HAYNES International

HAYNES® R-41 alloy

Vacuum-melted, nickel-based HAYNES® R-41 alloy has exceptionally high strength at temperatures in the range of 1200 to 1800°F (649 to 982°C). The alloy is a precipitation-hardening type and strength is developed by various solutioning and aging heat treatments. Because of its high strength and good oxidation resistance, the alloy is being used in afterburner parts and nozzle diaphragm partitions in current gas turbine engines. In the annealed condition, the alloy is ductile and has essentially the same forming characteristics as 18-8 stainless steel and other nickel-based alloys. It is stronger, however, and has a greater resistance to forming. The alloy has been formed with success on drop hammers, expanding mandrels and stretch formers.

Sound fusion welds are dependent on cleanliness and good joint fit-up. Inert-gas-shielded arc welding with a direct current power supply gives best results. Shielding gas should be used for both the arc and back-up. The weld area should be kept cool by use of copper back-up bars or water-cooled fixtures.

Good resistance welds are made by using high tip pressures and short welding times. Clean and well-fitted laying surfaces are essential. Wrought products except wire are normally furnished solution heat-treated at 1975°F (1079°C), rapid quenched. Wire is normally mill annealed.

Mechanical properties can be tailored by selecting various combinations of solutioning and aging treatments. In general, higher solution heat-treating temperatures result in better room-temperature ductility and improved formability. Stress-rupture strength is also improved by this type of treatment. Lower solutioning temperatures produce higher tensile strengths at temperatures up to about 1700°F (927°C). The effect of solution heat-treating temperature on tensile strength and stress-rupture strength is shown on page 3.

HAYNES R-41 alloy is made in the form of sheet, strip, plate, bar, and wire.

The following specifications have been established for R-41 alloy:

Plate, Sheet, and Strip:	AMS5545
Bar (Solution Heat Treated):	AMS5712

PROPERTIES DATA - The properties listed herein are typical or average values based on laboratory tests conducted by the manufacturer. They are indicative only of the results obtained in such tests and should not be considered as guaranteed maximums or minimums. Materials must be tested under actual service conditions to determine their suitability for a particular purpose.

Nominal Chemical Composition, Weight Percent

Nickel[a]	Chromium	Cobalt	Iron	Molybdenum	Titanium	Aluminum	Silicon	Manganese	Carbon	Boron
58	19	11	5*	10	3.1	1.5	0.5*	0.1*	0.09	0.006

* Maximum [a] As balance

Average Physical Properties

Physical Property	Temp., °F	British Units	Temp., °C	Metric Units
Density	70	0.298 lb./in.^{3}	21	8.25 g/cm^3
Melting Range	2385-2450		1310-1345	
Mean Coefficient of Thermal Expansion	70-1000	7.5 microinches/in.-°F	21-538	13.5 x 10^{-6} m/m-K
	70-1200	7.8 microinches/in.-°F	21-649	14.0 x 10^{-6} m/m-K
	70-1400	8.2 microinches/in.-°F	21-760	14.8 x 10^{-6} m/m-K
	70-1500	8.5 microinches/in.-°F	21-816	15.2 x 10^{-6} m/m-K
	70-1600	8.8 microinches/in.-°F	21-871	15.7 x 10^{-6} m/m-K
	70-1700	9.1 microinches/in.-°F	21-927	16.3 x 10^{-6} m/m-K
	70-1800	9.4 microinches/in.-°F	21-982	16.8 x 10^{-6} m/m-K
Thermal Conductivity (Approximate)	300	80 Btu-in./ft.^{2}-hr.-°F	149	11.5 W/m-K
	400	87 Btu-in./ft.^{2}-hr.-°F	204	12.5 W/m-K
	500	95 Btu-in./ft.^{2}-hr.-°F	260	13.6 W/m-K
	600	102 Btu-in./ft.^{2}-hr.-°F	316	14.7 W/m-K
	800	117 Btu-in./ft.^{2}-hr.-°F	427	16.8 W/m-K
	1000	131 Btu-in./ft.^{2}-hr.-°F	538	18.8 W/m-K
	1100	139 Btu-in./ft.^{2}-hr.-°F	593	20.0 W/m-K
	1200	146 Btu-in./ft.^{2}-hr.-°F	649	21.0 W/m-K
	1300	153 Btu-in./ft.^{2}-hr.-°F	704	22.0 W/m-K
	1400	161 Btu-in./ft.^{2}-hr.-°F	760	23.1 W/m-K
	1500	168 Btu-in./ft.^{2}-hr.-°F	816	24.1 W/m-K
	1600	175 Btu-in./ft.^{2}-hr.-°F	871	25.1 W/m-K
Specific Heat	70	0.108 Btu/lb.-°F	21	0.108 cal./g.-°C
Magnetic	70	<1.002 at 200 oersteds	21	<1.002 at 200 oersteds

Tensile Data, Sheet

Form	Condition	Test Temp., °F	Ultimate Tensile Strength, psi	Yield Strength at 0.2% offset, psi	Proportional Limit, psi	Elongation in 2 in., percent	Elastic Modulus psi x 10^6
Sheet, 0.025 in. thick*	Solution heat-treated at 1979 °F, WQ, plus 30 min. at 1950 °F, aged 16 hrs. at 1400 °F, AC	1200 1400 1600	158,800 140,100 100,700	128,400 119,000 76,800	90,800 84,600 47,700	7 4 2	26.9 23.7 15.9
Sheet 0.050 in. thick*	Solution heat-treated at 1975 °F, WQ, plus 30 min. at 1950 °F, AC; aged 16 hrs. at 1400 °F, AC	70 1000 1200 1400 1600 1800 2000	194,800 172,200 171,000 151,100 106,400 41,500 11,400	155,200 140,600 134,900 125,100 81,600 25,600 5,700	117,100 101,900 96,700 96,700 51,600 17,600 4,400	14 14 8 6 5 15 47	32.2 24.0 23.5 19.3 17.4 16.2 -

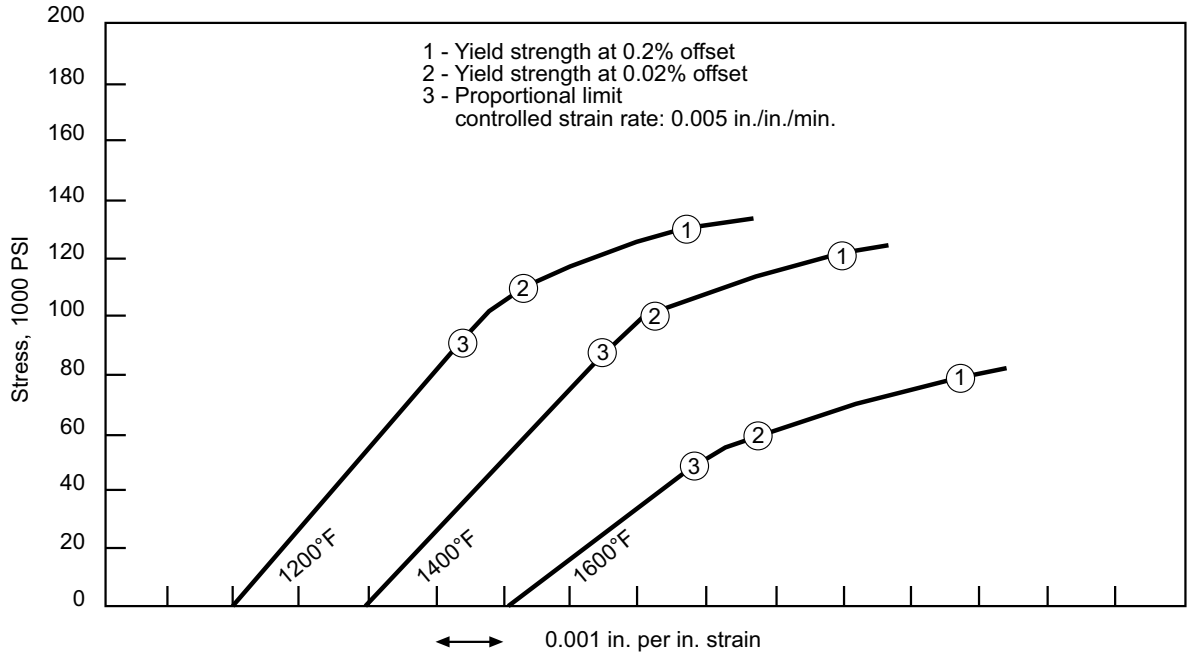
*Strain rates controlled at 0.005 inches per inch per minute to a point beyond the 0.2 percent yield strength.
WQ-Water-Quenched AC-Air-Cooled

Tensile, Stress-Rupture and Hardness Data, Sheet

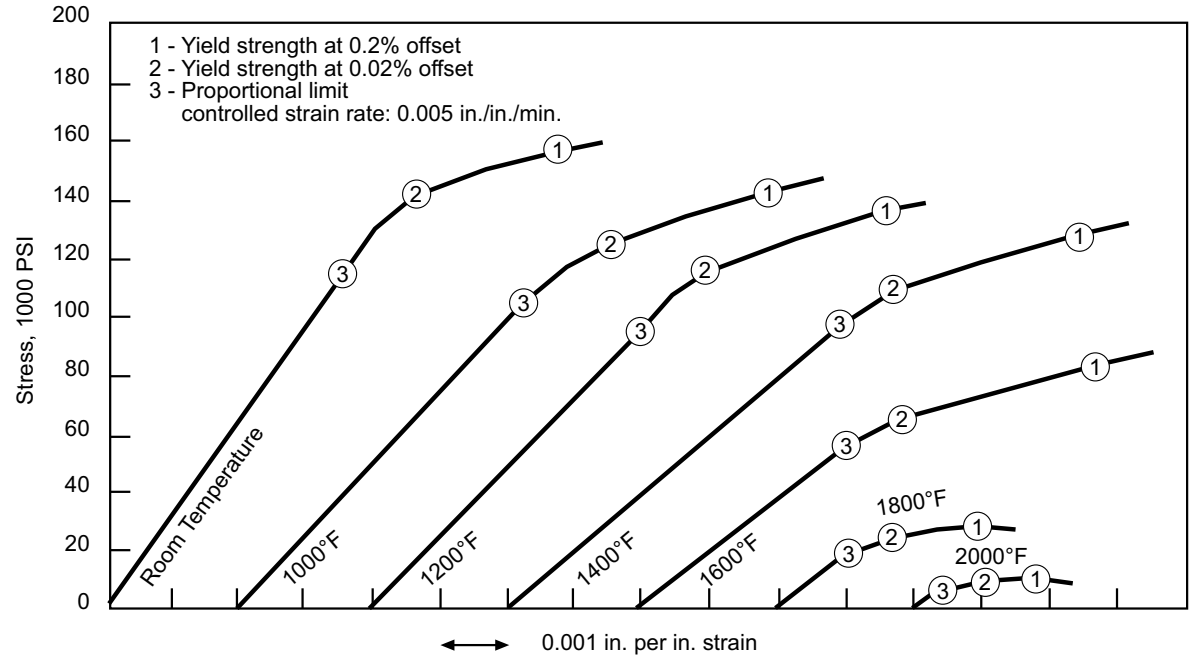
Form	Condition	Test Temp., °F	Ultimate Tensile Strength, psi	Yield Strength at 0.02% offset, psi	Elongation in 2 in., percent	Stress-Rupture at 25,000 psi 1650°F		Rockwell Hardness	
						Life, hrs.	Elongation percent	Annealed	Aged
Sheet less than 0.030-in. thick	30 min. at 1950°F, AC; aged 16 hrs. at 1400°F, AC	1400	144,400[a]	120,500[a]	5[a]	-	-	Rb 86	Rc 39
	30 min. at 2050°F, AC; aged 16 hrs. at 1650°F, AC	1400	131,100[b]	104,200[b]	8[b]	24.3	5	Rb 88	Rc 33
Sheet 0.030-0.100-in. thick excl.	30 min. at 1950°F, AC; aged 16 hrs. at 1400°F, AC	1400	153,700[c]	124,200[c]	10[c]	-	-	Rb 87	Rc 40
	30 min. at 2050°F, AC; aged 16 hrs. at 1650°F, AC	1400	136,500[d]	106,400[d]	12[d]	40.9	11	Rb 97	Rc 34

AC-Air-Cooled Based on statistical average of: a-13 tests; b-46 tests; c-32 tests; d-48 tests

Tensile Stress-Strain Curves for 0.025-in. Sheet*



Tensile Stress-Strain Curves for 0.050-in. Sheet*



* See page 3 for heat-treatment.

Elastic Modulus, Shear Modulus, and Poisson's Ratio

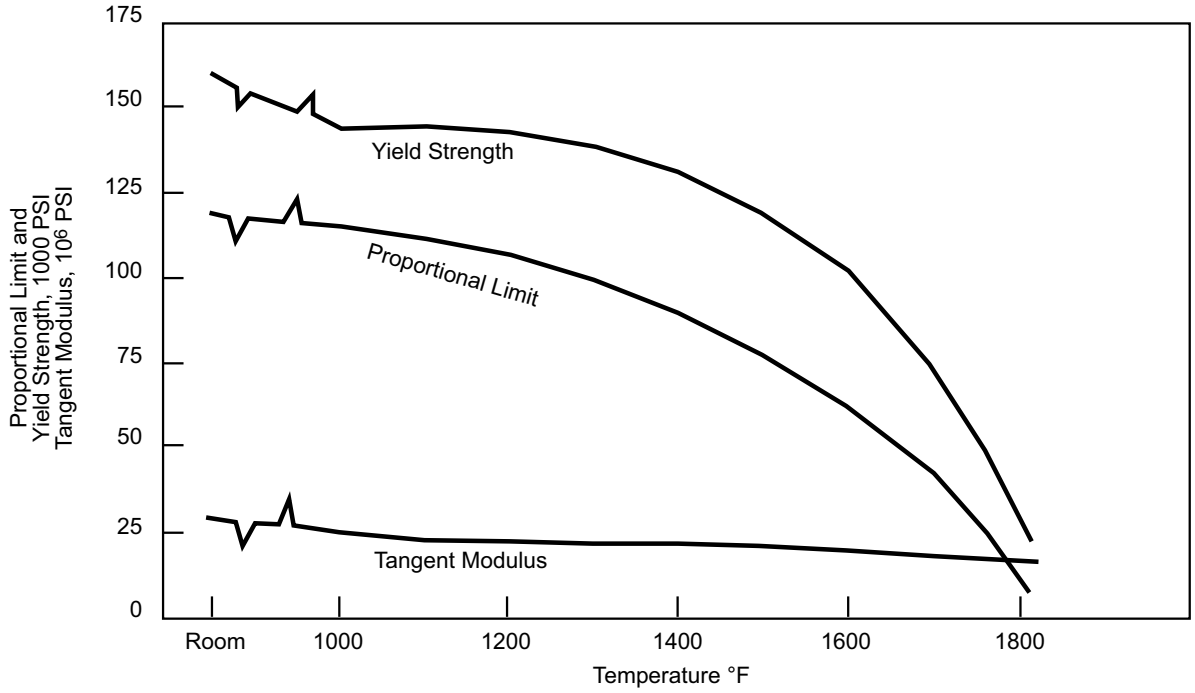
Test Temp., °F	Modulus of Elasticity, psi	Shear Modulus, psi	Poisson's Ratio
80	31,600,000	12,100,000	0.31
300	30,900,000	11,700,000	0.31
500	29,600,000	11,200,000	0.32
700	28,700,000	10,900,000	0.32
900	27,600,000	10,400,000	0.32
1000	27,200,000	-	-
1100	26,400,000	10,000,000	0.33
1200	25,900,000	-	-
1250	25,800,000	9,700,000	0.33
1400	24,800,000	9,300,000	0.33
1500	24,100,000	-	-
1550	23,700,000	8,800,000	0.34
1600	23,200,000	-	-
1700	21,800,000	8,000,000	0.35

Compression Data, Sheet

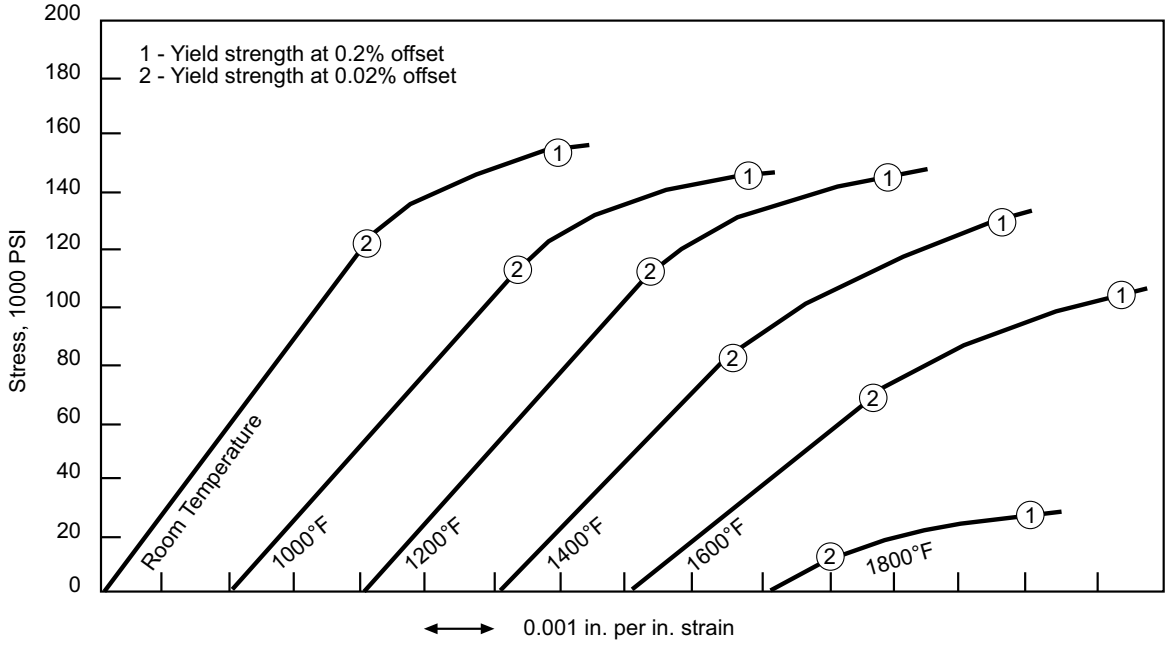
Form	Condition	Test Temp., °F	Yield Strength at 0.2% offset, psi	Proportional Limit, psi	Tangent Modulus, 10^6 psi
Sheet, 0.050 in. thick	Solution heat-treated at 1975°F, WQ; plus 30 min. at 1950°F, AC; aged 16 hrs. at 1400°F, AC	Room	158,700	121,200	30.4
		1000	145,200	113,100	25.9
		1200	147,100	113,400	25.3
		1400	130,100	81,200	23.2
		1600	102,600	68,300	19.7
		1800	27,100	12,200	16.0

WQ - Water-Quenched AC - Air-Cooled

Compression Data, 0.050-in. Sheet*



Compressive Stress-Strain Curves, 0.050-in. Sheet



* See page 5 for heat-treatment.

STANDARD PRODUCTS

By Brand or Alloy Designation:

HAYNES International

HASTELLOY® Family of Corrosion-Resistant Alloys

B-3®, C-4, C-22®, C-276, C-2000®, C-22HS®, G-30®, G-35®, G-50®, HYBRID-BC1™, and N

HASTELLOY Family of Heat-Resistant Alloys

S, W, and X

HAYNES® Family of Heat-Resistant Alloys

25, R-41, 75, HR-120®, HR-160®, 188, 214®, 230®, 230-W®, 242®, 263, 282®, 556®, 617, 625, 65SQ®, 718, X-750, MULTIMET®, NS-163™, and Waspaloy

Corrosion-Wear Resistant Alloy

ULTIMET®

Wear-Resistant Alloy

6B

HAYNES Titanium Alloy Tubular

Ti-3Al-2.5V

Standard Forms: Bar, Billet, Plate, Sheet, Strip, Coils, Seamless or Welded Pipe & Tubing, Pipe Fittings, Flanges, Fittings, Welding Wire, and Coated Electrodes

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