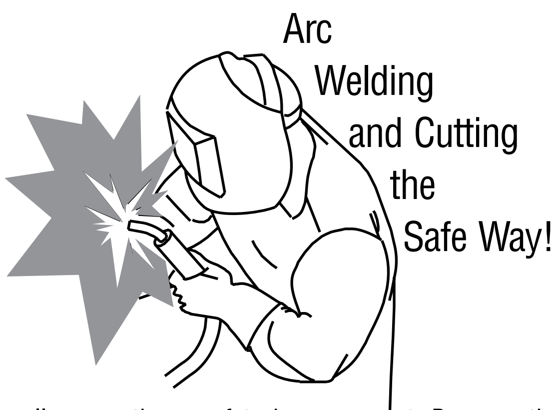
HOBART
FILLER METALS

Topic A.

Welding Process Training Series

Introduction To 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.** Metal Cutting
- **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.

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Figure 1 – Early Metalworking

Introduction

Metalworking history goes back to the time when some anonymous caveman found that he could shape one "rock" by hammering on it with another. The "rock" likely was a relatively pure piece of copper or iron that he had found. Ancient manuscripts detail the beautiful metalworking done in the time of the Pharaohs of Egypt. From this it can be determined that the art of metalworking was one of the earliest endeavors known to man.

Ancient history tells us that mankind's higher culture rested on the ability to tame metals. Gold and silver were some of the earliest metals worked, usually into ornaments. Their intrinsic value was much less than that of iron, copper, tin, or bronze. Pure metals such as copper or meteoric iron were readily available to the tribes living near the Great Lakes area of North America and other areas in the northern hemisphere. Archaeologists agree that pure metals, found accidentally, were hammered into shapes before they were ever smelted or heated and shaped.

Iron came into the historic picture much later. Historical calendars indicate that iron became known to Europe about 1000 B.C. This was several thousand years after the advent of copper and bronze. However, the people of that era were slow to use iron because their bronze implements were satisfactory and they already knew how to work with the copper-tin alloy.

In the western hemisphere, iron was unknown before Columbus made his momentous voyage. Its use caught on rapidly among the American Indians and later the Polynesian people.

The use of iron spread rapidly over the known parts of the world as man traveled and explored. At last, here was a material that was tougher and stronger than copper or even the copper-tin alloy bronze. This was the beginning of the era that has since been named the Iron Age.

Today, it is difficult to imagine life without metals. They have become an integral part of our daily lives. Without metal there would be no modern forms of transportation, communication, construction, etc. Indeed, metal offers unique properties for applications that no other materials can match.

The America Welding Society defines metal as an opaque, lustrous, elemental chemical substance that is a good conductor of heat and electricity, usually malleable, ductile, and more dense than other elemental substances.

Applications for metal can be found all around us. Metals possess a high strength per unit mass that makes them useful for carrying heavy loads (bridges) and in items that need to be able to resist impact damage (automobile bumpers).

The strength and resilience of metals makes them excellent choices for the construction of buildings, bridges, vehicles, appliances, tools, railroad rails, etc.

The ability of metals to conduct electricity allows them to be used in electrical devices and appliances as well as carrying electric current over long distances with little lost energy.

The thermal conductivity of metals allows them to be used for containers to heat material over a flame. Additionally, metal is often used to protect sensitive equipment from overheating.

The pure metals found in nature are typically too soft, brittle, or chemically reactive for practical use. This led to the development of metal alloys. A metal alloy is a mixture of two or more elements in a solid solution in which at least one component is a metal. Early experiments in alloying metals began around 2,000 B.C. when it was discovered that adding a small amount of tin to copper would make the copper tougher. This discovery led to the alloy now called bronze.

Combining different ratios of metals as alloys modifies the properties of pure metals to produce desirable properties such as being less brittle, harder, corrosion resistant, or have a more desirable color or luster.

Metal Properties

A metal's properties are the characteristics that make it useful and different from other metals. Properties determine a metal's behavior under various conditions. In welding, the metal in the welded joint must have properties that are equal to or better than the properties of the base metal. Understanding these properties reduces errors in filler metal selection and welding procedures.

Metal properties are a result of the chemical composition of the particular metal. Metals are produced to a chemistry range specification in order to insure the metal has the required properties. Each type of metal will be provided with either a typical chemistry range or actual chemistry documentation.

Actual and typical chemistry ranges are shown in Figure 2. Typical chemistry range indicates the alloying elements used to produce the metal fall within the ranges listed.

In critical applications like aerospace it may be necessary to know the actual chemistry of the metal being used. In those instances an actual chemistry chart will be provided.

The properties of a metal can be divided into two categories: mechanical properties and physical properties.

Mechanical Properties

Mechanical properties determine how a metal stands up to a force applied to it. Mechanical properties describe the way a metal will bend, scratch, dent, stretch, or break. These are the most common attributes to know for welding.

Alloy Content	Actual	Typical
Carbon (C)	0.30	0.28-0.33
Chromium (Cr)	0.95	0.80-1.10
Magananese (Mn)	0.80	0.70-0.90
Molybdenum (Mo)	0.24	0.15-0.25
Phosphorus (P)	0.028	0.035 max
Silicon (Si)	0.30	0.15-0.35
Sulpher (S)	0.03	0.04 max

Figure 2 – Actual and Typical Chemistry of a 4130 Steel

Tensile Strength

Reference Figure 3 and locate point "B" on the graph. The term applied to point "B" is the ultimate tensile strength or tensile strength. The value on the chart indicates the highest load that was placed on the sample that resulted in failure. In other words, point "B" represents the greatest load in pounds that was placed on the sample metal. When this load was reached, the sample continued to stretch but the amount of stress decreased until it finally failed at point "C".

The tensile strength of a material is given in pounds per square in. (psi) or mega pascals (MPa). It is determined by dividing the area of the sample into the maximum unit stress (for psi, total pounds of load divided by the cross sectional area measured in square inches). This value will represent the maximum amount of load per unit of measure a material can be subjected to before it breaks in tension.

A metal with a high tensile strength would be used in applications where the metal is subjected to a stretching type of load. For example, the cables on a suspension bridge or crane would need to have a high tensile strength.

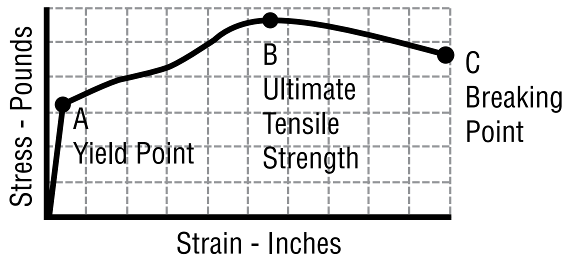

Figure 3 – Stress Strain Curve

Yield Strength (Yield Point)

Yield point is the place on the graph where the stress exceeds the elastic limit of the material. Look at Figure 3 again. Point "A" on the graph is the yield point. Yield point is measured in pounds per square inch, and is found by dividing the cross sectional area of the sample metal into the load indicated on the graph.