HOBART
FILLER METALS

Topic D.

Welding Process Training Series

Stainless Steel

HOBART FILLER METALS

SAFETY

As in all occupations, safety is paramount. Because there are numerous safety codes and regulations in place, we recommend that you always read all labels and the Owner's Manual carefully before installing, operating, or servicing the unit. Read the safety information at the beginning of the manual and in each section. Also read and follow all applicable safety standards, especially ANSI Z49.1, Safety in Welding, Cutting, and Allied Processes.

ANSI Z49.1:, Safety in Welding, Cutting, and Allied Processes is available as a free download from the American Welding Society at: http://www.aws.org

Here is a list of additional safety standards and where to get them.

Safe Practices for the Preparation of Containers and Piping for Welding and Cutting, American Welding Society Standard AWS F4.1, from Global Engineering Documents (Phone: 1-877-413-5184, website: www.global.ihs.com).

National Electrical Code, NFPA Standard 70, from National Fire Protection Association, Quincy, MA 02269 (Phone: 1-800-344-3555, website: www.nfpa.org and www. sparky.org).

Safe Handling of Compressed Gases in Cylinders, CGA Pamphlet P-1, from Compressed Gas Association, 4221 Walney Road, 5th Floor, Chantilly, VA 20151 (Phone: 703-788-2700, website:www.cganet.com).

Safety in Welding, Cutting, and Allied Processes, CSA Standard W117.2, from Canadian Standards Association, Standards Sales, 5060 Spectrum Way, Suite 100, Ontario, Canada L4W 5NS (Phone: 800-463-6727, website: www.csa-international.org).

Safe Practice For Occupational And Educational Eye And Face Protection, ANSI Standard Z87.1, from American National Standards Institute, 25 West 43rd Street, New York, NY 10036 (Phone: 212-642-4900, website: www.ansi.org).

Standard for Fire Prevention During Welding, Cutting, and Other Hot Work, NFPA Standard 51B, from National Fire Protection Association, Quincy, MA 02269 (Phone: 1-800-344-3555, website: www.nfpa.org.)

OSHA, Occupational Safety and Health Standards for General Industry, Title 29, Code of Federal Regulations (CFR), Part 1910, Subpart Q, and Part 1926, Subpart J, from U.S. Government Printing Office, Superintendent of Documents, P.O. Box 371954, Pittsburgh, PA 15250-7954 (Phone: 1-866-512-1800) (There are 10 OSHA Regional Offices—phone for Region 5, Chicago, is 312-353-2220, website: www.osha.gov).

Booklet, *TLVs, Threshold Limit Values*, from American Conference of Governmental Industrial Hygienists (ACGIH), 1330 Kemper Meadow Drive, Cincinnati, OH 45240 (Phone: 513–742–3355, website: www.acgih.org).

Towing a Trailer – Being Equipped for Safety, Publication from U.S. Department of Transportation, National Highway Traffic Safety Administration, 400 Seventh Street, SW, Washington, D.C. 20590

U.S. Consumer Product Safety Commission (CPSC), 4330 East West Highway, Bethesda, MD 20814 (Phone: 301-504-7923, website: www.cpsc.gov).

Applications Manual for the Revised NIOSH Lifting Equation, The National Institute for Occupational Safety and Health (NIOSH), 1600 Clifton Rd, Atlanta, GA 30333 (Phone: 1-800-232-4636, website: www.cdc.gov/NIOSH).

Prepared by the Miller Electric Mfg. Co. Training Department.

⚠ WARNING

This document contains general information about the topics discussed herein. This document is not an application manual and does not contain a complete statement of all factors pertaining to those topics.

The installation, operation, and maintenance of arc welding equipment and the employment of procedures described in this document should be conducted only by qualified persons in accordance with applicable codes, safe practices, and manufacturer's instructions.

Always be certain that work areas are clean and safe and that proper ventilation is used. Misuse of equipment and failure to observe applicable codes and safe practices can result in serious personal injury and property damage.

Welding Process and Filler Metals Training Series:

Welcome to the Welding Process and Filler Metals Training Series. This training series was developed for the purpose of providing a basic set of educational materials that can be used individually or in a classroom setting.

The topics covered in the series are:

Filler Metals

- **Topic A.** Introduction To Metals
- **Topic B.** Tubular Wires
- **Topic C.** Low Alloy Steel
- **Topic D.** Stainless Steel
- **Topic E.** Aluminum
- **Topic F.** Hard Surfacing

Welding Processes

- **Topic 1.** Introduction To Welding
- **Topic 2.** Welding Safety
- **Topic 3.** Basic Electricity For Welding
- **Topic 4.** Welding Power Source Design
- **Topic 5.** Engine Driven Power Sources
- **Topic 6.** Shielded Metal Arc Welding
- **Topic 7.** Gas Tungsten Arc Welding
- **Topic 8.** Gas Metal Arc Welding
- **Topic 9.** Flux Cored Arc Welding
- **Topic 10.** Plasma Arc Cutting And Gouging
- **Topic 11.** Troubleshooting Welding Processes
- **Topic 12.** Submerged Arc Welding

Please note, this series was not developed to teach the skill of welding or cutting, but rather to provide a foundation of general knowledge about the various processes and related topics.

MICROGRAPH IMAGES COURTESY

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The American Society for Metals has generously permitted photographic reproductions of a number of illustrations from the online Micrograph Center: asminternational.org

Table of Contents

Note that the term "passivation" is often used to describe a cleaning operation with nitric acid especially to dissolve iron contamination from the surface of stainless steels. References:

ASTM Standards 1985 Section I Volume 01.03.Steel – Plate, Sheet and Wire. ASTM A380 Page 196.

Carpenter Stainless Steels Working Data, Page 184 – Cleaning and Passivation of Stainless Steels – Carpenter Technology Corp., Reading, PA 19603.

Bradford Derustit Corp. – Curtis Industrial Park, Rte. 67, Ballston Spa, NY 12020. Offers liquid and paste forms of Derustit SS-3 chemical cleaner for stationery or immersible applications.

Cleaning and Descaling Stainless Steels – Nickel Development Institute, 15 Toronto St., Suite 402, Toronto Ontario, Canada M5C2E3.

Grains And Grain Boundaries?

Before discussing the major classes of stainless steels and appropriate welding filler metals it would be prudent to review the mechanism of solidification and subsequent formation of grains and grain boundaries. When a liquid steel cools through the solidification temperature range peculiar to that particular grade of steel, the process of crystallization commences. Although individual atoms have great freedom (mobility) in the liquid state, once freezing starts they begin to orient themselves in a specific type of crystal lattice or arrangement.

Nucleation of crystals occurs simultaneously in various locations. The pattern in each location repeats itself. Crystal growth resembles pine tree formations and is described as dendritic (branching). See Figure 1 and Figure 2. During the process of solidification the separate crystals, growing at varying rates in different locations (each in their own orientation or plane of atoms), converge to form boundaries. The individual areas of uniform crystal structure are called grains and the boundary areas, grain boundaries. Grain size and shape are determined by the manner in which the branches from dendrites meet. See Figure 2.

Grain boundaries represent junctions of differently oriented crystals or regions of disarray in the atomic arrangement. The atomic structure in converging grains at random orientation cannot match perfectly at their interfaces. Therefore, between any two grains there exists a transition layer where the atoms are not in their proper places with respect to either grain. Exposure to a chemical etching solution results in preferential attack in these vulnerable grain boundary locations. Thus, the metallurgist can prepare and etch a metallographic specimen from stainless steel base metal or a weld deposit. His "crystal" ball for determining the intricacies of grain size, shape, structure etc., is called a microscope.

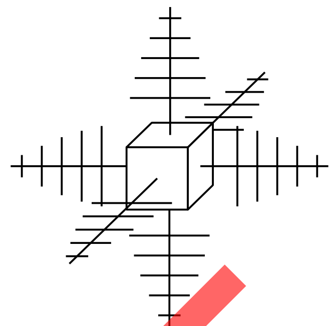

Figure 1 – Dendritic Growth Of Cubic Crystal

Figure 2 – Grain Size And Shape Are Determined By The Manner In Which The Branches From Dendrites Meet.

Subsequent to solidification, say after cooling to room temperature, grain growth – where larger grains grow at the expense of smaller ones – may occur during heating and cooling cycles. Explanation of this phenomenon lies in the realm of thermodynamics involving so-called free energy at grain interfaces. Grain growth occurs above the recrystallization temperature because grains have a tendency to decrease their surface energy. Large grains have smaller grain boundary area per unit volume, hence smaller surface energy. Because larger grains grow at the expense of smaller ones, energy is conserved.

Ferrite, Austenite, Martensite And Solid Solutions

What Are They?

Since the three main classes of stainless steels are named in accordance with their predominant metallurgical phases, i.e. ferritic, austenitic and martensitic, is seems advisable to explain these phases before discussing each stainless steel class in further detail. An elementary knowledge of solid solutions in metals will also lead to a better understanding of stainless steels.

Ferrite And Austenite

Pure iron freezes at 2802°F in a crystal form called ferrite. It has a body-centered cubic (BCC) structure with the basic cell containing one atom at each of eight corners and one atom in the middle. See Figure 3. Upon cooling to 2552°F the ferrite structure transforms into a modification called austenite, the unit cell of which is face-centered cubic (FCC) containing one atom at each of eight corners and one atom on each face (none in the middle). At 1670°F the austenite phase reverts to ferrite, the form stable at room temperature.

Although structurally identical, the ferrite forming at the higher temperature is designated delta ferrite while the ferrite forming at the lower temperature is called alpha ferrite. Austenite is often designated as the gamma phase. Note the gaps between the eight corner atoms are larger in austenite than in ferrite.

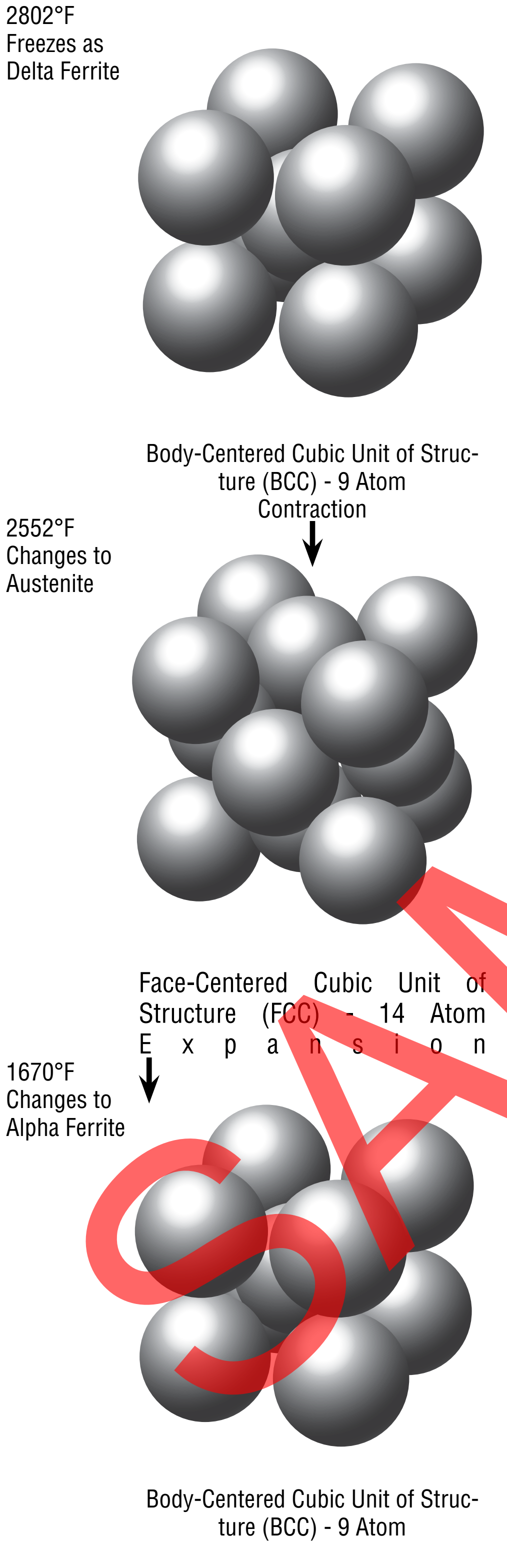

Figure 3 – Pure Iron Has Two Structurally Distinct Forms Note Changes As Temperature Decreases

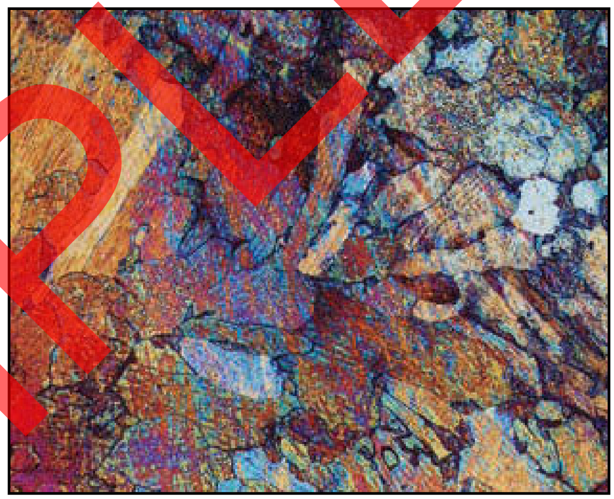

Figure 4 – An As-Welded Weld Deposit On Uns S40900 Type 409 Stainless Steel Magnified 100 Times Showing Large, Columnar Ferrite Grains With Martensite At The Grain Boundaries. The Image Was Produced Using An Optical Light Microscope With Bright-Field (Bf) Illumination And The Etchant Was 3 G Potassium Disulfite, 10 G Sodium Thiosulfate, 2 Ml Hydrochloric Acid, And 100 Ml Water.