	496	39
1 200	649	29 000	200	54 000	372	56
1 400	760	22 600	156	32 100	221	85
1 500	816	14 200	98	24 800	171	91

////TYPICAL PROPERTIES OF ALLOY 800H AND 800AT WHICH WAS ANNEALED AT 2100 °F (928 °C)

Temperature		Yield Strength 0.2 % Offset		Ultimate Tensile Strength		Elongation
°F	°C	psi	MPa	psi	MPa	% in 2"
70	21	29 000	200	77 000	531	52
200	93	24 100	166	71 000	490	53
600	316	19 000	131	66 600	459	53
800	427	18 100	125	65 800	454	53
1 000	538	16 500	114	63 500	438	51
1 200	649	14 800	102	55 700	384	50
1 400	760	14 400	99	32 300	223	78
1 600	871	11 600	80	18 600	128	120
1 800	982	8 900	61	10 200	70	120

////SHORT TIME ELEVATED TEMPERATURE PROPERTIES

////The two tables above illustrate the short time high-temperature tensile properties f **Alloys 800**, **800H** and **800AT**. The strength of **Alloys 800H** and **800AT** is lower because the heat treatment of **Alloys 800H** and **800AT** at 2 100 °F (1 149 °C) results in a larger grain size to provide better creep and rupture stress rupture resistance. The 1 800 °F (982 °C) anneal of **Alloy 800** results in a finer grain size to provide better cold formability.

ALLOY 800/800H/800AT

PHYSICAL PROPERTIES

Density
0.287 lb/in³
7.94 g/cm³

Magnetic Permeability
75 °F (21 °C) and 200 oersted
1.0006 (15.9 kA/m)
Annealed = 1.014
Hot Rolled = 1.009

Specific Heat
0.11 Btu/lb-°F
460 J/kg-°K

Melting Range
°F = 2475–2525
°C = 1357–1385

ELECTRICAL AND THERMAL PROPERTIES

Temperature		Electrical Resistivity		Thermal Conductivity		Coefficient of Expansion[a]	
°F	°C	Ω circ mil/ft	μΩ cm	Btu.in/ft².h°F	W/m°C	10^{-6} in/in/°F	mm/m/°C
70	20	595	0.989	80	11.5	–	–
100	37	600	1.035	83	13	–	14.4
200	93	620	1.089	89	14.7	7.9	15.9
400	204	657	1.127	103	16.3	8.8	16.2
600	315	682	1.157	115	17.9	9	16.5
800	426	704	1.191	127	19.5	9.2	16.8
1000	537	722	1.223	139	21.1	9.4	17.1
1200	648	746	1.251	152	22.8	9.6	17.5
1400	760	758	1.266	166	24.7	9.9	18
1600	871	770	1.283	181	27.1	10.2	–
1800	982	776	1.291	214	31.9	–	–
2000	1093	788	–	–	–	–	–

[a] : Magnetic Permeability

MODULUS OF ELASTICITY

Temperature		Tensile Modulus		Shear Modulus		Poisson's Ratio (μ)[b]	
°F	°C	10^3 ksi	GPa	10^3 ksi	GPa	English	Metric
–310	–190	30.55	210.6	11.45	78.9	0.334	0.334
75	20	28.50	196.5	10.64	73.4	0.339	0.339
200	100	27.82	191.3	10.37	71.2	0.341	0.343
400	204	26.81	184.8	9.91	68.5	0.353	0.349
600	315	25.71	178.3	9.47	66.1	0.357	0.357
800	426	24.64	171.6	9.04	63	0.363	0.362
1000	537	23.52	165	8.60	60.3	0.367	0.373
1200	648	22.37	157.7	8.12	57.4	0.377	0.373
1400	760	21.06	150.1	7.58	54.3	0.389	0.381
1600	871	19.20	141.3	6.82	50.7	0.408	0.394

[b] : Calculated from moduli of elasticity

ALLOY 800/800H/800AT

CORROSION RESISTANCE //

//// **Alloy 800** is highly resistant, although not totally immune, to stress corrosion cracking. In extensive field experience, **Alloy 800** has shown excellent service performance in many types of equipment in the petroleum, chemical, food, and pulp and paper industries. Thus, although **Alloy 800** may offer a distinct advantage for use in moderately corrosive environments where service experience has indicated a tendency toward stress corrosion cracking of other austenitic stainless steels. However, the alloy is not immune to stress corrosion cracking as judged by the extremely severe magnesium chloride test.

////OXIDATION RESISTANCE

//// **Alloys 800**, **800H** and **800AT** are particularly well suited for high temperature applications such as furnace parts and related heating equipment, for petrochemical reforming units and isocracker tubes, and for handling superheated steam in nuclear and conventional power plants. With the specified high levels of chromium and nickel, the alloys offer superior resistance to oxidation and scaling, and to carburization as well.

//// The following oxidation data for **Alloy 800** were obtained by exposing samples to the indicated temperature for 100 hours in still air and cooling. In general, total weight gains greater than 10 mg/cm² indicate that additional exposure at these temperatures will lead to failure.

//// Since oxidation rates are greatly affected by heating and cooling rates as well as by the atmospheres involved, these data can only be used as approximate guidelines.

////100 HOURS STILL AIR CONTINUOUS OXIDATION TESTS

Alloy	Sample Weight Gain (mg/cm²)				
	1700 °F (927 °C)	1700 °F (927 °C)	1700 °F (927 °C)	1700 °F (927 °C)	1700 °F (927 °C)
Alloy 800	0.77	1.8	2.09	2.1	5.06
T309 Stainless Steel	0.80	1.2	2.1	2.5	4.0
T310 Stainless Steel	0.80	1.1	2.6	3.2	5.2

////CORROSION RATES IN REFINERY FURNACE ATMOSPHERE

Alloy	Corrosion Rate	
	mpy	mm/y
Alloy 800H, 800AT	6.0	0.15
T309 Stainless Steel	8.9	0.23
T310 Stainless Steel	84.5	2.15
T304 Stainless Steel	Complete Oxidation	Complete Oxidation

////CORROSION RATES IN REFINERY FURNACE ATMOSPHERE

////The high nickel content of **Alloys 800H** and **800AT** provided good resistance to carburizing environments.

////RESULT OF 100 HOUR GAS-CARBURIZATION TESTS IN HYDROGEN + 2 % METHANE

Alloy	Weight Gain (mg/cm²)	
	1700 °F (925 °C)	1800 °F (980 °C)
Alloy 600	2.66	–
Alloy 601	2.72	4.32
Alloy 800H, 800AT	4.94	11.6
T330 Stainless Steel	6.42	12.4

////RESULTS OF GAS-CARBURIZATION TESTS AT 2000 °F (1095 °C) 25 HOURS TESTS IN HYDROGEN + 2 % METHANE

Alloy	Weight Gain (mg/cm²)
Alloy 600	2.78
Alloy 800H, 800AT	5.33
T310 Stainless Steel	18.35
T309 Stainless Steel	18.91

////RESULTS OF GAS-CARBURIZATION TESTS AT 2000 °F (1095 °C) 100 HOURS TESTS IN HYDROGEN + 2 % METHANE & 5 % ARGON

Alloy	Weight Gain (mg/cm²)
Alloy 600	12.30
Alloy 601	16.18
Alloy 800H, 800AT	21.58
T330 Stainless Steel	24.00

////SULFIDATION

////Because of their high chromium content, **Alloys 800H** and **800AT** have good resistance to many sulfur-containing atmospheres at high temperatures.

////RESULTS OF GAS-CARBURIZATION TESTS AT 2000 °F (1095 °C) 100 HOURS TESTS IN HYDROGEN + 2 % METHANE & 5 % ARGON

Alloy	Weight Loss (mg/cm²)	
	1100 °F (600 °C)	1290 °F (700 °C)
Alloy 601	15.6	79.3
Alloy 800H, 800AT	29.5	147
T310 Stainless Steel	32.6	138.4
T304 Stainless Steel	37.8	191.6

////NITRIDING

////Studies show that the resistance of nickel-iron-chromium alloys to nitriding increases with the increase of the nickel content. Although **Alloy 600** (76 % nickel) is usually preferred for nitriding service, **Alloys 800H** and **800AT** (32 % nickel) still have good resistance to many nitriding atmospheres.

////RESULTS OF NITRIDING TESTS AT 1000 °F (540 °C) 3 YEARS TESTS IN 65 % HYDROGEN AND 35 % NITROGEN AT 11 KSI (75.8 MPA)

Alloy	Depth of nitriding			
	1 Year		3 Years	
	in.	mm	in.	mm
Alloy 800**H,** 800**AT**	0.0054	0.137	0.0053	0.135
T310 **Stainless Steel**	0.0088	0.224	0.0092	0.234
T309 **Stainless Steel**	0.0095	0.241	0.0096	0.244
T446 **Stainless Steel**	0.0417	1.059	0.0453	1.151
T304 **Stainless Steel**	0.0427	1.085	0.0440	1.118

FORMABILITY //

////**Alloy , 800H, 800AT** exhibit excellent cold forming characteristics normally associated with chromium-nickel stainless steels. The high nickel content prevents the austenite to martensite transformation which can occur when **T301** or **T304** stainless steel are cold worked. The alloys have a lower work hardening rate than **T301** or **T304** stainless steels and can be used in multiple draw forming operations where large amounts of deformation occur between anneals.

////As a consequence of the anneal cycle used on the **800H** and **800AT** alloys the large grain size produces a visibly undulated surface called “orange peel” after forming.

HEAT TREATMENT ///

////The anneal cycle conducted on **Alloy 800** is typically in the 1 800-1 900 °F (982-1 038 °C) range. The purpose is to soften the material after forming operations while maintaining a relatively fine grain size.

////The heat treatment conducted on the **800H** and **800AT** alloys is typically in the range of 2 050-2 150 °F (1 121-1 177 °C). In addition to softening the material after forming operations, an additional purpose of this heat treatment is the development of larger grains for improved resistance to creep and rupture.

WELDING //

////The **Alloy 800**, **800H** and **800AT** alloys can be joined by tungsten arc (GTAW), gas consumable electrode (MIG), or by stick electrode welding techniques commonly used on stainless steels. A number of welding rods and wires are commercially available for joining the **800** series of alloys. Since these alloys form tightly adhering scales, which can be removed only be grinding, inert gas shielding is desirable.