RADATA SHEET

RA309 alloy

Features

- Oxidation resistance to 2000°F
- Moderate strength at high temperature
- Ease of fabrication
- Availability
- Low cost

Applications

- Burner parts
- Heat exchangers & combustion chambers
- Kilns
- Annealing covers & boxes
- Incinerators
- Muffles, retorts
- Radiant tubes
- Power boiler tube hangers
- Anchor bolts
- Brazing fixtures
- Glass forming equipment
- Chemical plant equipment
- Furnace fans, shafts & housings
- Thermowells
- Paper mill equipment
- Neutral salt pots

Composition

UNS S30908 DIN 1.4833

Chromium	22.00 - 24.00	
Nickel	12.00 - 15.00	
Carbon	0.08	max
Silicon	1.00	max
Manganese	2.00	max
Phosphorus	0.045	max
Sulfur	0.030	max
Iron	balance	

General

RA309 is an austenitic heat resistant alloy with useful oxidation resistance to 2000ºF under constant temperature conditions. When frequent heating and cooling is involved the alloy is resistant to about 1850ºF.

RA309 is particularly suited for oxidizing environments involving constant temperature or mild cycling with slow rates of heating and cooling. Because of its relatively high rate of thermal expansion the alloy is not suggested for applications involving severe thermal cycling, such as liquid quenching.

The high chromium and relatively low nickel contents of RA309 make it the preferred choice among the austenitic grades for high temperature sulfur bearing atmospheres. Under the most severe conditions, however, alloys completely free of nickel may be required.

RA309 is one of the most commonly used heat resisting alloys in the range of 1500-2000ºF under oxidizing conditions.

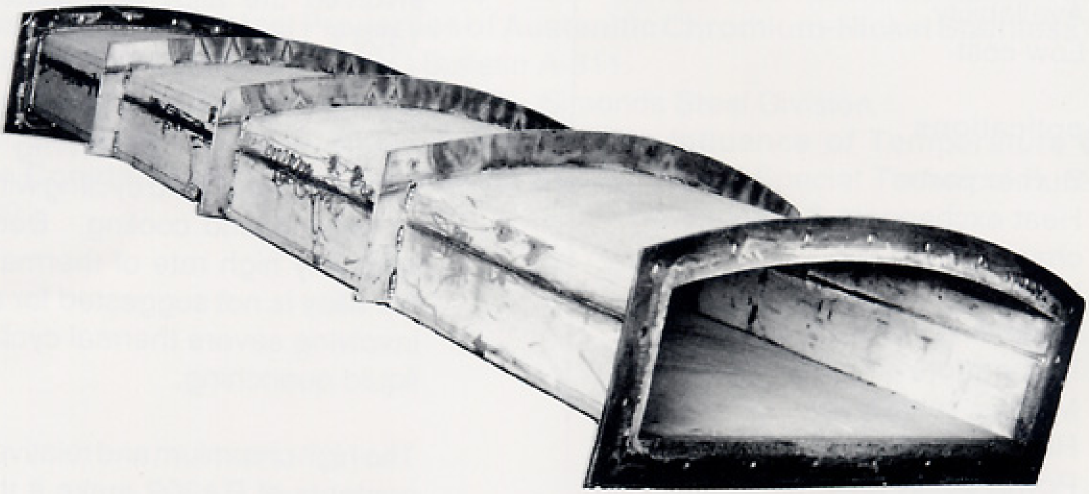
CARBURIZATION

RA309 has a degree of resistance to carbon absorption in some environments. Low cost, good sulfidation and moderate carburization resistance combine to make RA309 the most widely used alloy for carbon saggers.

Test coupons exposed to fifteen simulated one week bake cycles at 1750-1900ºF (955-1040ºC) in carbon electrode green mix showed the following:

Alloy	UNS No.	% Carbon Absorbed	Remaining Tensile Ductility, in % Elong
302B	S30215	2.3	0
214	—	0.38	4
800H	N08810	0.97	1
RA309	S30908	0.11	16
RA330	N08330	0.27	19

Results valid only for the conditions of this test.



Muffle of 3/16" (4.76mm) RA309 plate. Gas fired 1200-1600ºF(650-870ºC), endothermic atmosphere, bright annealing copper, brass and steel. Typical life 4-5 yrs.

SIGMA

Prolonged exposure to the 1100-1600ºF (590-870ºC) temperature range results in the formation of sigma phase in RA309. Sigma formation reduces ductility and impact strength at room temperature, although the material remains ductile at elevated temperature. Care should be taken to avoid heavy mechanical impact or thermal shock to fabrications which have seen extensive service in this temperature range. Sigma may be removed by annealing above 1900ºF (1040ºC). However, it will again form should the metal subsequently be exposed for long times in the 1100-1600ºF (590-870ºC) range.

The annealed structure of RA309 is primarily austenitic. Small amounts of ferrite may occasionally be present.

SPECIFICATIONS

	ASTM	ASME
Plate, sheet & strip	A 240	SA-240
Seamless & welded pipe	A 312	SA-312
Bars & shapes	A 276	SA-479

WELDING

RA309 is readily welded by all methods in common usage. RA309 weld fillers contain typically 7% ferrite for resistance to hot tears or fissures in welding. In addition to joining RA309 base metal, RA309-16 covered electrodes are often used for joining the stainless steels to mild steel.

Suggested weld fillers for dissimilar metal joints, RA309 base metal to:

Base Metal	Carbon or Low Alloy Steel	Ferritic Stainless RA446,430,405,409	Austenitic Stainless 304,316,321, RA310	RA253MA®
Weld Wire or Electrode	ER309, E309	ER309,E309 (RA446 only--E312)	ER309, E309	ER309,E309, 253MA wire or electrodes

Base Metal	RA85H® Wrought or Cast	Cast Heat Resistant HK, HT	Nickel Alloys RA330®,RA333®, RA600 RA601
Weld Wire or Electrode	ER309, E309	RA330-80-15 High Carbon Electrodes	ERNiCr-3, ENiCrFe-3 (RA330 only-RA330-04, RA330-04-15)

FORMING

RA309 may be formed in the same manner as the conventional austenitic stainless steels. The work hardening rate of RA309 is similar to that of 304 stainless.

Heavy duty lubricants may be used in cold forming to prevent galling and reduce die wear. Lubricants should be removed prior to welding, annealing, or use 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.

If forging or hot forming is required, the work piece should be heated uniformly throughout its section to a starting temperature in the range 2050-2150ºF (1120-1180ºC), finishing by 1750ºF (950ºC). Overheating this grade may cause formation of significant amounts of delta ferrite, which adversely affects forgeability.

No forming or bending should be performed in the low ductility range of 1200-1600ºF (650-870ºC).

ANNEALING

The purposes of annealing RA309 are to soften the metal after heavy cold work, remove residual forming stresses and to redissolve precipitated carbides. For most high temperature applications, RA309 fabrications are not annealed after forming or welding.

If processing or final application dictate a full anneal, the suggested procedure is to heat 1950-2050°F (1060-1120°C) long enough to insure a uniform actual metal temperature, followed by rapid air cooling or quenching to below 800°F (425°C).

As with other austenitic alloys, RA309 is not amenable to hardening by thermal treatment. Increased strength may be obtained only by cold working.

MACHINING

RA309 and other austenitic grades are quite ductile in the annealed condition. However, these chromium-nickel alloys work harden more rapidly and require 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 reground 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 paraffin 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.

CLEANING & PICKLING

Machining lubricants or other contamination may be removed from RA309 by alkaline cleaning agents or suitable solvents.

Black annealing or hot working scale is considered beneficial, as it provides some initial measure of protection against the service environment. Normally the scale should be removed only in areas which are to be welded.

Light scale may be removed by nitric-hydrofluoric pickling solutions.

Heavy scale may require pretreatment by steel shot blasting or molten salt baths, followed by nitric-hydrofluoric acid pickling.

RA309 PROPERTIES

Physical Properties

Density [1]

0.285	lb/cu.in.
7890	kg/m^3

Melting Range

2500-2590°F
1370-1420°C

Specific Heat

0.12 Btu/lb•°F
500 J/kg•K

Thermal Conductivity [2]

Temperature,°F	Btu•ft/ft^2•hr•F	W/m•K
70	7.4	12.8
200	8.0	13.8
500	9.3	16.1
1000	11.5	19.9
1200	12.4	21.5

Electrical Resistivity

Temperature, °F	ohm•circ mil/ft	microhm•m
68	470	0.78
200	500	0.83
400	547	0.91
600	590	0.98
800	632	1.05
1000	668	1.11
1200	698	1.16
1400	722	1.20
1600	746	1.24
1800	764	1.27

Mean Coefficient of Thermal Expansion[4]

Temperature Range °F	in/in•°F x 10^{-6}	m/m•K x 10^{-6}
77-200	8.8	15.84
77-302	8.9	16.02
77-398	9.0	16.2
77-500	9.2	16.56
77-600	9.3	16.74
77-702	9.4	16.92
77-750	9.5	17.1
77-1000	9.7	17.46
77-1250	9.9	17.82
77-1500	10.0	18.0
77-1600	10.1	18.18

Elastic Properties

Temperature °F	Modulus of Elasticity (dynamic) psi x 10^6	Modulus of Rigidity[5] (static) psi x 10^6	Poisson's ratio[5] (from static data)
70	28.5	11.0	0.27
200	27.7	--	--
300	--	10.4	0.28
400	26.4	--	--
500	--	9.8	0.30
600	25.1	--	--
700	--	9.4	0.30
800	23.8	--	--
900	--	9.0	0.29
1000	22.5	--	--
1100	--	8.4	0.27
1200	21.0	--	--
1300	--	7.7	0.32
1400	19.5	--	--
1500	--	6.8	0.25
1600	18.0	--	--

Note: Elastic properties are not valid for design purposes above 1000°F, as RA309 becomes creep limited and no longer behaves in an elastic manner.

RA309 Mechanical Properties

Typical Room Temperature Mechanical Properties, Annealed

Ultimate tensile strength, psi (MPa)	90,000 (620)
0.2% offset yield strength, psi (MPa)	45,000 (310)
Elongation in 2", %	45
Reduction of area, %	67
Hardness, Rockwell B	75-85

Typical Short-Time Elevated Temperature Tensile Properties, Annealed

Temperature °F	Ultimate Strength psi (MPa)	0.2% Offset Yield Strength psi (MPa)	Elongation %	R.A. %
1200 (649)	52,000 (358)	22,000 (151)	26	30
1300 (704)	44,000 (303)	20,000 (138)	23	28
1500 (816)	26,000 (179)	19,000 (131)	25	33
1600 (871)	18,000 (124)	—	32	36
1800 (982)	8,500 (58.6)	—	55	49

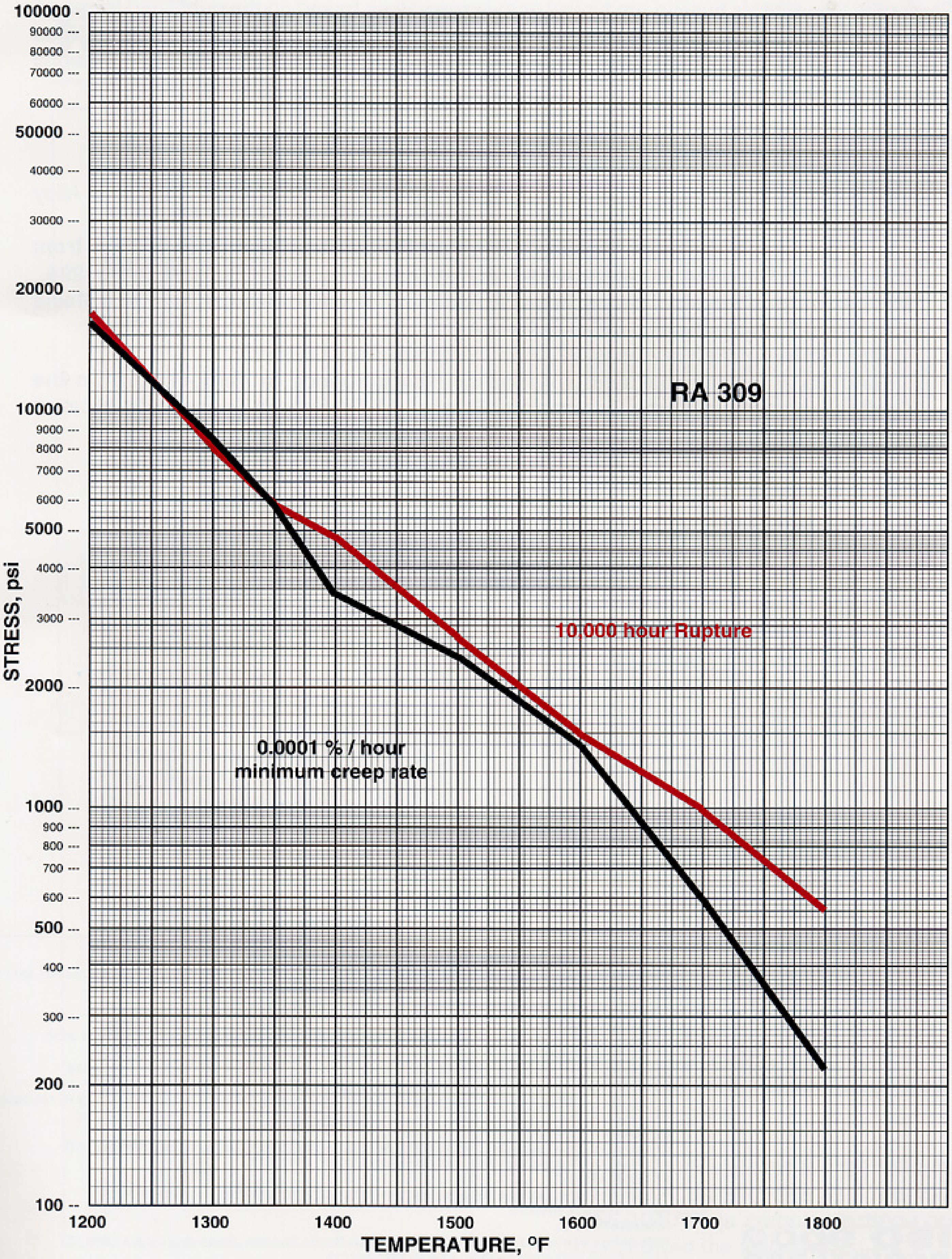
Note: Above 1000°F, RA309 deforms with time under load, even if stressed below the tensile yield point. This deformation is known as creep. For this reason, equipment intended for long time service in the creep range should not be designed on the basis of short-time tensile properties.

Stress to Rupture, Annealed psi (MPa)

Temperature, °F(°C)		10,000 hour	
1200	(649)	17,000	(117)
1300	(704)	8,000	(55)
1400	(760)	4,800	(33)
1500	(816)	2,700	(19)
1600	(871)	1,600	(11)
1700	(927)	1,000	(6.9)
1800	(982)	560	(3.9)

Stress for Secondary Creep Rate of 0.0001 %/hour

Temperature, °F (°C)		Stress, psi (MPa)	
1200	(649)	16,000	(110)
1300	(704)	8,800	(60.7)
1400	(760)	3,400	(23.4)
1500	(816)	2,400	(16.6)
1600	(871)	1,400	(9.7)
1700	(927)	600	(4.1)
1800	(982)	220	(1.5)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100
STRESS, psi
1200
1300
1400
1500
1600
1700
1800
TEMPERATURE, °F
RA 309
10,000 hour Rupture
0.0001 % / hour
minimum creep rate

RA309

Properties listed in this bulletin are typical or average values based on the published literature and on laboratory tests conducted for Rolled Alloys. 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.

References

1. Private communication of February 17, 1977, Crucible Inc, Stainless Steel and Alloy Divisions.
2. E.A. Eldridge and H.W. Deem, **Report on Physical Properties of Metals and Alloys from Cryogenic to Elevated Temperatures,"** ASTM Special Technical Publication No. 296.
3. "**Mechanical and Physical Properties of Austenitic Chromium-Nickel Stainless Steels at Ambient Temperatures**," INCO Bulletin A-311.
4. Private communication of August 27, 1971, Simonds Steel Division.
5. F. Garofalo, P.R. Malenock and G.V. Smith, **"The Influence of Temperature on the Elastic Constants of Some Commercial Steels**," ASTM Special Technical Publication No. 129.