Nickel Based Superalloy Hastelloy B-3 (UNS N10675)

Hastelloy B-3 is manufactured for providing excellent resistance to reducing acids at the different content %s and temperature limits. It shows better stability over Hastelloy B2. Good ductility while prolong exposures at medium temperatures.

Hastelloy B-3 alloy is comprised of good chemical structure to obtain the fine thermal stabilization. It provides outstanding resistance to pitting corrosion and stress corrosion cracking and in the heated sections.

Chemical Composition

Nickel (Ni)	65 %
Chromium (Cr)	1 to 3%
Molybdenum (Mo)	27 **to** 32 %
Manganese (Mn)	1 %
Copper (Cu)	0.2 %
Silicon (Si)	0.1 %
Carbon (C)	0.01 %
Sulfur (S)	0.01 %
Phosphorous (P)	0.03 %
Titanium (Ti)	0.2 %
Aluminum (Al)	0.5 %
Cobalt (Co)	3 %
Niobium (Nb)	0.2 %
Vanadium (V)	0.2 %
Iron (Fe)	1 to 3 %

Physical Properties

Density	0.333 lb/in.3	At room temperature
Melting Point	2500-2585oF	

Electric Resistivity

oF	μΩ-inch	oC	μΩ-cm
Room temp	53.8 μΩ-inch	Room temp	137 μΩ-cm
200 of	53.9 μΩ-inch	100 oC	137 μΩ-cm
400 of	54.1 μΩ-inch	200 oC	137 μΩ-cm
600 of	54.3 μΩ-inch	300 oC	138 μΩ-cm
800 of	54.4 μΩ-inch	400 oC	138 μΩ-cm
1000 of	55.4 μΩ-inch	500 oC	140 μΩ-cm
1200 of	57.5 μΩ-inch	600 oC	143 μΩ-cm
1400 of	54.7 μΩ-inch	700 oC	142 μΩ-cm
1600 of	52.6 μΩ-inch	800 oC	137 μΩ-cm
1800 of	51.2 μΩ-inch	900 oC	132 μΩ-cm
		1000 oC	130 μΩ-cm

Average Coefficient Of Thermal Expansion

Temperature		μinches/in- deg f	Meter/meter-deg C
78 of to 200 of	25 oC to 100 oC	5.7	10.6 x 10(-6)
78 of to 400 of	25 oC to 200 oC	6.1	11.1 x 10(-6)
78 of to 600 of	25 oC to 300 oC	6.3	11.4 x 10(-6)
78 of to 800 of	25 oC to 400 oC	6.5	11.6 x 10(-6)
78 of to 1000 of	25 oC to 500 oC	6.6	11.8 x 10(-6)
78 of to 1200 of	25 oC to 600 oC	6.5	11.8 x 10(-6)
78 of to 1400 of	25 oC to 700 oC	7.1	12.2 x 10(-6)
78 of to 1600 of	25 oC to 800 oC	7.6	13.1 x 10(-6)
78 of to 1800 of	25 oC to 900 oC	8	13.9 x 10(-6)
	25 oC to 1000 oC		14.4 x 10(-6)

Thermal Diffusivity

Temperature		Inch 2 per sec	Cm2 per sec
Room temp	Room temp	4.6 x 10 (-3)	3 x 10 (-3)
200 oF	100 oC	4.9 x 10 (-3)	3.2 x 10 (-3)
400 oF	200 oC	5.4 x 10 (-3)	3.4 x 10 (-3)
600 oF	300 oC	5.8 x 10 (-3)	3.7 x 10 (-3)
800 oF	400 oC	6.3 x 10 (-3)	4 x 10 (-3)
1000 oF	500 oC	6.8 x 10 (-3)	4.4 x 10 (-3)
1200 oF	600 oC	7.3 x 10 (-3)	4.5 x 10 (-3)
1400 oF	700 oC	7.5 x 10 (-3)	4.9 x 10 (-3)
1600 oF	800 oC	7 x 10 (-3)	4.7 x 10 (-3)
1800 oF	900 oC	7.4 x 10 (-3)	4.5 x 10 (-3)

Thermal Conductivity

Temperature		Btu-inch/ft2.hr.of	W/m-K
Room temp	Room temp	78	11.2

200 of	100 oC	83	12.1
400 of	200 oC	93	13.4
600 of	300 oC	104	14.8
800 of	400 oC	116	16.3
1000 of	500 oC	129	17.9
1200 of	600 oC	142	19.6
1400 of	700 oC	156	21.4
1600 of	800 oC	172	23.3
1800 of	900 oC	188	25.4
	1000 oC		27.5

Specific Heat Capacity

of	oC	Btu/lb.of	J/Kg-K
Room temp	Room temp	0.089	373
200 of	100 oC	0.092	382
400 of	200 oC	0.098	409
600 of	300 oC	0.102	421
800 of	400 oC	0.104	431
1000 of	500 oC	0.104	436
1200 of	600 oC	0.112	434
1400 of	700 oC	0.143	595
1600 of	800 oC	0.138	589
1800 of	900 oC	0.137	577

Room Temperature Mean Thermal Stability

Test temperature		time, hrs	Tensile strength		Yield strength		Elongation	Reduced area %	Charpy notch impact
Nil		Nil	129.1 ksi	890 Mpa	55.8 ksi	385 Mpa	60.4 %	73 %	264 ft-lbs
358 of	425 oC	1000	130.5 ksi	900 Mpa	58.8 ksi	405 Mpa	57.2 %	71.7 %	264 ft-lbs
358 of	425 oC	4000	131 ksi	905 Mpa	59.5 ksi	410 Mpa	56.8 %	71.6 %	264 ft-lbs
358 of	425 oC	8000	126.3 ksi	870 Mpa	57.1 ksi	395 Mpa	57.4 %	70.5 %	264 ft-lbs
358 of	425 oC	12000	127.3 ksi	880 Mpa	58.9 ksi	405 Mpa	57.5 %	70.4 %	264 ft-lbs
358 of	425 oC	16000	132.6 ksi	915 Mpa	59.6 ksi	410 Mpa	57.6 %	71.4 %	264 ft-lbs
900 of	480 oc	1000	140.8 ksi	970 Mpa	77.5 ksi	535 Mpa	50 %	67.1 %	262 ft-lbs
900 of	480 oc	4000	144.6 ksi	995 Mpa	84 ksi	580 Mpa	48.3 %	65.5 %	264 ft-lbs
900 of	480 oc	8000	139.2 ksi	960 Mpa	80.5 ksi	555 Mpa	48.9 %	64.4 %	210 ft-lbs
900 of	480 oc	12000	141.1 ksi	975 Mpa	81.7 ksi	565 Mpa	49.9 %	65.2 %	231 ft-lbs
900 of	480 oc	16000	147.7 ksi	1020 Mpa	85.5 ksi	590 Mpa	48.8 %	64.6 %	175 ft-lbs
1000	540 oC	1000	145.8 ksi	1005 Mpa	82.9 ksi	570 Mpa	48.4 %	64.7 %	236 ft-lbs
1000 of	540 oC	4000	152.9 ksi	1055 Mpa	89.1 ksi	615 Mpa	45.6 %	61.4 %	107 ft-lbs
1000 of	540 oC	8000	152 ksi	1050 Mpa	90.7 ksi	625 Mpa	47.1 %	59.5 %	58 ft-lbs
1000 of	540 oC	12000	153.6 ksi	1060 Mpa	92.4 ksi	635 Mpa	44.2 %	59.2 %	82 ft-lbs
1000 of	540 oC	16000	162.7 ksi	1120 Mpa	96 ksi	660 Mpa	43.7 %	57.5 %	58 ft-lbs
1100 of	595 oC	1000	169.2 ksi	1165 Mpa	104.1 ksi	720 Mpa	38.8 %	54.9 %	25 ft-lbs
1100 of	595 oC	4000	178.5 ksi	1230 Mpa	117.8 ksi	810 Mpa	31.5 %	37.2 %	15 ft-lbs
1100 of	595 oC	8000	175.3 ksi	1210 Mpa	118.5 ksi	815 Mpa	28.7 %	35.7 %	13 ft-lbs
1100 of	595 oC	12000	178.1 ksi	1230 Mpa	120.4 ksi	830 Mpa	26.4 %	31.7 %	13 ft-lbs
1100 of	595 oC	16000	186 ksi	1280 Mpa	126.1 ksi	870 Mpa	25.3 %	29.6 %	8 ft-lbs

Dynamic Modulus of Elasticity

Temperature, oF		Dynamics of modulus of elasticity,	
Room temp	Room temp	31.4 x 10-6 psi	216 GPa
200 of	100 oC	30.9 x 10-6 psi	213 GPa
400 of	200 oC	30.1 x 10-6 psi	208 GPa
600 of	300 oC	29.3 x 10-6 psi	202 GPa
800 of	400 oC	28.3 x 10-6 psi	197 GPa
1000 of	500 oC	27.2 x 10-6 psi	190 GPa
1200 of	600 oC	26.5 x 10-6 psi	185 GPa
1400 of	700 oC	24.9 x 10-6 psi	178 GPa
1600 of	800 oC	23.3 x 10-6 psi	168 GPa
1800 of	900 oC	21.6 x 10-6 psi	157 GPa
	1000 oC		147 GPa

Fabrication

The improved thermal firmness of B-3 alloy reduces the complications of fabrication of components as occurred in B-2 alloy. This is feasible due to minimum capacity of alloy to precipitate the toxic intermetallic phases in B-3 alloy, so it receives more ductility over alloy B-2 in the various thermal cycling environments. Alloy B-3 offers an improved overall formation and weldable features. It can be forged or hot processed at the temperatures of 2250oF or 1230oC for time required to get the entire sample at the same temperature limit. Alloy B-2 is a low carbon concentration material, reduced hot finishing temperatures are required to obtain the controlled grain size.

Hastelloy B-3 alloy can also be fabricated by cold processing. It is toughened quickly, alloy B-3 parts can be fabricated by using the standard fabrication methods. The controlled analysis in boiling 20 % hydrochloric acid shows that the symmetric resistance to corrosion of B-3 alloy is not affected by cold reduction about 50% than the alloy in the solution hot processed form. **Hastelloy B-3** is welded by following the traditional welding processes though oxyacetylene and submerged arc welding are not preferred when the formed material is required to use in the corrosion service. The special care is taken to avoid the broad heating.

Mechanical Properties

Temperature, oF	Ultimate tensile strength, ksi	0.2 % yield strength, ksi	Elongation %
70 oF	125	60.6	53.4
200 oF	120.7	55.3	56.9
400 oF	110	47	59.7
600 oF	104.4	43.5	63.4
800 oF	102	42.4	62
1000 oF	97.8	39	59

Tensile Properties

Temp, oF		Tensile Strength,		Yield Strength, ksi		Elongation %
Room		125.0 ksi	860 MPa	60.6 ksi	420 MPa	53.4
200	85	120.7 ksi	830 MPa	55.3 ksi	380 MPa	56.9
400	205	110.0 ksi	760 MPa	47.0 ksi	325 MPa	59.7
600	315	104.4 ksi	720 MPa	43.5 ksi	300 MPa	63.4
800	425	102.0 ksi	705 MPa	42.4 ksi	290 MPa	62.0
1000	540	97.8 ksi	675 MPa	39.0 ksi	270 MPa	59.0
1200	650	103.5 ksi	715 MPa	45.8 ksi	315 MPa	55.8

Corrosion Resistance

Acid Media	Weight %	Mean corrosion rate per year	
		Mills per year	Mm per year
Acetic Acid	10	0.2	0.005
Acetic Acid	30	0.2	0.005
Acetic Acid	50	0.2	0.005
Acetic Acid	70	0.2	0.005
Acetic Acid	99	0.7	0.017
Formic Acid	10	0.4	0.010
Formic Acid	20	0.6	0.015
Formic Acid	30	0.6	0.015
Formic Acid	40	0.5	0.013
Formic Acid	60	0.3	0.008
Formic Acid	89	0.2	0.005
Hydrochloric Acid	1	0.3	0.005
Hydrochloric Acid	2	1.2	0.03
Hydrochloric Acid	5	3.8	0.10
Hydrochloric Acid	10	5.5	0.14
Hydrochloric Acid	15	8.6	0.22
Hydrochloric Acid	20	12.1	0.31
Hydrochloric Acid	20	13.6 as welded	0.35 as welded
Hydrochloric Acid	20	80 (50 ppm iron 3+)	2 (50 ppm iron 3+)
Phosphoric Acid	10	2.4	0.06
Phosphoric Acid	30	2	0.05
Phosphoric Acid	50	3	0.08
Phosphoric Acid	85	2.9	0.07
Sulfuric Acid	2	0.4	0.010
Sulfuric Acid	5	0.7	0.018
Sulfuric Acid	10	0.8	0.020
Sulfuric Acid	20	1.2	0.03
Sulfuric Acid	30	1.2	0.03
Sulfuric Acid	30 (50 ppm iron 3+)	18.8	0.48

Sulfuric Acid	40 (50 ppm iron 3+)	1.2	0.03
Sulfuric Acid	50 (50 ppm iron 3+)	1.7	0.04
Sulfuric Acid	50 (as welded)	2.4	0.06
Sulfuric Acid	50 (aged for 48 hours at 1000oF or 540oC)	2	0.05
Sulfuric Acid	60	2.3	0.06
Sulfuric Acid	70	6.6	0.17

Boiling acids corrosion resistance

Acid Medium	Average Corrosion Rates Per Year, Mils (mm)							
	B-3®		B-2		316L		Monel UNS 4400	
50% Acetic Acid	0.2 mpy	0.005 mmy	0.4 mpy	0.010 mmy	0.2 mpy	0.005 mmy	-	-
40% Formic Acid	0.5 mpy	0.013 mmy	0.7 mpy	0.018 mmy	41 mpy	1.041 mmy	2.1 mpy	0.053 mmy
50-55% Phosphoric Acid	3.0 mpy	0.076 mmy	6 mpy	0.152 mmy	18 mpy	0.457 mmy	4.5 mpy	0.114 mmy
50% Sulfuric Acid	1.7 mpy	0.043 mmy	1.2 mpy	0.030 mmy	Above 20,000 mpy	>500 mmy	185 mpy	4.699 mmy
20% Hydrochloric Acid	12 mpy	0.305 mmy	15 mpy	0.381 mmy	Above 20,000 mpy	>500 mmy	1587mpy	40.31 mmy

Aqueous corrosion resistance after cold processing in boiling 20% HCl

% Cold processing	Hardness, Rc	Tensile Strength		Yield Strength		Elongation, %	Annual Corrosion rate (mm)	
0 %	18 Rc	125 ksi	860	62 ksi	425 Mpa	57 %	13 mpy	0.33 mmy
10 %	30 Rc	140 ksi	965 Mpa	100 ksi	690 Mpa	40 %	13 mpy	0.33 mmy
20 %	37 Rc	159 ksi	1095 Mpa	130 ksi	895 Mpa	25 %	13 mpy	0.33 mmy
30 %	41 Rc	180 ksi	1240 Mpa	154 ksi	1060 Mpa	13 %	13 mpy	0.33 mmy
40 %	44 Rc	202 ksi	1395 Mpa	172 ksi	1185 Mpa	9 %	13 mpy	0.33 mmy
50 %	46 Rc	221 ksi	1525 Mpa	183 ksi	1260 Mpa	8 %	13 mpy	0.33 mmy

Applications

Hastelloy B-3 is suitable for employing in the various fields similar to the alloy B-2. Just like B-2, alloy B-3 is not preferred for employing in the ferric or cupric salts because these salts cause the rapid corrosion of alloy. The ferric or cupric salts may be produced when the hydrochloric acid is placed in the contact of iron or copper metals.

Available Forms

Wire, Mesh, Strip, Sheet, Plate, Tubings, Pipes, Rods, Bars, Flanges, Foil