HAYNES® 214® alloy Welding Information

Introduction

HAYNES® alloy No. 214® is a nickel-base alloy with outstanding oxidation resistance to 2200°F. 214® alloy has also been shown to have excellent carburization, nitriding, and chlorination resistance. The alloy contains nominally 4.5 weight percent aluminum. The presence of a significant amount of aluminum greatly enhances the environmental resistance of the alloy but also requires that some degree of care and caution be exercised when welding.

General

HAYNES® alloy No. 214® is a precipitation-strengthened alloy. When the gamma prime (Ni_3Al) precipitates, the alloy undergoes a slight volumetric contraction. It is possible that stress and strain caused by welding and mechanical deformation caused by the precipitation may cause cracking.

Good welding practice used to join gamma prime alloys applies to 214® alloy:

- Base metal should normally be in solution-annealed condition
- Minimize heat input
- Minimize restraint
- Cleanliness is critical
- Use stringer beads
- Interpass temperature 200°F maximum
- Grind between passes to remove oxide
- Interpass peening may be beneficial (but can easily be overdone)
- Use butter layers or forgiving fillers (HASTELLOY® alloy X or S) as required
- A convex profile (crowned) weld bead is mandatory
- No partial penetration welds

HAYNES® alloy No. 214® has been joined successfully using the GTAW, GMAW, and PAW process. Closely matching chemistry filler metal is available for use with these processes. HASTELLOY® alloy X electrodes may be used with the SMAW process. However, when using alloy X electrodes, the environmental resistance of the weld will be inferior to that of the base metal and a cover pass using GTAW with 214® alloy wire is suggested as a means to increase environmental resistance.

Cleaning

Prior to welding, the weld surface and adjacent area should be cleaned thoroughly of grease, dirt, oil or other foreign substances. Welds should also be ground between passes. One-inch wide areas along each side of the weld joint should be ground to expose bright metal before welding.

Weld Joints

A square butt joint is used for sheet material up to 7/64-inch. A V-joint is used for butt welds in thickness from 7/64-inch up to 3/8-inch, a double-V or U-joint for thickness of 3/8-inch-5/8-inch (a double-V-joint is preferred if both sides of the plate are accessible) and a double-U joint for thicknesses over 5/8-inch. T-joints are used when required by design. Partial penetration or filler welds are not recommended.

V-joints should be beveled to 60° included angle for GTAW welding, (70° for SMAW) while U-joints should have bevels with an included angle of 30° and a minimum bottom radius of 3/16-inch. J-grooves, which are sometimes required by design, should have a 15° bevel with a minimum bottom radius of 1/4-inch. For coated electrodes, the joint should be opened up an additional 10-15°.

The type of joint chosen will not necessarily be affected by a change of welding process since these joint designs are standard. To makes these joints suitable for automatic welding operations, certain slight modifications may be necessary.

Edge Preparation
The use of full machine tool in beveling is the surest way to obtain correct fits, although hand grinding can also yield satisfactory results. The edges of sheet or plate should be squared, aligned properly, and tacked before welding. Careful preparation to assure good welds is well justified. Thermal cutting and beveling, using such methods as plasma arc, are acceptable (oxyacetylene thermal cutting is not). It is necessary to grind plasma cut edges to remove oxides and dross prior to welding.

Weld Penetration
For full penetration, material 12-gage (7/64 in) and heavier should be welded from both sides. Material thinner than 12-gage may be welded from one side by using proper edge spacing to alloy full penetration. Care should be exercised to prevent incomplete penetration. This condition can leave undesirable crevices and voids in the underside of the joint. Incomplete penetration in material used for high-temperature applications creates stress raisers for focal points of mechanical failure.

When welding from both sides is not practical, the joint spacing should be increased and a copper backing bar used. Currents slightly higher than normal are then used to obtain complete penetration.

HAYNES® alloy No. 214® has a lower thermal conductivity than steel; therefore when using standard groove, it is necessary to use slightly larger clearance than would be needed for steel. This larger clearance insures complete penetration of the weld.

Heat Input
For optimum properties of the finished weldment, excessive heat input should be avoided. The lowest amperage and voltage possible are preferred. Minimize weave, use stringer beads when possible. Avoid excessively slow travel speeds buildup. Fast travel speeds result in teardrop-shaped weld puddles. Slow travel speed is bad (but it can be compensated for by low amps). High travel speed is bad and leads to centerline cracking. Interpass temperatures should be kept low, generally 200°F (93°C) nor less. Water quenching between passes is acceptable as long as part is dried.

Jigs and Fixtures
Proper jigging and clamping of the weld joint holds buckling and warping to a minimum. The use of backing bar helps to obtain a more uniform bead penetration. The bar also serves as a chill to the base metal and helps prevent excessive bead penetration. When an arc process is used, the portion of the fixture contacted by the arc should be copper. The bar should have a groove of the proper contour to permit good penetration and bead contour. For arc welding, the grooves should be of a minimum depth, usually from 1/32 to 3/32-inch, and approximately 1/16 to 3/16-

inches wide. The corners of the groove should be rounded. Square corners can cause poor bead contour and non-uniform heat transfer. The spacing between the hold-down clamps should be approximately 1/4 to 1/2-inch to permit the welding hear to dissipate slowly enough to minimize cooling stresses. Jigs and fixtures can be used to particular advantage when using the gas tungsten-arc process.

Dissimilar Filler Metals
Alternate filler metals such as HASTELLOY® S and X alloys have been used to successfully join 214® alloy. Use of these filler metals may be recommended when making highly restrained welds in thickness of 1/4 inches or greater. To preserve the environmental resistance of weld, it is necessary to cover the exposed welds with one (preferable two) layer deposits of 214® alloy. Alloy S is also recommended for joining 214® alloy to other hear-resistant materials.

Postweld Heat Treatment
HAYNES® alloy No. 214® and other high-temperature alloys are normally put into service in the as-welded condition.

For fabrications that will be in service at 1200-1800°F, weldments made of greater than 1/4-inch thickness, or those which have been welded into configurations which create significant residual stresses, an annealing treatment is suggested. The objective of a postweld heat treatment is to minimize and eliminate stress concentrations in the assembly.

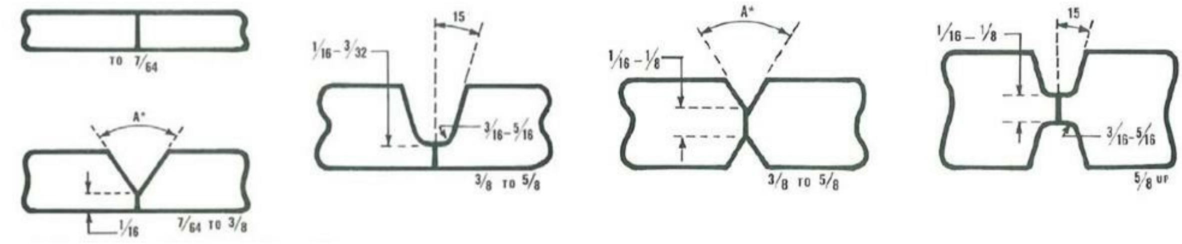
A heat treatment at a metal temperature between 1850-1950°F has been successful. The metal at temperature as little as 5 minutes is usually sufficient. If no additional welding is to be performed, the fabrication may be furnace cooled or air cooled.

Care must be taken when annealing. Heating 214® alloy through the temperature range of 1200-1800°F will cause gamma prime (Ni_3Al) to precipitate. This gamma prime precipitation results in a net shrinkage as well as an increase in strength and corresponding loss of ductility. In weldments and other highly stressed components, strain-age cracking may occur. This occurs when the residual stresses from forming and welding, augmented by stresses caused by precipitation, exceed the rupture strength of the base metal. It is important to heat the material through the 1200-1800°F temperature range as rapidly as possible. DO NOT STRESS RELIEVE IN THE 1200-1800°F RANGE.

In general, it is preferable to heat components to above 1850°F as rapidly as possible during the initial post-fabrication heat treatment. In those instances where the fabrication is large, or there are significant differences in section size, it is beneficial to hear to about 1150°F and then allow the fabrication to equilibrate for a short time, up to an hour, before heating as rapidly as possible through the 1200-1800°F range. This minimizes stresses caused by differential thermal expansion.

Torch heating or heating methods employing direct flame impingement on the fabrication should be avoided. Heating has been successfully done in an air atmosphere, as well as a protective atmosphere.

Standard Weld Joints



*A should be 75-80 for shielded metal-arc
A should be 60 for gas tungsten-arc and gas metal-arc
All linear dimensions are in inches

Nominal Weld Parameters

These welding parameters are given as a guide and are based upon welding conditions used in Haynes International, Inc. laboratories.

Automatic GTAW Welding Square Butt Joint – Autogenous welding (no filler metal added)			
-	Material Thickness		
-	0.040 in	0.062 in	0.125 in
Current (DCEN)	50A	80A	120A
Voltage	8V	8.5V	9.5V
Travel Speed	10 ipm	12 ipm	12 ipm
Electrode (EWTH-2)	1/16 in	3/32 in	1/8 in
Electrode Shape	45° inc.	45° inc.	45° inc.
Cup Size	#8	#8	#8
Shield Gas – 100% Argon	30 CFH	30 CFH	30 CFH
Backing Gas – 100% Argon	10 CFH	10 CFH	10 CFH

Manual GTAW Welding V- or U-Groove All thickness 1/8 in and greater	
Technique	Stringer Bead
Current (DCEN)	120A Root, 140-150A Fill
Voltage	11-14V
Filler Metal	1/8 in and 3/32 in via 214® alloy
Travel Speed	4-6 ipm
Electrode Shape	30° included
Cup Size	#8 or larger
Shield Gas – 100% Argon	30 CFH
Backing Gas – 100% Argon	10 CFH or back-gouge to sound metal and fill from root side
Preheat	Ambient
Interpass temperature	200°F max

GMAW Welding (Short Circuiting Transfer) All Thickness 0.125 in and greater	
Wire Type	214® alloy
Wire Size	0.035 in or 0.045 in diameter
Wire Feed Speed	170-190 ipm
Current (DCEP)	100-110A
Voltage	19-21V
Stickout	182-3/4 in
Travel Speed	8-10 ipm
Torch Gas	A1025 (90 He, 7.5 Ar, 2.5 CO_2) or 75% Ar-25% He, 50 CFH
Preheat	Ambient
Interpass Temperature	200°F max

SMAW Welding

No matching chemistry SMAW electrodes are currently available for HAYNES® 214® alloy. HASTELLOY® X alloy electrodes have been successfully used to join 214 alloy. Typical welding parameters of HASTELLOY X alloy electrodes (flat position only) are given below.

Electrode Diameter	Voltage	Current (DCEP)	Travel Speed
in	**volts**	**amps**	**ipm**
3/32	22-24	60-80	3-5
1/8	22-24	80-110	4-6
5/32	23-25	105-165	4-6