RADATA SHEET

RA330®

Features

- Oxidation resistance to 2200°F
- Resistant to carburization and nitriding
- Resistance to thermal shock
- Good strength at elevated temperature
- Metallurgical stability
- Chloride ion stress corrosion cracking resistance

Applications

- Furnace containers-carburizing, carbonitriding, annealing, malleablizing
- Muffles, retorts
- Quenching fixtures
- Bar frame heat treating baskets
- Heat exchangers
- Radiant tubes
- Salt pots, both neutral and cyanide
- Gas turbine parts
- Conveyors
- Hot pressing platens

Composition

Chromium	18.00 - 20.00
Nickel	34.00 - 37.00
Carbon	0.08 max.
Silicon	1.00 - 1.50[a]
Manganese	2.00 max.
Phosphorus	0.030 max.
Sulfur	0.030 max.
Copper	1.00 max.
Iron	balance

Specifications

UNS N08330 **EN 1.4886**

ASTM B 511, B 512, B 535
B 536, B 546, B 710, B 739
ASME SB-511, SB-535, SB-536, SB-710
AMS 5592, 5716

[a]all product forms except welded pipe and tube, silicon 0.75-1.50

General

RA330 is an austenitic heat and corrosion resisting alloy offering an exceptional combination of strength and resistance to carburization, oxidation and thermal shock. Carburization and oxidation resistance to 2200°F are enhanced by a nominal 1.25% silicon addition. RA330 finds wide application in high temperature industrial environments where good resistance to the combined effects of carburization and thermal cycling is a prime requisite. RA330 remains fully austenitic at all temperatures and is not subject to embrittlement from sigma formation.

Sizes and Availability

RA330 is available from stock in a greater variety of items and product forms than any other heat resisting alloy composition. Refer to current RA stock list for details. Special shapes, sizes or quantities may be mill produced promptly.

Welding

RA330 is readily welded using RA330-04 weld fillers of matching composition. RA 330-04 DC lime type electrodes are available from stock in popular sizes. RA 330-04 bare welding wire is available as straight lengths for GTA welding or spooled for GMA welding.

For best results do not preheat, keep interpass temperature low and use reinforced bead contours. Detailed coverage of heat resistant alloy welding techniques is given in Bulletin 201.

Forming

RA 330 is formed in the same manner as the conventional austenitic stainless steels. The work hardening rate of RA330 is comparable to that of 305 stainless.

Heavy duty lubricants may be used in cold forming to prevent galling and reduce die wear. Lubricants must be removed prior to welding, annealing oruse in high temperature service, to avoid possible hot corrosive attack.

Sulfur-chlorinated lubricants, in particular, must be thoroughly removed. Lubricants containing either sulfur or chlorine should not be used for spinning. The spinning operation tends to burnish the lubricant into the surface of the metal, rendering complete removal difficult.

Forming at room temperature is suggested whenever possible. If hot forming or forging is required, the workpiece should be heated uniformly througout its section to a starting temperature of 2050-2150°F (1120-1180°C), finishing above 1750°F (950°C). Overheating or excessive hold time at starting temperature should be avoided to minimize grain growth.

No forming or bending should be performed in the low ductility range of 1200-1600°F (650-870°C). Forming in this temperature range may cause intergranular tearing in austenitic alloys.

Machining

RA330 and other austenitic grades are quite ductile in the annealed condition. However, these chromium-nickel alloys work harden more rapidly and reuqire more power to cut than do the plain carbon steels. Chips tend to be stringy, cold worked material of relatively high ductility.

Machine tools should be rigid and used to no more than 75% of their rated capacity. Both work piece and tool should be held rigidly; tool overhang should be minimized.

Tools, either high speed steel or cemented carbide, should be sharp, and regound at predetermined intervals. Turning operations require chip curlers or breakers.

Feed rate should be high enough to ensure that the tool cutting edge is getting under the previous cut thus avoiding work-hardened zones. Slow speeds are generally required with heavy cuts. Lubricants, such as sulfur-chlorinated petroleum oil, are suggested. Such lubricants may be thinned with parafin oil for finish cuts at higher speeds. The tool should not ride on the work piece as this will work harden the material and result in early tool dulling or breakage.

All traces of cutting fluid must be removed prior to welding, annealing, or use in high temperature service.

Suggested speeds, surface feet per minute (m/min) with high speed tools

Turning[1,5]	Drilling	Reaming[3]	Milling[4]	Threading and Tapping
30-45 (9-14)	30-45 (9-14)	15-25 (4.6-7.6)	30-40 (9-12)	10-15 (3-4.6)

1. Roughing feeds 0.010 - 0.015 inch per revolution (0.25 - 0.38 mm per revolution)

2. | Drill dia., inch (mm) | | Feed, ipr (mmpr) | |
   |---|---|---|---|
   | 1/16-1/4 | (1.59-6.35) | 0.001-0.0035 | (0.025-0.09) |
   | 1/4-1/2 | (6.35-12.7) | 0.0035-0.005 | (0.09-0.13) |
   | 1/2-1-1/2 | (12.7-38.1) | 0.005-0.008 | (0.13-0.20) |
   | over 1-1/2 | (38.1) | 0.008-0.010 | (0.20-0.25) |

3. Reaming feeds are approximately three times the feed used for a corresponding drill size

4. Feed 0.003 - 0.006 inch (0.08 - 0.15 mm) per tooth

5. With carbide tools use 100 - 175 sfpm (30 -53 m/min) and feeds 0.010 - 0.015 ipr (0.24 - 0.38 mmpr)

Cleaning and Pickling

Machining lubricants or other organic contaminants may be removed from RA330 by alkaline cleaning agents, water-emulsion cleaners or suitable solvents.

Light oxides may be removed by nitric-hydrofluoric acid pickling solution. Heavy hot work or annealing scale may be removed by steel grit blasting,followed by a short pickle in nitric-hydrofluoric, or sulfuric acid, solution, to remove the surface iron contamination. Hot water rinse. RA330 is sensitive to intergranular corrosion in nitric-hydrofluoric pickle baths - limit time in pickle to avoid possible intergranular attack (a.k.a. "sugaring").

Heat Treatment

RA330 is a fully austenitic alloy which does not harden by thermal treatment. Increased room temperature strength may be obtained only by cold working.

The purposes of annealing RA330 are to remove residual forming stresses or to redissolve precipitated carbides. For most high temperature applications, RA330 fabrications are not annealed after forming or welding.

If the final application requires a full anneal, the suggested procedure is to heat in a low-sulfur atmosphere 1950-2050°F (1060-1120°C) long enough to ensure a uniform actual metal temperature, followed by rapid air cooling or quenching to below 800°F (425°C). Residual stresses and work hardening from severe forming operations may be removed by an 1850-1900°F (1010-1040°C) anneal.

Aqueous Corrosion and Stress Corrosion

RA330 has useful resistance to 10-15% sulfuric acid pickling baths. Heat treating baskets of RA 330, required to withstand red heat, have been used to transport the same workload through the pickling bath.

Corrosion in 15% H2SO4 plus 0.15% Oakite® PC-10 inhibitor, 160°F (71°C)

Alloy	Corrosion Rate mils/year	Corrosion Rate mm/year
RA330	18.8	0.478
1018 steel	293	7.44
RA333®	9.85	0.250
600	8.07	0.205
20Cb-3®	5.00	0.127

From Rolled Alloys Investigation 12-84, baskets to anneal and pickle alloy steel parts.

RA330 is highly resistant to chloride ion stress corrosion cracking. This alloy can be a sound engineering choice for those applications where lower alloy materials have failed by stress corrosion.

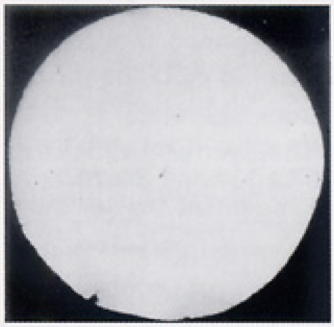
Results in U-Bend Stress Corrosion Tests in 45% Boiling (154°C) Magnesium Chloride

Alloy	Heat No.	Condition	Time to Crack, hours
RA 330	624351	1950°F annealed	144
	"	"	170
	624275	"	NC*
	624351	cold rolled 30%	288
	"	"	216
	624275	"	NC
	"	"	NC
800	HH0907A	annealed 1950°F	<10
	"	"	<10
	HH5555A	"	<10
	"	"	<10
	HH0907A	cold rolled 30%	<10
	"	"	<10
	HH5555A	"	<10
	"	"	<10

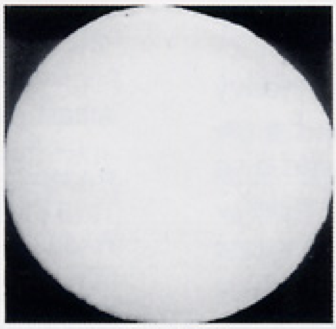
*NC test discontinued in 350 hours.

Prolonged exposure to temperatures in the 1000-1400°F (540-760°C) range, or the heat of welding may sensitize RA330 so that it is susceptible to intergranular corrsion in particularly aggressive aqueous environments. Aqueous corrosion resistance may be restored by a full anneal. This sensitization has little or no effect on the alloy's performance at elevated temperatures.

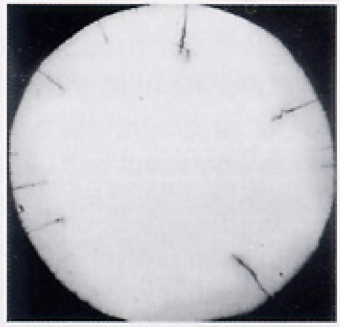
The use of a more highly alloyed weld filler, such as RA333®, is preferred where RA330 fabrications are to be used in aqueous corrosion.



RA330
35Ni-19Cr-1.25Si



Alloy 600
76 Ni-15.5Cr-0.2Si

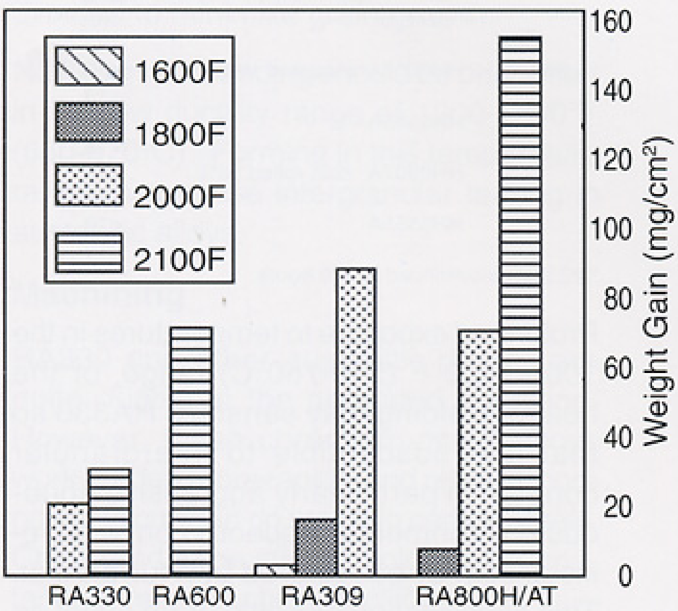


Alloy 800
32.5Ni-21Cr-0.5Si

Oxidation

RA330 is highly resistant to oxidation under cyclic conditions, providing useful service life at extreme temperatures. The following laboratory data illustrate the relative performance of RA330 and other materials at elevated temperature.

CYCLIC OXIDATION TEST
Exposed for 1640 Hours
Cycled Every 160 Hours



Note: Actual weight loss figures are valid only for the specific conditions of the test. Neither this nor other laboratory oxidation data should be used to quantitatively predict metal wastage in actual service.

Carburization

Carburization resistance of materials used for industrial heating applications is a prime consideration in alloy selection. The 35% nickel content of RA330 has long been considered near the optimum for both mechanical properties[1] and carburization resistance.[2] Silicon, maintained at a nominal 1.25%, is recognized as the one element most potent in conferring resistance to carburization.[2-4] Carburization rates are also affected by mechanical and thermal strains which damage the protective scale. Relative carburization resistance of commercial alloys is most reliably studied by exposing the materials to actual service conditions. These samples, cut from a multi-alloy bar frame basket, illustrate the alloys' behavior in commercial heat treating service:

The carbon contents of 0.060 surface turnings from these bars are: RA330 0.35%, 600 0.97%, 800 2.40%. Service: 23 months in commercial heat treat shop, 80% carburizing, 15% carbonitriding, balance neutral hardening.

RA330 HC

A modified grade of RA330, designated RA330HC, is produced to a nominal 0.40% carbon content. RA330HC is stocked in round bars for use as belt pins in cast link furnace belts, and for bolting. A special heat treatment, in combination with the higher carbon content, results in exceptional high temperature strength with some loss in ductility. RA330HC is not suited for formed and welded fixtures intended for liquid quenching service.

Physical Properties

Density[5]

0.287 lb/cu. in.
7944 kg/m³

Melting Range

2450-2540°F
1345-1395°C

Permeability, Annealed

u = 1.009 at H = 2810 oersted

Specific Heat[5]

Temperature, °F	Btu/lb °F	J/kg•K
100	0.117	490
300	0.119	500
500	0.122	510
700	0.124	520
900	0.126	530
1100	0.129	540
1300	0.131	550
1500	0.134	560
1700	0.136	570
1900	0.139	580
2000	0.140	590

Thermal Conductivity[6]

Temperature °F	(°C)	Btu•ft/ft2•hr•°F	W/m•K
75	(24)	7.2	12.5
1000	(538)	12.8	22.1
1200	(648)	13.2	22.9
1400	(760)	13.7	23.8
1500	(815)	14.0	24.2
1600	(871)	14.2	24.6
1800	(981)	14.7	25.4
2000	(1093)	15.1	26.2

Electrical Resistivity[7,8]

Temperature, °F	ohm•circ mil/ft	microhm•m
75	616	1.02
1000	665	1.11
1200	680	1.13
1400	720	1.20
1600	745	1.24
1800	765	1.27
2000	830	1.39

Mean Coefficient of Thermal Expansion

Temperature Range °F	in/in•°F x 10⁻⁶	m/m•K x 10⁻⁶
77 - 200	8.3	14.9
77 - 300	8.4	15.1
77 - 400	8.6	15.5
77 - 500	8.7	15.7
77 - 600	8.9	16.0
77 - 700	9.0	16.2
77 - 1000	9.3	16.7
77 - 1100	9.4	16.9
77 - 1250	9.6	17.3
77 - 1500	9.7	17.5
77 - 1600	9.8	17.6
77 - 1700	9.9	17.8
77 - 1800	10.0	18.0

Elastic Properties

Poisson's Ratio, room temperature 0.297

Temperature °F	(°C)	Dynamic Modulus of Elasticity psi x 106	(MPa)
75	(24)	28.5	(196,000)
200	(93)	28.0	(193,000)
400	(204)	27.0	(186,000)
600	(315)	26.0	(179,000)
800	(426)	25.0	(172,000)
1000	(538)	23.8	(164,000)
1200	(648)	22.3	(154,000)
1400	(760)	21.0	(145,000)
1600	(871)	19.5	(134,000)
1800	(981)	18.0	(124,000)

Mechanical Properties

Typical Room Temperature Mechanical Properties, Mill Annealed

Ultimate tensile strength, psi (MPa)	85,000	(586)
0.2% offset yield strength, psi (MPa)	39,000	(269)
Elongation in 2" (50mm), %	47	
Reduction of area, %	65	
Hardness, Rockwell B	70-85	
ASTM Grain Size	4-7	
Erichsen cup depth, mm, (0.025 inch sheet)	10	

Cryogenic Tensile Properties, Mill Annealed

Temperature °F	(°C)	Ultimate Tensile Strength, psi (MPa)	0.2% Offset Yield Strength psi (MPa)	Elongation %
0	(-18)	87,100 (600)	40,000 (276)	44
-50	(-46)	90,500 (624)	42,700 (294)	43
-100	(-73)	94,500 (652)	44,800 (309)	48
-200	(-129)	105,200 (725)	53,800 (371)	55
-320	(-196)	131,500 (907)	64,400 (444)	52.5

Cryogenic Charpy V-notch Properties9
All Weld Metal Specimens
RA 330-04-15 DC Lime Electrodes

Temperature F°	(C°)	Charpy V-notch ft•lb (J)	Lateral Expansion mils (mm)
-200	(-129)	54.7 (74.2)	44.0 (1.12)
-250	(-157)	42.4 (57.5)	32.7 (0.83)
-320	(-196)	40.4 (54.8)	30.0 (0.76)

Weldment Elevated Temperature Tensile Properties

Test Temperature °F (°C)	Specimen	Ultimate Tensile Strength psi (MPa)	0.2% Offset Yield Strength psi (MPa)	Elonation in 4D, %	Reduction of Area, %
1100 (593)	weldment	69,200 (477)	28,100 (194)	34.1	51.5
	1/2" plate	69,100 (476)	23,500 (162)	43.7	52.5
1200 (648)	weldment	61,400 (423)	34,400 (237)	35.7	47.9
	1/2" plate	58,900 (406)	22,400 (154)	49.0	54.2

Note: Results of single tests. Weldments: 1/2" RA330 plate, Double V-joint, GMAW with 0.045" RA 330-04 filler, argon shielding. Weldment in center of tensile gage length, failure location in base metal. Same heat of 1/2" plate used for all four tests.

Mechanical Properties, Continued

Short Time Elevated Temperature Tensile Properties (average of multiple tests, mill annealed sheet, plate and bar)

Test Temperature °F (°C)	Ultimate Tensile Strength psi (MPa)	0.2% Offset Yield Strength psi (MPa)	Elongation %	Reduction of Area, %
75 (24)	85,600 (590)	37,200 (256)	48	68
200 (93)	79,200 (546)	35,600 (245)	46	62
300 (149)	76,200 (525)	33,100 (228)	46	60
400 (204)	75,300 (519)	31,600 (218)	43	59
500 (260)	74,300 (512)	29,800 (205)	43	58
600 (315)	74,400 (513)	29,600 (204)	45	56
700 (371)	75,100 (518)	29,200 (201)	47	55
800 (426)	74,200 (512)	27,800 (192)	46	46
900 (482)	74,200 (512)	27,200 (188)	47	53
1000 (538)	71,000 (490)	25,000 (172)	46	52
1100 (593)	66,400 (458)	24,200 (167)	46	54
1200 (648)	56,700 (391)	22,000 (152)	43	54
1300 (704)	44,300 (305)	21,000 (145)	69	72
1400 (760)	35,900 (248)	20,700 (143)	78	64
1500 (815)	26,800 (185)	17,300 (119)	56	76
1600 (871)	21,100 (145)	15,400 (106)	79	76
1800 (981)	10,400 (71.7)	8,500 (58.6)	79	60
2200(1204)	3,200 (22.1)	2,000 (13.8)	28	27

Note: At sufficiently elevated temperature metals deform with time under load, even if stressed below the tensile yield point. This deformation is known as creep. For this reason, creep or rupture properties should be considered in any design intended for long time service at temperatures above about 1000°F. (538°C)

Effect of Elevated Temperature Exposure on Room and Short-Time Elevated Temperature Properties of Mill Annealed Bar[10]

Test Temperature °F (°C)	Aging Temperature °F (°C)	Aging Time hours	Ultimate Strength psi (MPa)	0.2% Offset Yield Strength psi (MPa)	El. %	R.A. %	Hardness Rockwell B	Charpy V-notch impact energy ft•lb (J)
75 (24)	none	—	85,000 (586)	34,900 (241)	47.5	70	76.5	240 (325)
75 (24)	1400 (760)	100	88,200 (608)	34,300 (236)	40.5	60.5	79	— —
75 (24)	1400 (760)	1000	88,500 (610)	32,600 (225)	40.5	60.5	83	96 (130)
1400 (760)	none	—	35,000 (241)	18,800 (130)	65	59	—	167 (226)
1400 (760)	1400 (760)	1000	—	—	—	—	—	130 (176)

RA330HC DATA

Short Time Elevated Temperature Tensile Properties, Annealed

Test Temperature °F (°C)	Ultimate Tensile Strength psi (MPa)	0.2% Offset Yield Strength psi (MPa)	Elongation %	Reduction of Area, %
70 (21)	100,000 (689)	50,000 (345)	41	55
1400 (760)	41,700 (288)	30,100 (208)	28	21
1600 (871)	24,200 (167)	20,200 (139)	40	45
1800 (981)	14,800 (102)	12,700 (88)	25	39

RA 330HC Charpy V-notch impact strength, room temperature 41 ft•lb (55.6 J)

Effect of Annealing Temperature on Hardness of Cold Rolled RA330[11]

Annealing Temp. °F	C°	Hardness at Indicated % Cold Reduction, Rb 10	20	40	60
As Rolled		95	101	105	108
1400	760	94	97	102	101
1500	816	90	95	102	91
1600	871	88	92	92	82
1700	927	87	89	81	83
1800	982	87	85	81	82
1900	1038	69	70	71	71
2000	1093	68	68	68	—

Starting material: 11 gage hot rolled annealed sheet

Short Time Elevated Temperature Compressive Strength, Mill Annealed

Test Temperature °F	(°C)	0.2% Offset Yield Strength psi	(MPa)
1400	(760)	19,900	(137)
1500	(816)	17,700	(122)
1600	(871)	15,600	(108)
1700	(927)	11,500	(79.3)
1800	(982)	7,900	(54.5)
1900	(1038)	5,900	(40.7)

Hot Hardness, Mill Annealed

Temperature °F	(°C)	Brinell Hardness No.
70	(21)	145
1400	(760)	56.8
1600	(871)	29.0
1800	(982)	16.5

Note: Brinell type hardness testing was empoyed. Testing was performed with both the penetrator and specimen at the testing temperature. Alll loads were applied for five minutes. These loads for given testing temperatures are as follows: 1400°F (760°C) - 2000 kg, 1600°F (871°C) - 1000 kg, 1800°F (982°C) - 500 kg. Lesser loads were used at higher temperatures to reduce the tendency for the softer material to deform excessively.

Maximum Allowable Design Stresses for ASME Boiler and Pressure Vessel Code, 1999 Addenda Section VIII, Divisions 1 and 2, Plate only

Design stress intensity values, psi (MPa), in tension. U.S. Customary units govern.

Temperature °F	(°C)	Division 1 psi	MPa	Division 2 psi	MPa
-20 to 100	(-29 to 38)	20.0	138	20.0	138
200	(93)	17.7	122	20.0	138
300	(149)	16.4	113	20.0	138
400	(204)	15.5	107	20.0	138
500	(260)	14.7	101	19.7	136
600	(316)	14.0	96.5	18.8	130
650	(343)	13.7	94.5	18.3	126
700	(371)	13.4	92.4	18.1	125
750	(399)	13.1	90.3	17.6	121
800	(427)	12.9	88.9	17.4	120
850	(454)	12.6	86.9	--	--
900	(482)	12.4	85.5	--	--
950	(510)	12.1	83.4	--	--
1000	(538)	11.9	82.0	--	--
1050	(566)	10.0	68.9	--	--
1100	(593)	7.8	53.8	--	--
1150	(621)	6.0	41.4	--	--
1200	(649)	4.7	32.4	--	--
1250	(677)	3.8	26.2	--	--
1300	(704)	3.1	21.4	--	--
1350	(732)	2.4	16.5	--	--
1400	(760)	1.8	12.4	--	--
1450	(788)	1.5	10.3	--	--
1500	(816)	1.1	7.6	--	--
1550	(843)	0.90	6.2	--	--
1600	(871)	0.68	--	--	--
1650	(899)	0.48	--	--	--
Notes		G29, H1, T14		G1, G4	

Division 1 notes

G29 Creep-fatigue, thermal ratcheting, and environmental effects are increasingly significant failure modes at temperatures in excess of 1500°F (815°C) and shall be considered in design.

H1 For temperatures above 1000°F (538°C), these stress values may be used only if the material is annealed at a minimum temperature of 1900°F (1038°C) and has a carbon content of 0.04% or higher.

T14 Allowable stress values for temperatures of 1050°F (565°C) and above are values obtained from time-dependent properties.

Division 2 notes

G1 Due to the relatively low yield strength of these materials, these higher stress values were established at temperatures where the short time tensile properties govern to permit the use of these alloys where slightly greater deformation is acceptable. The stress values in this range exceed 66 2/3% but do not exceed 90% of the yield strength at temperature. Use of these stresses may result in dimensional changes due to permanent strain. These stress values are not recommended for the flanges of gasketed joints or other applications where slight amount of distortion can cause leakage or malfunction. Table Y-2 (see ASME Section II Part D) lists multiplying factors which, when applied to the yield strength values shown in Table Y-1, will give allowable stress values that will result in lower levels of permanent strain.

G4 Design stress intensity values for 100°F (38°C) may be used at temperatures down to -325°F (-198°C) without additional specification requirements.

Creep Strength

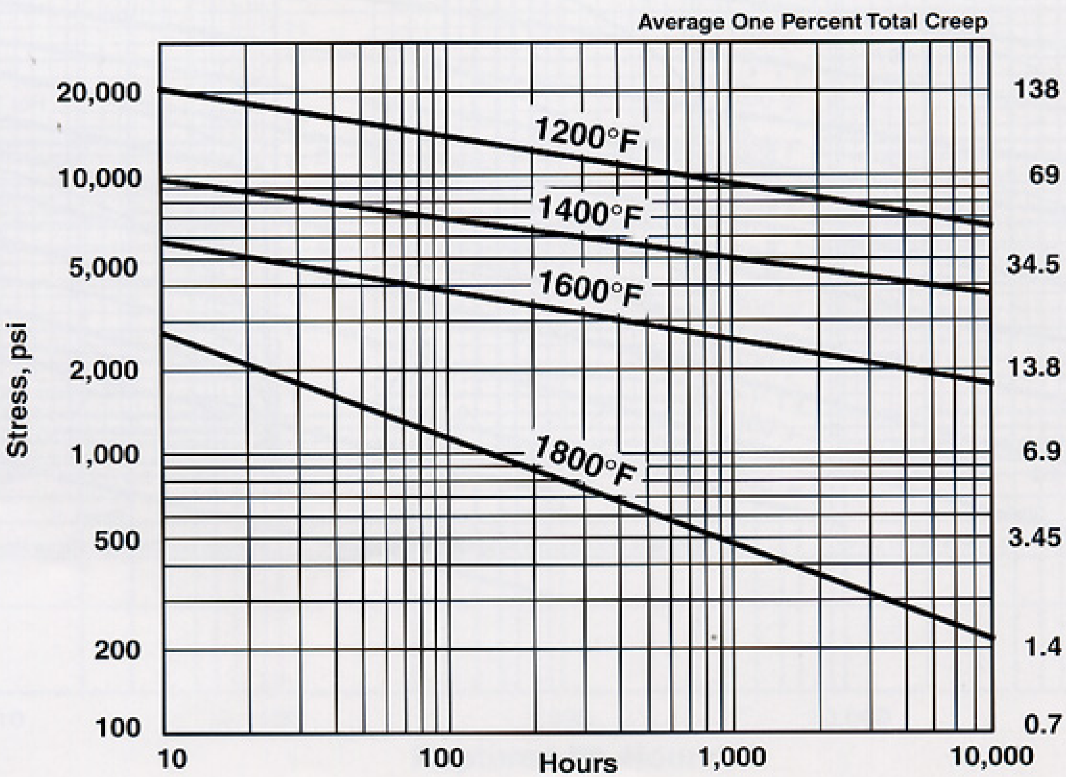
Temperature °F	(°C)	Stress, psi (MPa), for secondary creep rate of 0.00001%/hr		0.0001%/hr	
1000	(538)	14,500	(100)	21,000	(145)
1100	(593)	7,400	(51.0)	10,500	(72.4)
1200	(649)	5,800	(40.0)	7,600	(52.4)
1300	(704)*	3,900	(26.9)	5,300	(36.5)
1400	(760)	2,600	(17.9)	3,600	(24.8)
1500	(816)*	1,900	(13.1)	2,700	(18.6)
1600	(871)	1,500	(10.3)	2,100	(14.5)
1700	(927)*	520	(3.58)	1,000	(6.89)
1800	(982)	290	(2.0)	500	(3.45)

*interpolated

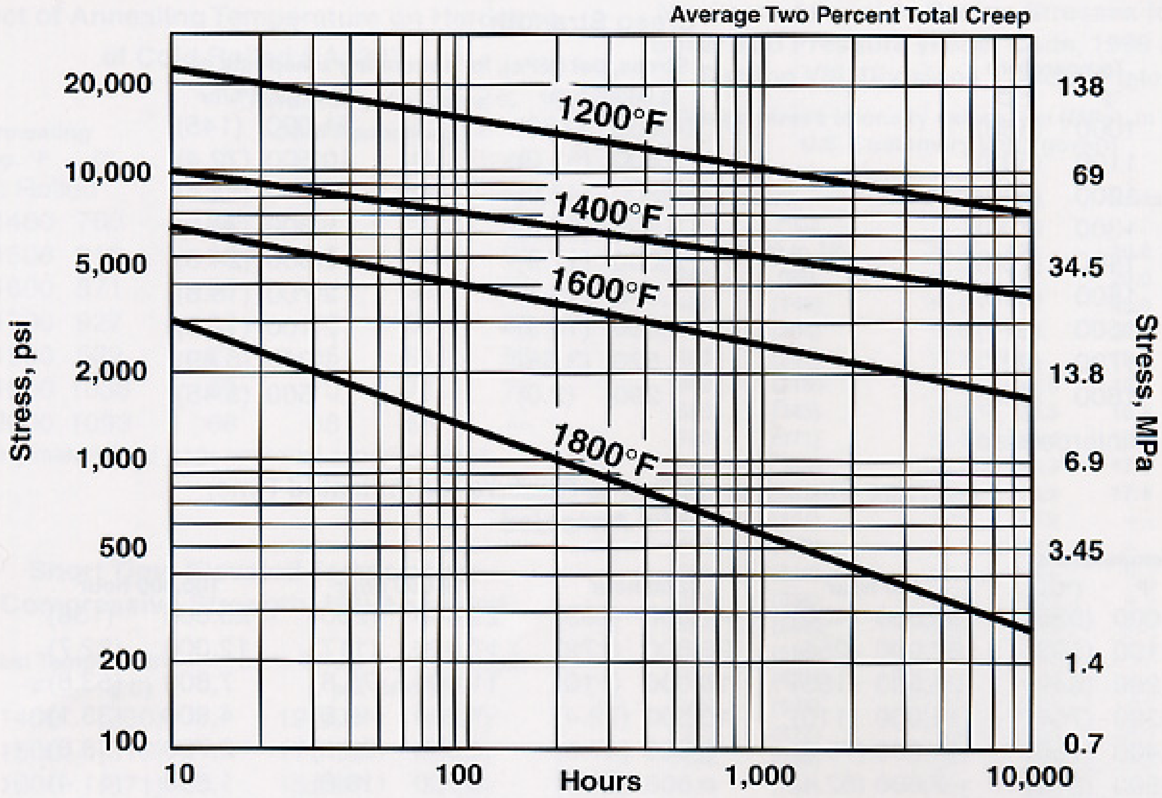
Average Stress, psi (MPa), to Rupture for Indicated Time, Mill Annealed

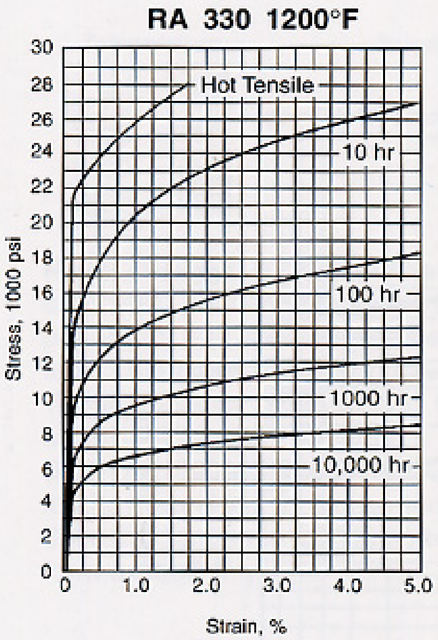
Temperature °F	(°C)	100 hour		1000 hour		10,000 hour		100,000 hour	
1000	(538)	58,000	(400)	41,000	(283)	29,000	(200)	20,000	(138)
1100	(593)	37,000	(255)	25,000	(172)	17,000	(117)	12,000	(82.7)
1200	(649)	22,500	(155)	16,000	(110)	11,000	(75.8)	7,800	(53.8)
1300	(704)*	16,000	(110)	10,500	(72.4)	7,200	(49.6)	4,800	(33.1)
1400	(760)	11,000	(75.8)	6,900	(47.6)	4,300	(29.6)	2,700	(18.6)
1500	(816)	7,600	(52.4)	4,600	(31.7)	2,700	(18.6)	1,650	(11.4)
1600	(871)	5,200	(35.9)	3,000	(20.7)	1,700	(11.7)	1,000	(6.89)
1700	(927)*	3,500	(24.1)	1,900	(13.1)	1,050	(7.24)	580	(4.0)
1800	(982)	2,300	(15.9)	1,200	(8.27)	630	(4.34)	330	(2.28)
1900	(1038)*	1,400	(9.65)	750	(5.17)	400	(2.76)	—	
2000	(1093)	900	(6.21)	500	(3.45)	—		—	
2200	(1204)	380	(2.62)	220	(1.52)	—		—	

*interpolated by Larson-Miller technique[10]
T(C + log t) = constant, using C = 14.45

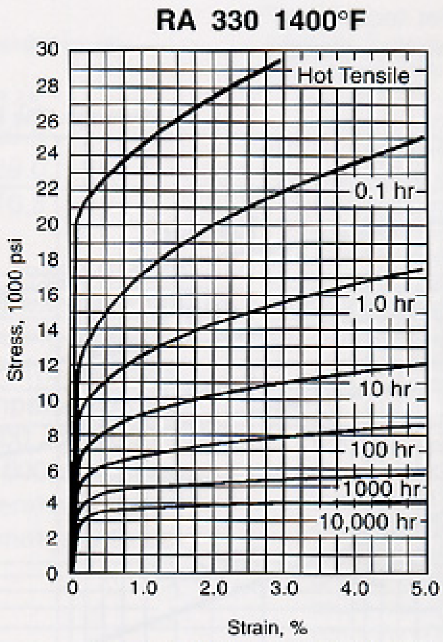


RA330

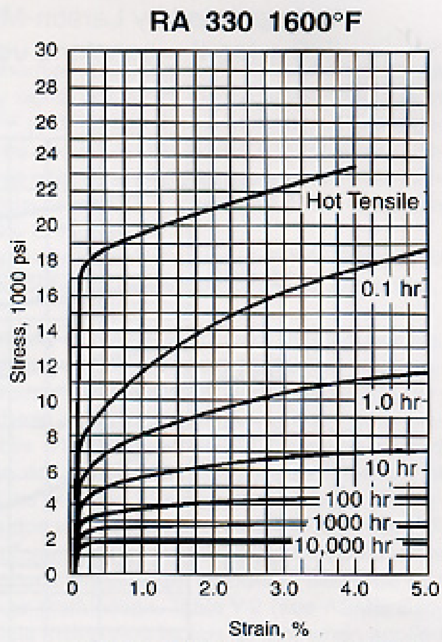




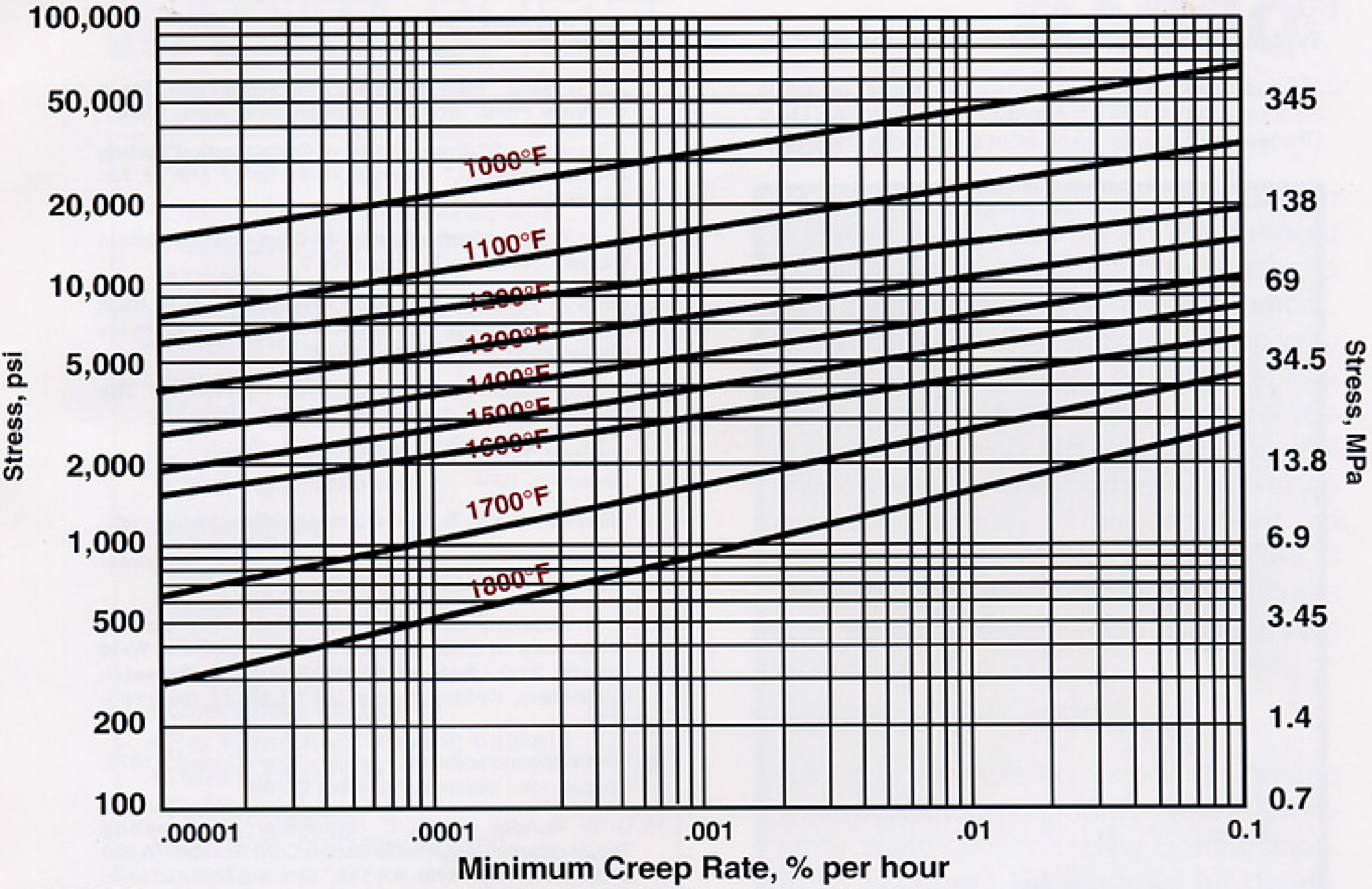
Average isochronous stress-strain curve

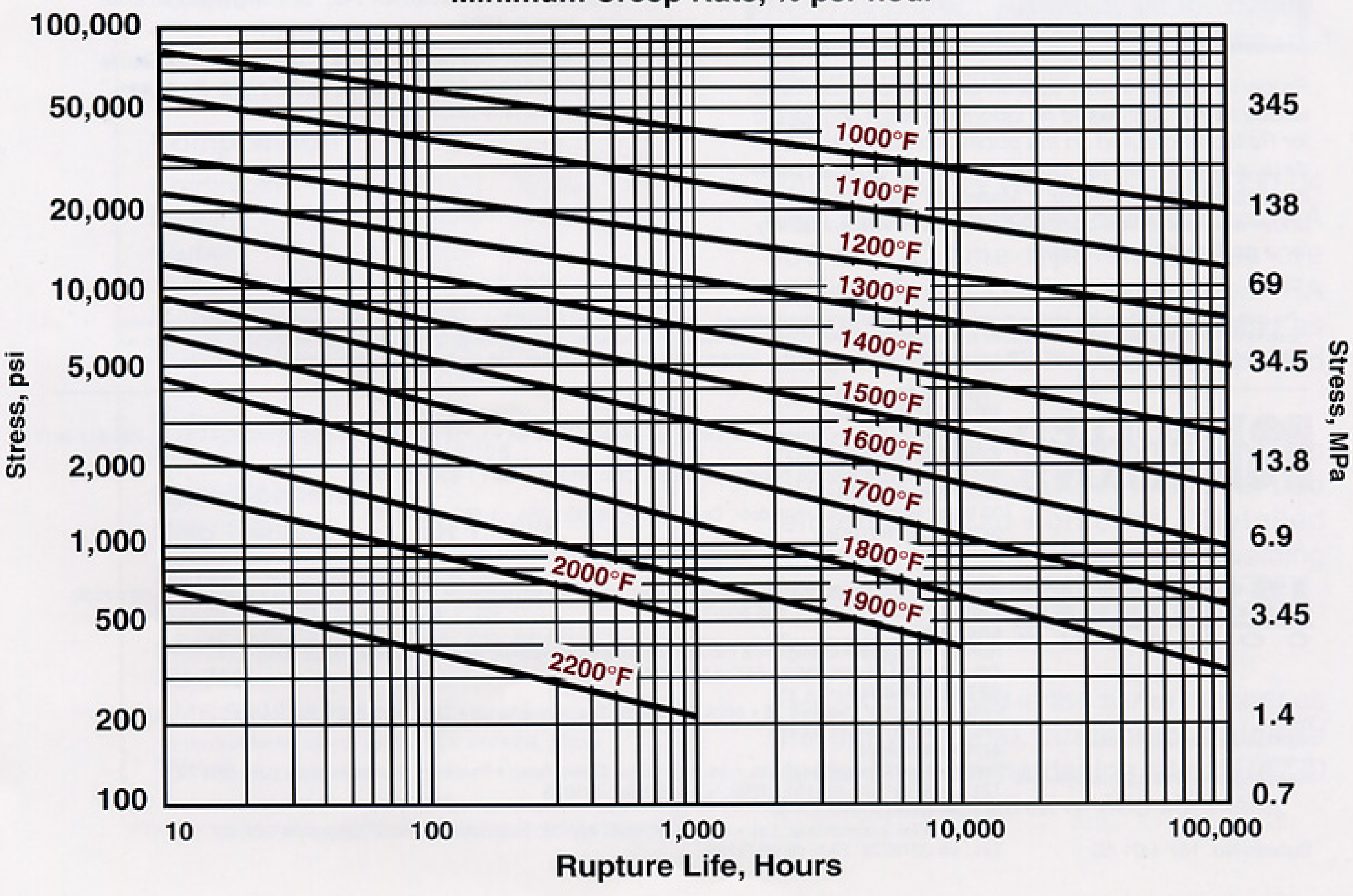


Average isochronous stress-strain curve



Average isochronous stress-strain curve


100,000
50,000
20,000
10,000
5,000
2,000
1,000
500
200
100
Stress, psi
345
138
69
34.5
13.8
6.9
3.45
1.4
0.7
Stress, MPa
1000°F
1100°F
1200°F
1300°F
1400°F
1500°F
1600°F
1700°F
1800°F
.00001
.0001
.001
.01
0.1
Minimum Creep Rate, % per hour


100,000
50,000
20,000
10,000
5,000
2,000
1,000
500
200
100
Stress, psi
345
138
69
34.5
13.8
6.9
3.45
1.4
0.7
Stress, MPa
1000°F
1100°F
1200°F
1300°F
1400°F
1500°F
1600°F
1700°F
1800°F
1900°F
2000°F
2200°F
10
100
1,000
10,000
100,000
Rupture Life, Hours

RA330

Typical Microstructure of Mill Annealed RA 330.

100X; Etchant, Mixed Acids (25 parts HCl, 10 parts alcohol, 7 parts HNO_3); Average Grain Size, ASTM-5 (Transverse Sample Taken from Bar Stock).

Properties listed in this bulletin are typical or average values for RA 330 based on laboratory tests conducted for Rolled Alloys and on the published literture. These data should not be considered as guaranteed maximums or minimums. Materials must be tested under actual service conditions to determine suitability for a particular application.

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