RA333® Alloy Welding

RA333 weld fillers are necessary to ensure that the weld joint has the same strength and oxidation resistance as the RA333 base metal in the fabrication.

RA333 plate, sheet and bar is welded with matching chemistry RA333 bare filler wire (spooled and straight lengths) and with RA333-70-16 AC/DC Titania covered electrodes.

These specialty weld fillers are not included in AWS specifications. The chemistry of the bare wire meets UNS N06333*, and that of the covered electrodes UNS W86333.

Availability of RA333 Matching Weld Fillers from Rolled Alloys – 1-800-521-0332

Designation	Process	Diameters	Quantities
RA333	GMAW (MIG)	0.035" & 0.045"	25# Spools
RA333	GTAW (TIG)	1/16", 3/32", 1/8"	10# Package (36" lengths)
RA333-70-16	SMAW	3/32", 1/8", 5/32", 3/16"	10# Package (5# in 3/32" dia)

Welding Parameters for RA333® may vary somewhat depending upon the individual welding machine and the job at hand. The following are suggestions for starting parameters.

Gas Metal Arc Welding (MIG)

Wire Dia.	Transfer Mode	Polarity	Amperage	Voltage	Shield Gas
0.035	Spray Arc	DCRP, Electrode Positive	160	28	Argon (100%)*
0.045	Spray Arc	DCRP, Electrode Positive	190	28	Argon (100%)*
0.045	Globular	DCRP, Electrode Positive	165-180	18	Argon (100%)
0.035	Short Circuit	DCRP, Electrode Positive	75-120	18-20	75 Ar – 25 He
0.045	Pulse Arc	DCRP, Electrode Positive	150-165	20-21	75 Ar – 25 He

*Spray Arc - argon with 10 to 20% helium is suggested. A small amount, no more than 1%, of CO_2 will help stabilize the arc. 100% argon may be used, but the welder will find it less satisfactory.

** Short-circuiting transfer usually calls for a higher helium level. Some gas mixtures which have been used include: 90% helium 7 ½% argon 2 ½% CO_2; 81% argon 18% helium 1%CO_2; and 66% argon 33% helium 1% CO_2

Gas Tungsten Arc Welding (TIG), 2% Thoriated Tungsten Electrode

Base Metal Thickness	Electrode Diameter	Wire Diameter	Current (DCSP), Amps	Voltage, Volts	Shielding Gas
1/16" to 1/8"	3/32"	1/16" or 3/32"	50-90	12	Argon (100%)***
1/8" to ¼"	3/32" to 1/8"	3/32" or 1/8"	70-120	12	Argon (100%)***
¼" to ½"	3/32" to 1/8"	3/32" or 1/8"	100-150	12	Argon (100%)***

***For machine welding a hotter arc may be obtained by adding some helium.

Shielded Metal Arc Welding with RA333-70-16 AC/DC Covered Electrodes

Electrode Diameter	Current (DCRP), Amps	Current (AC), Amps
3/32"	40-70	45-80
1/8"	70-100	75-110
5/32"	100-135	105-145
3/16"	125-180	130-190

ADDITIONAL RA333 FABRICATION INFORMATION IS AVAILABLE IN BULLETIN #120 FROM ROLLED ALLOYS 1-800-521-0332

RA333
Covered Electrodes and Welding Wire

FEATURES

- Weldor appeal--excellent flow & tie-in
- Excellent oxidation resistance at 2000°F & beyond
- Resists metal dusting (catastrophic carburization)
- Carburization resistant
- Hot corrosion resistant under oxidizing conditions
- High creep-rupture strength
- Reducing acid corrosion resistance
- Immune to chloride stress corrosion cracking (SCC), resistant to polythionic acid SCC

APPLICATIONS

- Joining *RA333* base metal for both high temperature and aqueous corrosion applications
- Repair welding furnace fixturing of both wrought and cast heat resistant alloys
- Welding cast alloys HOM-3, 22-H®, Super 22H®

TYPICAL CHEMICAL COMPOSITION

Element	Weight %
Nickel	45
Chromium	25
Molybdenum	3
Cobalt	3
Tungsten	3
Manganese	3
Silicon	1
Carbon	0.05
Iron	17

Covered Electrodes UNS W86333*
Welding Wire UNS N08333*

* except manganese

22-H and Super 22-H are registered trademarks of Duraloy Blaw-Knox

PERFORMANCE PROFILE

RA333 weld fillers are designed to match the high temperature properties of the nickel base superalloy *RA333*. This alloy is characterized by exceptional oxidation resistance right up to the incipient melting point in open-fired environments, excellent carburization resistance and ability to tolerate repeated thermal shock.

Repair welding using *RA333* has proven to be a cost-effective means of greatly extending the life of furnace components, not only wrought but also cast. Because of the fluid weld puddle developed by this silicon enhanced grade, it is possible to operate *RA333* weld fillers at a lower current than other nickel alloy grades. The resultant lower heat input is particularly beneficial when weld repairing alloy parts which have been in carburizing service.

PHYSICAL PROPERTIES

Density 0.294 lb/in³
Melting Range 2375-2450°F
Thermal Conductivity

°F	Btu•ft/ft² • hour °F
200	7.0
1000	11.0
1800	15.6

Mean Coefficient, Thermal Expansion

°F	in/in °F
70-200	7.0
-1000	8.6
-1800	9.7

Electrical Resistivity
1800°F 770 ohm•circ mil/ft

Elastic Modulus
room temp, 29.2 x 10^6 psi

WELDING CONDITIONS

Suggested current ranges:

Electrode diameter, inch	3/32	1/8	5/32	3/16
Current (DCRP) amperes [a] range [b]	40-70	70-100	100-135	125-180
optimum	60	85	125	165

[a] add 5-10 amperes with AC current

[b] low end of range is representative for out-of-position welding

For best results in welding RA333 use the lowest current at which the arc is stable--indicated value on welder is approximate. Nickel alloy electrodes tend to heat up quickly, so that optimum currents will be lower than for stainless steels. If the electrode should become red hot when only about 1-1/2" remains, reduce the current until there is no visible evidence of overheating. Maintain arc as short as possible. Use stringer beads without weaving, fill in craters. Do not preheat, keep interpass temperatures below 212°F. Remove all flux from each deposit and from final weld before placing in service.

MECHANICAL PROPERTIES

Shielded metal arc weldments made with RA333-70-16 in 1" RA333 plate have the following average tensile and impact properties, compared with that of the plate.

Test Temp °F	Specimen	Ultimate Tensile Strength psi	0.2% Offset Yield Strength psi	Elongation %	Reduction of Area, %	Charpy V-notch Impact Energy ft-lb
80	Weldment Plate	110,200 105,700	54,800 47,200	33 41	44 47	63.2 43.3
1800	Weldment Plate	16,200 15,600	10,900 10,300	50 89	79 78	-- --

Average 1800°F Rupture Strength, psi

	100 hour	1000 hour	10,000 hour
RA333 Weldment	3100	1700	900

CHEMISTRY

The typical composition of an RA333-70-16 weld deposit is:

Carbon	Manganese	Silicon	Chromium	Nickel	Molybdenum	Cobalt	Tungsten	Iron
0.05	2.5	0.85	25	45	3	3	3	17

ELECTRODE CARE AND STORAGE

RA333-70-16 covered electrodes are supplied in sealed containers to prevent absorption of moisture. Once the container has been opened, store these electrodes at 225°F in an electric oven. Electrodes which have absorbed excess moisture may be reclaimed by first heating two hours at 225°F, followed by one hour at 400°F.

Moisture in these electrodes may cause weld porosity and undesirable arc characteristics.

PACKAGING

Size	Weight Per Standard Can, Lb.	Approximate Sticks Per Lb.
3/32 dia X 9"	5	38
1/8 dia X 14"	10	14
5/32 dia X 14"	10	9
3/16 dia X 14"	10	7

RA333 bare welding wire

The typical composition of RA333 welding wire is:

Carbon	Manganese	Silicon	Chromium	Nickel	Molybdenum	Cobalt	Tungsten	Iron
0.05	3	1	25	45	3	3	3	17

OXIDATION RESISTANCE

RA333 has oxidation resistance far exceeding that of ERNiCr-3 (alloy 82) commonly used in heat resistant alloy fabrication. Results of 2000°F, 20 hour cyclic oxidation testing on both grades are:

Weight gain, mg/cm² after 500 hours

RA333	6.5
82	51

MECHANICAL PROPERTIES

Gas tungsten arc (TIG) weldments in 16 ga (.062") RA333 sheet have the following average tensile properties.

Ultimate tensile strength, psi	84,500
0.2% offset yield strength, psi	51,700
Hardness, Rockwell B	88

GAS METAL ARC WELDING (GMAW or MIG)

RA333 may be used in the spray-arc, pulsed-arc and short circuiting-arc transfer modes. This wire has excellent fluidity and wetting characteristics, unusual for a nickel base alloy. Spray-or pulsed-arc welding is done with argon or argon-helium shielding gas. Do not add oxygen. Good results in short-arc welding have been obtained with 90% helium 7-1/2% argon 2-1/2% carbon dioxide shielding gas.

Typical GMAW Parameters
Spray-arc, 100% argon shielding

Current (DCRP, electrode positive)

Wire dia. inch	Amperes	Volts
0.035	160	28
0.045	190	28
0.062	260	30

Pulsed-arc, 75% Argon 25% Helium Shielding, 120 Pulse/Sec

Wire dia. inch	Amperes	Volts
0.045	150-165	20-21

Globular Transfer, Argon Shielding

Wire dia. inch	Amperes	Volts
0.045	165-180	17.9-18.5

Useful for welding heavy plate, where lower heat input is desirable to minimize potential weld defects.

GAS METAL ARC WELDING (GMAW or MIG)

Short-circuiting arc, 90%He 7-1/2%Ar 2-1/2%CO_2 shielding, at 25-45 cfm, 1/4" wire stickout.

Wire dia. inch	Amperes	Volts
0.035	75-120	18-20
0.045	100-140	20-22

75% argon 25% helium may also be used , with shielding gas flow at the upper end of the range. Grinding may be necessary to avoid cold laps at starts and stops.

GAS TUNGSTEN ARC WELDING (GTAW or TIG)

If necessary, RA333 may be welded using strips sheared off RA333 sheet as filler. However, GTAW wire produced specifically for welding is preferred.

Use 2% thoriated tungsten electrodes (AWS EWTh-2), with direct current straight polarity (electrode negative). For good arc control, grind the electrode tip to a 30 to 60 degree point, with a small flat at the tip. Grind lines should be parallel to the electrode, not circumferential. Finish grind on a 120 grit wheel. Adjust the arc on clean scrap metal, with no scale. Gas cups should be as large as feasible, 1/2" or greater, with a gas lens (diffusing screen) to reduce turbulence.

Argon is the normal shielding gas for manual welding. Do not add hydrogen or nitrogen to the shielding gas, as porosity may result. Helium may be added to the argon shielding gas to increase heat input and travel speed in automatic welding. However, argon-helium mixtures are not practical for manual GTAW, as arc length cannot be controlled as accurately as necessary.

Typical GTAW Parameters

Base Metal Thickness, inch	Electrode diameter, inch	RA333 wire dia. amperes	Current DSCP, (electrode negative)	Voltage, V
1/16-1/8	3/32	1/16 or 1/32	50-90	12
1/8-1/4	3/32-1/8	3/32 or 1/8	70-120	12
1/4-1/2	3/32-5/32	3/32 or 1/8	100-150	12

SUBMERGED ARC WELDING (SAW)

For sound welds with this inherently high heat process, it is important to use a highly basic flux. Adjust the parameters to deposit a reinforced bead contour and keep the interpass temperature below 200˚F. Heat input should be held under 40 kilojoule per inch.

Suggested fluxes include Avesta® Flux 803, basicity index 2.5, Hobart® RECORD NiCrW, basicity 5.1. Absolutely do not attempt to use acid fluxes meant for stainless steel. Average flux consumption about one pound per pound of wire.

Typical SAW Parameters

Wire Size, inch	DCRP Current Amperes	Voltage	Wire Stickout, Inch	Travel Speed Inch/Minute
0.045	150-225	25-28	1/2	8-12
0.062	180-250	25-28	3/4	8-12
0.094	230-300	25-28	1	8-12

Flux must be dry. Moisture absorption by flux during storage is the most likely cause of porosity in SAW. RECORD NiCrW which has absorbed moisture may be restored by heating one hour minimum at 750˚F. Avesta Flux 803 may be redried by heating two hours minimum at 660˚F. Either flux should be mixed once during the heating period to ensure uniform drying.

MIDWEST REGION:
125 W. Sterns Road • Temperance, MI 48182-9546 USA •313-847-0561 • 800-521-0332 • FAX: 313-847-6917
CENTRAL REGION:
9944 Princeton-Glendale Road • Cincinnati, OH 45246 USA • 800-521-0332
EASTERN REGION:
401 Governors Highway • So. Windsor, CT 06074 USA • 203-290-5340 • 800-521-0332
CANADA:
Rolled Alloys-Canada, Inc. • 168A Oakdale Road, Suite 2 • Downsview, Ontario, Canada M3N 2S5 • 416-745-2660
800-521-0332 • FAX: 416-745-2770
ENGLAND:
Rolled Alloys, Ltd. • Grangefield Industrial Estate • Grangefield Road • Pudsey, Leeds (UK) LS28 6JT
TEL: (0113) 236-2992 • FAX: (0113) 236-2575
NETHERLANDS:
Rolled Alloys BV • Christiaan Huygensstraat 25 • 3331 EA Zwijndrecht • TEL: • 31-78-6122622 • FAX: + 31-78-6193078

ROLLED ALLOYS®
Heat and Corrosion Resistant Alloy Specialists

TÜV CERT
DIN ISO 9002
Certificate: 00 100 3243

Bulletin # 120 Revised 4/96