ROLLED ALLOYS
The world's heat, corrosion, titanium, and aerospace alloy specialists.

We are suppliers of high performance wrought alloys for heat and corrosion resistant service. This brochure describes those alloys specially suited for use at elevated temperatures. They are summarized in the table below. In addition, we describe briefly on this page some of our corrosion resistant alloys. We have a separate brochure on these materials, and would be happy to supply one to you.

Heat Resistant Alloys

NOMINAL CHEMICAL COMPOSITION						DESCRIPTION
ALLOY/W. Nr.	Ni	Cr	Fe	Si	Other	(See also specification table, page 25)
RA333®** 2.4608	45	25	18	1.0	Mo:3 Co:3 W:3 C:.05	A nickel base superalloy with excellent carburization, oxidation, and hot corrosion resistance. It has high creep-rupture strength with exceptional ability to withstand repeated thermal shock.
RA330®** EN 1.4886	35	19	43	1.25	C:.05	The workhorse of the austenitic heat resistant alloys. Good strength, carburization and oxidation resistance to 2200˚F. RA 330HC has high carbon for best hot shear strength and wear resistance for belt pin stock.
RA 602 CA™ 2.4633	63	25	9	0.03	Al:2.2 Y:0.08 C:0.18	One of the most oxidation resistant nickel alloys available. High strength for use in the 1800-2200°F range. Carburization resistant.
RA 353 MA®*** EN 1.4854	35	25	37	1.5	Ce:.05 C:.05 N:.15	A strong, micro-alloyed austenitic with oxidation resistance through 2300˚F. Carburization, oxidizing hot corrosion resistance. The upgrade from RA330 above 1800˚F.
RA 253 MA®*** 1.4893 EN 1.4835	11	21	65	1.7	Ce:.04 N:.17 C:.08 Mn:.6	An advanced micro-alloyed austenitic heat resistant alloy. High creep-repture stength and outstanding oxidation resistance through 2000˚F.
RA800H/AT	31	21	45	.4	Al:.4 Ti:.6	High strength austenitic heat resistant alloy for ASME code applications to 1650˚F.
RA309 1.4833	13	23	62	0.8	C:.05 Mn:1.6	Austenitic, oxidation resistant to 1900˚F, moderate strength. Useful in reducing sulfidizing atmospheres.
RA310 1.4845	20	25	52	0.5	C:.05 Mn:1.6	Austenitic heat resistant grade with higher chromium and nickel for oxidation resistance beyond 2000˚F. Good sulfidation and hot corrosion resistance.
RA446 1.4763	—	25	73	0.5	C:.05 N:.1 Mn:.7	High chromium ferritic alloy with excellent oxidation and sulfidation resistance. Low strength.
RA601 2.4851	61.5	22.5	14	0.2	C:.05 Al:1.4 Mn:.3	A nickel base alloy with high chromium and an aluminum addition. Outstanding oxidation resistance to 2200˚F, good strength and carburization resistance.
RA600 2.4816	76	15.5	8	0.2	C:.08 Mn:.3	A nickel-chromium alloy with good carburization and oxidation resistance through 2000˚F.
RA321 1.4541	9.3	17.3	70	0.7	C:.04 Ti:.4	A titanium stabilized austenitic stainless steel commonly used for service in the 1000-1600˚F temperature range.
RA17-4 1.4548	4.7	15.5	75	0.3	Cu:.3.3 Cb:.3	A precipitation hardening martensitic stainless. High strength is obtained by a simple, short-time low-temperature heat treatment. Corrosion resistant.
RA410 1.4006	–	12	87	0.2	C:.14	A martensitic stainless steel. High strength in quenched & tempered condition.

Corrosion Resistant Alloys

RA20 stainless is the alloy designed specifically to withstand sulfuric acid. Practical immunity to chloride stress corrosion cracking. Stabilized to prevent intergranular corrosion as welded.

RA625 a high strength 9% molybdenum nickel alloy with excellent resistance to hot seawater, scrubber environments and reducing acids.

AL-6XN®* stainless is a high molybdenum superaustenitic with outstanding resistance to chloride pitting, crevice corrosion and stress corrosion cracking.

RA2205 austenitic-ferritic stainless steel resistant to chloride stress corrosion cracking. High strength, very good pitting and general corrosion resistance.

* Registered trademark of ATI.
** Registered trademark of Rolled Alloys.
*** Registered trademark of AvestaPolarit.
™ Trademark of Krupp VDM

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Technical data is good; experience is better; Rolled Alloys has both to help you select the best high temperature alloy.

This chart is intended as guidance for what alloys might be tested or used in a given environment. It must NOT be used as the sole basis for alloy selection, or as a substitute for competent engineering support.

Alloy selection for high temperature equipment should be based on experience with similar environments and extensive testing under the exact service conditions of interest. Some points to consider: A major cause of distortion and cracking in elevated temperature service is the effect of thermal expansion. Total expansion in the range of 3/16 to 1/4" per foot, from room temperature to 1800°F, is common. It is important to allow this expansion to occur freely. Welds should be completely penetrated, as lack of fusion may start cracks in cyclic service. When thermal shock or fatigue is involved, design and weldment quality may override the effect of alloy selection on performance.

With respect to corrosion, high temperature corrosion rates are not uniform. Hot corrosion test data, most particularly sulfidation rates, can not be reliably extrapolated.

Heat Resistant Alloy Performance Guide

Resistance To Environment

Least — **Greatest**

CONDITION	Not Suggested	Good	Better	Best
STRENGTH	446	600 309 310	RA 253 MA RA330	RA 602 CA, RA333, RA 353 MA RA800H/AT 601
THERMAL SHOCK[a]	446 800H	310 309	RA 353 MA RA 253 MA, 601, 600	RA333 RA330
OXIDATION	—	309 RA800H/AT 446	RA330, 310, 600	RA 602 CA RA333 RA 353 MA, 601
CARBURIZATION	446 321 RA 253 MA	310 309 RA800H/AT	RA 353 MA RA330	RA333 600, RA 602 CA 601
OXIDIZING SULFUR (SO_2, SO_3)[e]	600	601 RA330 RA800H/AT	RA 602 CA RA 253 MA, RA 353 MA RA333	446 310 309
REDUCING SULFUR (H_2S)[b]	600, 601, RA333, RA330, RA800H/AT RA 353 MA, RA 253 MA	347	309 310 556	446
HOT HCI GAS (above the dew point)	446	RA333 RA330 RA 353 MA	RA 602 CA 601	200
MOLTEN METALS[c] Cu[d], Zn, Mg	600	309, 310 316 (zinc)	AL-6XN (in zinc)	446 430, 410

[a] Good thermal shock or fatigue strength requires fine grain size. Materials which are grain-coarsened to maximize creep-rupture strength do so at the expense of thermal fatigue strength.

[b] Underneath deposits conditions may be reducing, even though the atmosphere itself is oxidizing.

[c] High chromium and low nickel contents are necessary for any degree of resistance to high temperature reducing, sulfidizing (H_2S) environments.

[d] In general, the higher the nickel content, the more rapid the attack. Molten aluminum quickly dissolves all commercial alloys.

[e] Only the ferritic alloys, such as 430 or 446, withstand copper. All austenitics are attacked intergranularly.