WELDING RA 602 CA®

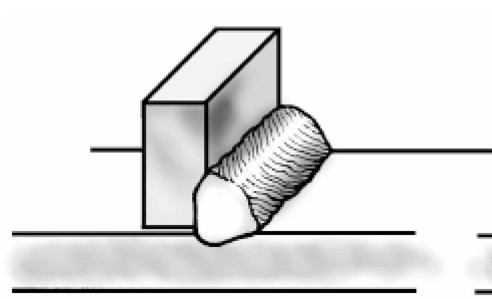
The heat resistant superalloy RA 602 CA is welded with practice similar to other high nickel alloys. A nitrogen addition to the shielding gas improves soundness of welds made with matching chemistry wire. RA 602 CA DC covered electrodes run well, and the alloy may be resistance welded.

Some important points for all nickel alloy welding:

1. REINFORCED BEAD CONTOUR

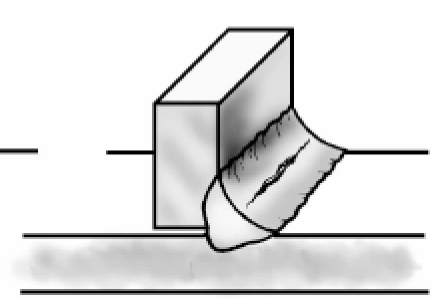
Make convex stringer beads with little or no weave. Broad, flat beads tend to crack down the center.

CONVEX BEAD



Desirable weld bead contour to avoid hot tearing as weld cools

CONCAVE BEAD



Undesirable bead shape for heat resisting alloys, tends to crack down the center

2. LOW HEAT INPUT

Keep heat input low and interpass temperatures below 250°F, lower preferred. Do not preheat RA 602 CA, beyond that necessary just to dry the work. Unlike steel, the faster a nickel alloy weld cools, the less likely it is to crack. No postheat is required.

Highly restrained welds are less likely to crack when made with covered electrodes, SMAW. This is because heat input (amount of molten metal deposited per hour) tends to be less with covered electrodes. In addition, DC basic covered electrodes naturally deposit a strong, reinforced bead contour.

3. USE THE RIGHT SHIELDING GAS

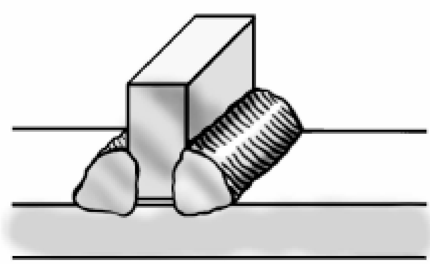
RA 602 CA GMAW and GTAW welds are highly resistant to cracking, as long as an appropriate nitrogen addition is made to the the weld shielding gas.

For gas tungsten arc welding (a.k.a TIG, or Heliarc®) the torch shielding gas is argon with a 2.5% addition of nitrogen, the range is 1 to 3% N_2. Shield the back side of the weld root with 100% welding grade argon—not nitrogen. Good root shielding is required because of the high aluminum content of RA 602 CA.

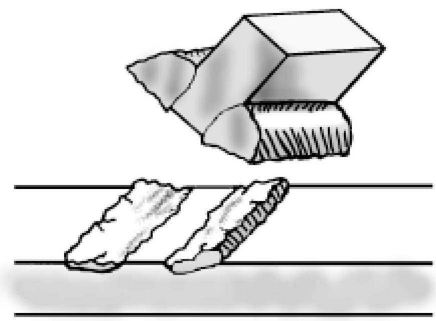
Gas metal arc welding (MIG) is done with a Linde patented gas, trademarked Cronigon® Ni 30. The approximate composition of this gas is argon + 5% nitrogen + 5—10% helium, and a trace of CO_2. For a distributor in your area, log on to: www.us.linde-gas.com

4. FULL PENETRATION JOINTS

Make completely penetrated welds. Lack of adequate penetration is the most common cause of weld failures in high temperature service.



This un-welded cavity acts as a crack starter. Repeated thermal expansion and contraction will cause cracks to grow out through the weld bead.

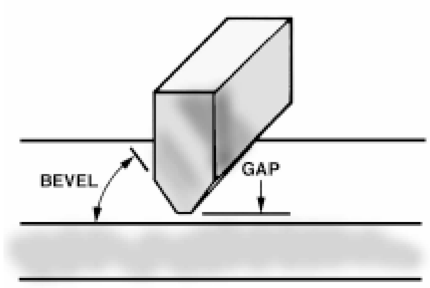


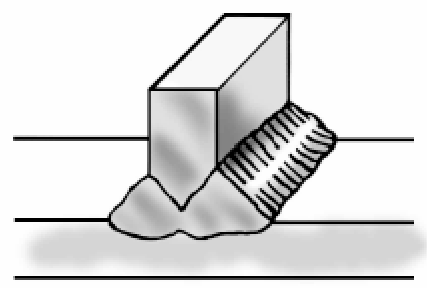
Until it beaks apart completely

Such failures are aggravated by heavy sections, very high temperature service, the severe thermal shock of quenching, or vibration such as may occur in fans.

In carburizing environments, carbon from the atmosphere may deposit in such cavities. As carbon deposits, it pries the cavity open progressively larger, to complete the fracture.

4. FULL PENETRATION JOINTS, continued



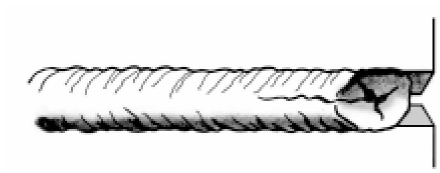


To get full penetration in RA 602 CA the joint must be open so that weld metal may be placed at the root. This is achieved by beveling one or both sides, and with a root gap of 1/16 to 1/8".

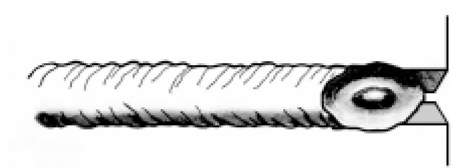
The result of such joint preparation is a fully penetrated weld with optimum strength.

5. FILL CRATERS

Craters at the end of a weld may crack unless filled. The cracks may then run back into previously sound metal. Craters may be filled by back stepping, or reversing direction for about 1/2" at the end of a weld.



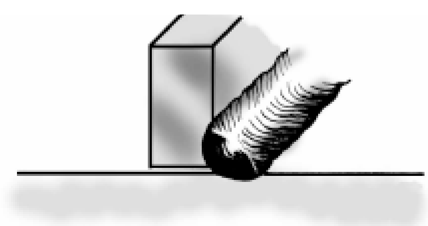
craters crack



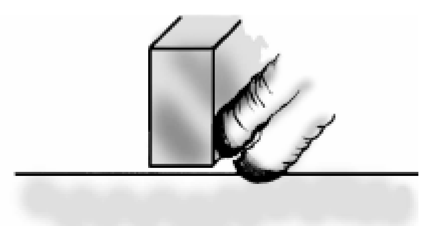
unless filled or backstepped

6. HEAVY STARTS

Starting beads should be filled in to minimize chances of cracking



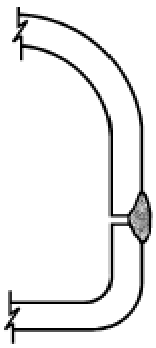
Starts should be as heavy as the rest of the bead



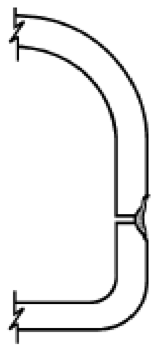
Thin, weak starting beads may crack

7. OXIDATION RESISTANCE OF THE JOINT

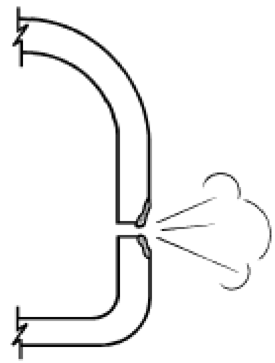
Muffles and radiant tubes, subject to environments above 2000°F, require both full penetration welds and the right filler metal for long life. A weld bead by its very nature isn't quite as resistant as is the base metal, to attack by carbon, molten salts or oxidation. The weld metal should at least match the base metal in chemistry. Sometimes a higher alloy weld filler may be used. For very high temperatures it is important to avoid any weld filler with a Cb (columbium) addition. Good for weldability and for carburization resistance, but bad for oxidation resistance.



This shallow weld in a D-shaped muffle may



thin by oxidation after long 2000°F service



and then leak atmosphere, which may burn and overheat or melt the area

Retort used at 2200°F, welded with alloy 82 (ERNiCr-3) wire. Weld bead heavily oxidized.

RA 602 CA weld filler would have prevented such weld attack.

8. CLEANLINESS—BEFORE AND AFTER

Copper, brass, lead, aluminum, zinc or oter low melting alloys smeared on the base metal cause both weld bead cracking and base metal heat affected zone cracking. Sources of metallic contamination include soft metal hammers, metallic zinc paint, Kirksite forming dies and, on occasion, the copper back-up bar. All machining or forming lubricants must also be removed prior to welding.

9. DISSIMILAR METAL WELDING

As a rough guide, when joining two different alloys use a weld filler suited to the more highly alloyed base metal.

Large differences in thermal expansion of the two base metals may need to be taken into account to minimize thermal stresses in service.

SUGGESTED WELD FILLERS FOR DISSIMILAR METAL JOINTS
Heat Resistant Alloys

Base Metals	Carbon or Low Alloy Steel[A]	Stainless (304, 316, 309, 310)	RA 253 MA®	RA330	RA333	RA 602 CA
HT, HK	182	309 RA330-80	RA333	RA330-80 RA333	RA333	RA333
RA446	308, 309	309	309	RA330-04 182	182, RA333	182
RA 253 MA	309[B]	309 RA 253 MA	RA 253 MA	RA333	RA333	RA333
RA330 RA800H/AT	182, RA333 RA330-04	RA330-04 182	RA333	RA330-04 RA333	RA333	RA333
RA333	182, RA333	RA333 82, 182	RA333	RA333	RA333	RA 602 CA, RA333
RA600	182	82, 182	RA333	182 RA330-04	182, RA333	182
RA601	182	182	RA333	RA333	RA 602 CA	RA 602 CA
RA 602 CA	182	82, 182	RA333 RA 602 CA	RA333	RA 602 CA	RA 602 CA

Notes

A. **Welding to carbon steel, be certain to grind all blue-black mill scale and rust from the steel on both sides of the joint. Preheat only as necessary for the carbon steel grade involved.**

B. **Do not use RA 253 MA weld fillers on carbon steel. The joint will crack down the center (this is because dilution by iron removes the ferrite from RA 253 MA weld metal).**

10. REPAIR WELDING

Heat resistant alloy equipment is often repair welded to extend its useful life. Cracked parts may be welded so long as they are not heavily carburized, permeated by heat treating salts.

A pocket magnet is a useful first guide as to whether a part may be repaired. Wrought austenitic heat resisting alloys are non-magnetic as supplied. Strong magnetism means the metal has been damaged, probably beyond repair. Most commonly, alloy becomes magnetic because it has been heavily carburized. Alloy may also become magnetic from severe intergranular oxidation such as may occur in salt pots, or in the skirts of sand sealed retorts. In all cases, it is unlikely that a sound weld can be made if the alloy has become magnetic.

Remove all scale from both sides of the area to be welded, and grind magnetic surfaces down to sound metal. Crack should be ground out—do not just weld over an existing crack. It will grow out through the weld bead, and that repair will be time wasted.

Coated electrodes are preferred for repairing used heat resistant alloy. The coating helps flux away some of the internal oxides and scale that might have been missed during joint preparation.

HT trays for neutral hardening or annealing operations have been repaired very successfully using RA333-70-16 AC/DC covered electrodes. The high strength of RA333 gave much better life than when 182 was used. Avoid AWS E312 electrodes, by any name. Welds made with this 29Cr—9Ni filler soon break in high temperature service.

In the case of RA 602 CA, one needs decide which is more important in the weld repair, strength or ductility. Strength is more likely to be needed for repair of those areas where the metal had been glowing bright red in service, say 1400°F or higher. In this case we would suggest using RA 602 CA bare wire or covered electrodes.

Cracks that occur in cooler areas, say near the ends of muffles or a couple feet from the seal on a retort are another matter. Repair of lower temperature zones might better be done with the most ductile available fillers. Here is where ENiCrFe-3 (182) covered electrodes or ERNiCr-3 (82) bare wire are appropriate. When in doubt, consult with Rolled Alloys' technology department.

11. TYPICAL OPERATING PARAMETERS

COVERED ELECTRODES (SMAW)

Diameter, inch	Current, DCRP (electrode positive), A Root Pass	Intermediate & Final	Volts
3/32, 1/8	40—70	70—100	21—22
1/8, 5/32	70—100	90—130	21—22

Electrodes that have picked up moisture in storage may be rebaked 475—575°F for 2 to 3 hours

GAS TUNGSTEN ARC WELDING (GTAW, TIG)

2% Thoriated Tungsten electrode dia, inch	DCSP (electrode negative) amperes	Voltage	Shielding Gas 97.5% Ar 2.5%N_2, CFH
0.040	25—80	10—14	17—21
0.062	50—145	12—16	17—21
0.094	135—235	12—20	17—21

GAS METAL ARC WELDING (GMAW, MIG)

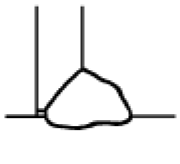
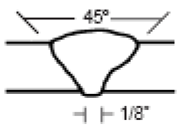
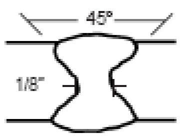
Spray arc transfer wire dia, inch	Current, DCRP	Volts
0.045	160—180	23—27

RA 602 CA CHEMISTRY, BASE METAL AND WELD FILLERS

nominal composition, weight %

Grade	AMS	Cr	Ni	C	Si	Mn	Al	Zr	Ti	Y	Fe
RA 602 CA base metal	- -	25	63	0.18	0.0	0.07	2.2	0.08	0.1	0.1	9.5
RA 602 CA wire	ERNiCrFe-12 W.Nr. 2.4649	25.4	62	0.18	0.04	0.07	2.2	0.08	0.14	0.08	9.5
RA 602 CA covered electrodes	ENiCrFe-12	25	62	0.2	0.6	0.1	1.8	0.03	0.1	0.02	10

ELECTRODE AND GMAW WIRE CONSUMPTION FOR VARIOUS JOINT DESIGNS

JOINT DESIGN	PLATE THICKNESS, INCHES	APPROXIMATE WEIGHT, IN POUNDS, OF		
		METAL DEPOSITED PER LINEAL FOOT WITH REINFORCEMENT	ELECTRODES REQUIRED (A)	GMAW WIRE REQUIRED (B)
SINGLE FILLET 	1/8	0.032	0.064	0.038
	3/16	0.072	0.144	0.085
	1/4	0.13	0.26	0.15
	3/8	0.29	0.58	0.34
	1/2	0.52	1.03	0.60
	5/8	0.80	1.61	0.94
"V" GROOVE 	1/4	0.37	0.73	0.43
	3/8	0.62	1.23	0.73
	1/2	0.85	1.7	1.00
DOUBLE "V" GROOVE 	1/2	0.77	1.53	0.90
	5/8	0.95	1.90	1.12
	3/4	1.32	2.63	1.55
	1	1.83	3.65	2.16

(A) Assumes 50% deposition efficiency
(B) Assumes 85% deposition efficiency

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Seven additional Rolled Alloys warehouses and sales offices are in Europe, the USA and Asia

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