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Recommended Practices for Plasma Arc Cutting and Gouging

American Welding Society

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Approved by
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Abstract

This revised recommended practice provides information regarding current practices for plasma arc cutting and gouging. The document explains the basic principles of operation, methods of operation, system components and their installation, optimization of cut quality, and cost considerations. Safety aspects associated with the process are also discussed.

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Table of Contents

Page No.

List of Tables

List of Figures

Recommended Practices for Plasma Arc Cutting and Gouging

1. General

1.1 Scope. This document describes the recommended practices of plasma arc cutting and gouging. It provides a brief history of its application process development and provides a general description of components used for the process, controls, power supplies, and process consumables. The types of cutting machines and the related control systems are described, along with associated pollution and hazard control methods. Methods of optimizing cut quality and economics associated with the process are discussed. Safety and health aspects associated with the plasma arc cutting and gouging process are discussed.

These recommended practices, prepared by the AWS C5J Subcommittee on Plasma Arc Cutting of the AWS Committee on Arc Welding and Cutting, are intended to guide plasma arc operators and supervisors in the use of plasma arc cutting and gouging equipment. These recommended practices are not intended to take the place of sound engineering principles and should be supplemented with the equipment manufacturers operation and safety instructions.

This standard makes use of the U.S. Customary Units. Approximate mathematical equivalents in the International System of Units (SI) are provided for comparison in parentheses ( ) or in appropriate columns in tables and figures.

1.2 Introduction. A nontechnical description of plasma is "the fourth state of matter," the three familiar states being solid, liquid, and gas. For a common substance such as water, these three states are ice, water, and steam. When energy in the form of heat is added to ice, the ice melts and forms water, as shown in Figure 1. When more energy is added, the water vaporizes into steam. By adding more energy to steam the water vapor will disassociate into hydrogen and oxygen. Additional energy will cause the hydrogen and oxygen to become ionized. These ionized gases are electronically conductive. The resulting high-temperature conductive gas is known as plasma.

1.3 General Process Description. Plasma arc cutting (PAC) is a process that severs metal by using the heat of a nozzle-constricted plasma arc to melt a localized area. The molten metal is removed by a high-velocity stream of high-temperature, ionized gas. Plasma arc gouging uses the same process to remove material from the surface of a plate without fully penetrating the workpiece. Welding research scientists discovered in the early 1950s that the characteristics of the open arc used in gas tungsten arc welding (GTAW) could be altered to perform cutting operations instead of welding. The arc was constricted by directing it through an orifice in a water-cooled copper nozzle located between the electrode and the workpiece, which greatly increased the arc's power density. They discovered that constricting the arc into a well-focused column raised the arc's voltage significantly, making it more concentrated than the open arc used for welding.

Figure 2 shows arcs operating at the same current. The plasma jet on the right is only moderately constricted by the nozzle, but it operates at about twice the voltage and it acts considerably hotter than the open arc (GTAW) on the left. Even higher energy intensity can be achieved by constricting the arc with a boundary layer of nonionized gas inside the nozzle bore. The effectiveness of this boundary layer can be increased by swirling the plasma gas and raising the flow rate, which forces the cool, non-ionized gas outward radially into a thicker boundary layer. This protects the nozzle orifice allowing it to operate at higher energy levels and prolonging its life.

The characteristics of the plasma jet vary according to the gas flow rate, nozzle orifice size and arc current, as well as the type of gas used (gases are discussed in 4.8). A low flow rate, for example, reduces the jet's momentum and forms a highly concentrated heat source ideal for welding, but inadequate for cutting or gouging. Conversely, if the gas flow is increased sufficiently, the momentum of the plasma jet will be high enough to expel the metal melted by the heat of the plasma arc, resulting in gouging or cutting.