ANSI/AWS D11.2-89 (R2006)
An American National Standard

Guide for Welding Iron Castings

American Welding Society

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Guide for Welding Iron Castings

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Abstract

This standard presents briefly the history and metallurgy of cast iron and the welding processes applicable to it.

A newly developed weldability test is described in detail and instructions given for its application in specific cases.

Provision is made for qualification of welding procedures and welders when necessary; quality control practice is also included.

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Guide for Welding Iron Castings

1. Scope and History

1.1 Scope. The term *cast iron* encompasses a family of ferrous alloys with a variety of metallurgical, mechanical, and physical properties. The chemical composition and welding requirements of the metals vary within the family. This document discusses the relative weldability of various types of cast irons and the filler metals and processes used to weld them. It recommends the steps for qualification of welding procedures, welding operators and welders, and requirements for the quality of welds. The terms *welding procedure*, *welding operator*, and *welder*, are used as defined in the latest edition of ANSI/AWS A3.0, *Standard Welding Terms and Definitions.*

1.2 History

1.2.1 Types of Iron. Although iron has been used in various forms for over two thousand years, iron castings in the form used today evolved in Europe in the 15th and 16th centuries. The microstructure of medieval castings basically was gray iron with areas of white iron and nonmetallic inclusions. Refinements in foundry practices and melt control resulted in a more uniform structure.

Malleabilizing, a method of increasing the ductility of white cast iron by heat treatment, was first developed in the early 1700's. About a century later, black heart malleable iron was developed.

In the 1940's, ductile (spheroidal graphite) iron was developed. The ductility is improved by spherodizing the graphite by the addition of magnesium, rare earth elements, or both.

The most recently developed form of cast iron is compacted graphite, a hybrid material with properties between gray and ductile irons.

1.2.2 Welding. Oxyfuel gas and arc welding of cast iron did not gain wide acceptance until early in the 20th century. The first filler metals were cast along with the iron castings so that the compositions were similar. Later, both ferrous and nonferrous (copper or nickel) base electrodes and rods were developed and are still in use today.

New, more refined welding processes and procedures were developed to extend greatly the number of applications where welding is used. Shielded metal arc (SMAW), gas metal arc (GMAW), flux cored arc (FCAW) and submerged arc (SAW) welding currently are popular arc welding processes.

Gas tungsten arc (GTAW) and proprietary processes are used in a variety of applications.

2. Cast Iron — Its Metallurgy and Weldability

2.1 Metallurgy

2.1.1 General. Cast iron may be described as an alloy of iron, carbon and silicon. All commercially produced irons also contain manganese. They may be alloyed with nickel, chromium, copper, molybdenum, tin, antimony, vanadium, and other elements. The alloying elements may be present individually or in combination.

The carbon content is in excess of the quantity that can be retained in solid solution by austenite. Thus, during solidification, a portion of the carbon separates from the melt as either iron carbide (Fe_3C) or graphite. If the cooling rate is rapid, the carbon rich phase will be iron carbide. Elemental carbon (graphite) precipitates if the cooling rate is slow enough. The type of carbon constituent and its shape (if graphite), in part, determines the type and properties of cast iron. The phases present in the matrix also affect the properties; therefore, the entire microstructure of the casting must be considered when planning a suitable welding procedure.

2.1.2 Gray Iron. The most commonly used form of cast iron is gray iron. In this material, the excess carbon precipitates as flakes of graphite in a matrix of ferrite, pearlite, or a mixture of the two microconstituents (see Figure 1). The resultant product has moderate strength,