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Recommended Practices for Welding Austenitic Chromium-Nickel Stainless Steel Piping and Tubing

American Welding Society

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Recommended Practices for Welding Austenitic Chromium-Nickel Stainless Steel Piping and Tubing

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Abstract

This document presents a detailed discussion of the metallurgical characteristics and weldability of many grades of austenitic stainless steel used in piping and tubing. The delta ferrite content as expressed by ferrite number (FN) is explained, and its importance in minimizing hot cracking is discussed.

A number of Figures and Tables illustrate recommended joint designs and procedures. Appendix A presents information on the welding of high-carbon stainless steel cast pipe fittings.

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Table of Contents

List of Tables

List of Figures

Recommended Practices for Welding Austenitic Chromium-Nickel Stainless Steel Piping and Tubing

Introduction

The ideal piping system would be a single piece of pipe, so formed, shaped, sized, and directed as to contain or convey the fluid required by the process in which it is involved. For most systems this cannot be. Changes in size, shape, direction, and operating conditions usually preclude such a fabrication. Joints become necessary. Piping systems usually must be made of many different components, and the joints that connect them must be as strong and serviceable as the components themselves. Therefore, engineers and mechanics should try to apply those joining methods which most nearly meet the conditions of one-piece fabrication and also allow for necessary assembly, erection, maintenance, and operation.

Most of the austenitic stainless steels are readily weldable when the proper procedures and techniques are followed. They can be joined by most of the fusion welding processes, and good pipe welders can adapt very quickly from carbon steel or low alloy steel to stainless steel. Orbiting pipe welding machines are also very adaptable to these materials.

The instructions in these recommended practices can be put to use by any competent pipe welder in any good shop or field site. Reasonable care is required, as in any pipe welding operation; however, careful adherence to the procedure requirements will usually produce excellent welds in stainless steel piping and tubing.

1. Material Compositions and Specifications

1.1 Compositions. Chemical composition ranges and type numbers for those stainless steels generally available in wrought piping and tubing are listed in Table 1. These are American Iron and Steel Institute (AISI) Standard Compositions. Chemical composition ranges and designations for five stainless steels generally available as cast pipe are shown in Table 2. These are included because cast valves and fittings are considered part of a piping system.

The weldability of castings may be somewhat less than that of a wrought stainless steel of the same type. This is because fully austenitic castings have much larger grains than similar wrought material. Consequently, there is less grain boundary area along which to disperse the impurities. As a result, there may be a tendency toward hot cracking when welding some castings. However, proper control of the composition of the casting, to obtain four to ten percent delta ferrite, can prevent hot cracking.

1.2 Specifications. Typical American Society for Testing and Materials (ASTM) specifications covering piping and tubing in both cast and wrought form (seamless or welded) are listed in Table 3. ASTM employs the AISI type numbers for designating the austenitic types. However, the ASTM chemical composition requirements differ slightly from the AISI requirements and will vary slightly in different ASTM specifications. The composition ranges specified for cast tubular products are identical with those of the American Castings Institute (ACI). Specifications for covered welding electrodes and welding rods and electrodes are provided in Tables 4 and 5.

2. Base Metals

2.1 Primary Types (304, 305, 309, and 310). These materials have many applications and are widely used for their corrosion and oxidation resistance, high-temperature strength, and low-temperature properties. However, there are a number of welding-related characteristics that may affect all of these, as noted below.

Types 304 and 305 may become sensitized by welding, depending on their carbon content and the manner in which they are welded, and as a result may require solution annealing to restore immunity to intergranular