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Plate

Duracorr®: Welding Guidelines

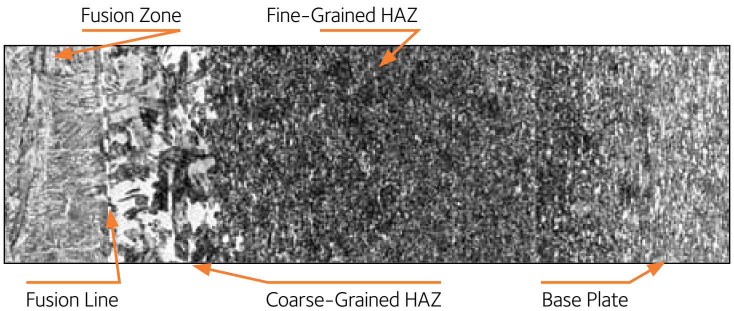
Introduction

Duracorr is a 12% Cr stainless steel with a fine-grained microstructure of ferrite and tempered martensite. Duracorr is readily weldable using common welding processes, both to itself as well as to carbon and stainless steels, provided that appropriate consumables and fabrication procedures are employed. Joints and the immediately adjacent surfaces should be free of loose/thick scale, moisture, grease, and/or other foreign materials that could potentially influence weld quality. Heavy surface oxide can interfere with wetting, making it difficult to obtain a smooth plate-to-weld bead transition. As for welding any material, welder fume exposure should be minimized through the use of ventilation, fume extractors, and/or respirators, as necessary for the given conditions.

Metallurgy

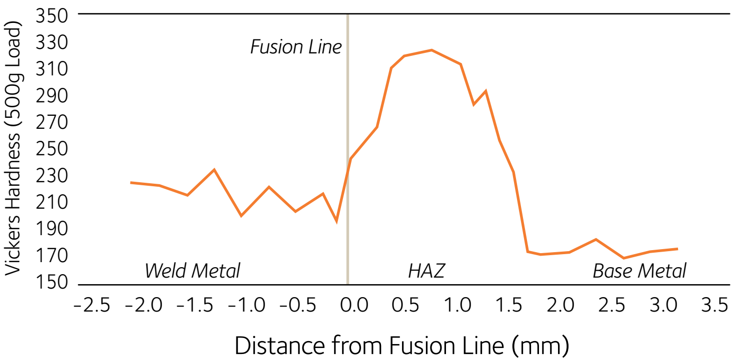
During arc welding of Duracorr, filler wire and base plate are melted together to produce a fused zone (FZ) having a composition somewhere between that of the wire and plate. Composition, in turn, is the primary determinant of fusion zone microstructure. The Duracorr FZ typically consists of ferrite, martensite and austenite. Welding according to recommended practice results in typical FZ hardnesses of 175 to 225 VHN. Excessive heat inputs cause more base plate to be melted, favoring martensite formation in the FZ and increasing the FZ hardness to values as high as 325 VHN.

Microstructure of Typical Duracorr Arc Weld



Material adjacent to the fusion zone experiences a weld-induced thermal cycle that alters the pre-weld microstructure and its properties. This "heat-affected zone" (HAZ) consists of a narrow band of grain-coarsened ferrite and martensite (immediately adjacent to the fusion zone) bordered by a region of fine martensite. The peak HAZ hardness is typically in the 310 to 350 VHN range and corresponds to the fine martensitic microstructure.

Typical Harness Profile of Weld in 1/4"-Thick Duracorr



Heat Input Control

Since grain coarsening is accompanied by some loss in toughness, limits have been placed on recommended weld heat input to constrain grain growth in the HAZ. Heat input is calculated using the following equation:

$$\mathbf{HI} = \frac{\mathbf{60\,(E \times I)}}{\mathbf{1000\,WS}}$$

Where
- HI = Heat input (kJ/in)
- E = Arc voltage (Volts)
- I = Weld current (Amps)
- WS = Welding speed (in/min)

The maximum recommended heat input is 25 kJ/in for thicknesses less than 1/2 inch. Thicker plates have been successfully welded to AWS requirements with heat inputs to 70 kJ/in. This value should only be exceeded where testing has demonstrated that weld properties meet the requirements for the desired application. In such instances, qualification of the welding procedures per an appropriate code; e.g., ANSI/AWS D1.1, "Structural Welding Code – Steel," should insure that a sound, acceptable weld is obtained.

As shown in the above equation, heat input can be controlled by restricting the welding current and/or increasing the welding speed. In general, the voltage and current employed should be set in the low to middle portion of the electrode manufacturer's range. Adjustment of torch angle and position may be required to maintain penetration and avoid slag entrapment as the speed is increased. Heat input control is also enhanced by using stringer beads (no weave) and avoiding overwelding.

Thermal Constraints

Preheat is recommended for welding Duracorr in order to drive off surface moisture. Weldments requiring multiple passes should be made while observing a maximum interpass temperature of 210 - 225ºF. Post-weld heat treatment is not required, although stress relieving at temperatures of 1300ºF or less is permissible.

Welding Processes

Within the heat input constraints specified, any arc welding process can be used to weld Duracorr. Flux-cored arc (FCAW), gas metal arc (GMAW), shielded metal arc (SMAW), and gas tungsten arc welding (GTAW) are common processes that are typically run in the <25 kJ/in range. However, heat inputs associated with GMAW spray mode as well as submerged arc welding (SAW) may exceed the recommended maximum. Therefore, fabrication using these latter techniques should only be done after demonstrating that the resulting weld properties meet or exceed the requirements for the particular application.

Welding Consumables

As shown in the table below, arc welds in Duracorr are made using low carbon, austenitic filler metals, preferably 309L, although 308L or 316L stainless are acceptable alternatives. Higher silicon versions of these fillers (309LSi, 308LSi, 316LSi) can be used, where necessary, to improve wetting and/or weld appearance, albeit at some risk of increased weld metal crack sensitivity. Welding Duracorr to carbon steel should always be done employing 309L. The use of "matching" filler metals, such as 409 and 410, is not recommended.

Recommended consumables by welding process

Welding Process	Filler Wire		Shielding Gas**
	Designation	Specification	
FCAW	E309LTx-x, E308LTx-x, E316LTx-x	ANSI/AWS A5.22	CO_2, Ar-O_2 (1-5%), Ar-CO_2 (5-25%)
GMAW	ER309L, ER308L, ER316L, ER309LSi*, ER308LSi*, ER316LSi*	ANSI/AWS A5.9	Ar-O_2 (1-5%), Ar-CO_2 (5-25%)
SMAW	E309L-xx, E308L-xx, E316L-xx	ANSI/AWS A5.4	Not Used
GTAW	ER309L, ER308L, ER316L	ANSI/AWS A5.9	Argon

* Higher silicon wires yield improved wetting and bead appearance. Some increased risk of weld metal cracking.

** Match to electrode per manufacturer's recommendation.

Further Information

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