Topics included in this overview are:

- **Introduction**
  - What is Arc Welding?
  - Why is Welding Important?
  - Why Learn to Weld?

- **Careers in Welding**

- **The American Welding Society (AWS)**

- **Welding Safety**

- **Basic Electricity**

- **Welding Fundamentals**

- **Welding Certification**
Upon successful completion of this unit of study, you will be able to …

- Identify definitions and terminology associated with welding
- Demonstrate safe working habits in the welding environment
- Name the parts and types of welds and weld joints
- Interpret basic welding symbol information
- Identify opportunities available to welders
Introduction
Arc welding is most commonly used to join two pieces of metal. The welder creates an electric arc that melts the base metals and filler metal (consumable) together so that they all fuse into one solid piece of metal.
Why is Welding Important?

- Many things around us are welded …
  - *Pipelines that bring fresh water*
  - *Towers that carry electricity to houses*
  - *Cars and buses that take people where they need to go*
Basic Steps of Arc Welding

- Prepare the base materials: remove paint and rust
- Choose the right welding process
- Choose the right filler material
- Assess and comply with safety requirements
- Use proper welding techniques and be sure to protect the molten puddle from contaminants in the air
- Inspect the weld
Welding Safety
Welding can be safe when sufficient measures are taken to protect yourself and others from potential hazards.

Students should read and understand the following before welding:

- *Warning Labels*
- *Material Safety Data Sheets (MSDS)*
• Understand and follow all warning labels found:
  – On welding equipment
  – With all consumable packaging
  – Within instruction manuals
Material Safety Data Sheets (MSDS) are:

- Required by law and OSHA
- Created by the manufacturer of a product per OSHA guidelines
- Designed to inform users
- Shipped with every box of consumable product
MSDS - Continued

- **MSDS outlines a product’s:**
  - Identity and composition
  - Potential hazards
  - Safe use
  - Handling information
  - Manufacturer contact information

**SECTION IV - HEALTH HAZARD DATA**

Threshold Limit Values: The ACGIH recommends general limits for Welding Fume NOS (Not Otherwise Specified) is 8 mg/m³. ACGIH 1996 practice states that the TLV TWA should be used as guidance in the control of health hazards and should not be used as fine times between safe and dangerous concentrations. See Section V for specific limits for substances which may modify this TLV. Threshold Limit Values are figures published by the American Conference of Governmental Industrial Hygienists. Units are parts per million (ppm) or parts per billion (ppm).

Effects of Overexposure: Electric arc welding may cause one or more of the following health hazards:

- **Increased** exposure to welding fumes can lead to alkaline joint deposits in long and may affect pulmonary function.
- **Increased** exposure to welding fumes can affect the central nervous system, resulting in impaired speech and movements. Respiratory and some long term effects have not been reported. **WARNING:** This product, when used for welding or cutting, produces fumes or gases which contain elements known to be the cause of various health effects, and in some cases, cancer. (Refer Health & Safety Code Section 25263.6 et seq.)
- **Acid** exposure to eyes and skin. All causes for reported.
- **Electric** shock can be either. If welding is performed on damp materials or with wet clothing, or in a damp environment, with a high risk of non-visible or accidental contact with workers, see the following equipment.
- **Manometic** DC Welder, DC Manual (No) Welder, or AC Welder with Reduced Voltage Control.

**Emergency and First Aid Procedures:** Call for medical aid. Employ first aid measures recommended by the American Red Cross.

If breathing becomes difficult or if exposure is continued, it is recommended to seek medical attention immediately.

**SECTION V - REACTIVITY DATA**

Hazardous Decomposition Products: Welding fumes and gases cannot be classified simply. The composition and quantity of both are dependent upon the metal being welded; the process, procedure, and electrode used.

Other conditions which also influence the composition and quantity of the fumes and gases to which workers may be exposed include: conditions on the metal being welded such as metal grade, condition of cleaning, the number of workers and the volume of the work area, the method and motion of welding, the size of the welding area, and the presence of inclusions in the molten metal.

**Emergency and First Aid Procedures:** Call for medical aid. Employ first aid measures recommended by the American Red Cross.

**SECTION VI AND VII**

CONTROL MEASURES AND PRECAUTIONS FOR SAFE HANDLING AND USE

- Wear non-flammable, fire-resistant welding helmets, and light-gauge welding gloves.
- Use safety glasses, other protective clothing, and protective clothing when welding is conducted in enclosed spaces or where work is performed near areas where hazardous materials are stored or processed.
- When welding is conducted in enclosed spaces or where work is performed near areas where hazardous materials are stored or processed, protective clothing should be worn, and a fire extinguisher should be readily available.

**Fire Precautions:** Melted metal or molten metal is hazardous to persons and property. Extinguish fires with carbon dioxide or dry chemical agents. Use water or other extinguishing agents that will cool the metal and prevent it from igniting. Use water or other extinguishing agents that will cool the metal and prevent it from igniting.

- **Proposed Infrastructure** - Proposed infrastructure should always be designed to prevent excessive noise or any other hazards that may cause serious damage or injury.
• ANSI Z49.1: Safety in Welding, Cutting, and Allied Processes
  - A safety document published by the American Welding Society that covers safe practices in the welding environment
  - To get your free copy, go to:

• E205: Arc Welding Safety
  - A safety document summarizing many of the hazards and safe practices for welding
  - Download and print your own copy at:
  - Free copies available from Lincoln Electric at:
    - www.lincolnelectric.com/products/litrequest

• Access the E-learning Site @ www.agedlearning.com
• Protect yourself and others from potential hazards including:
  - Fumes and Gases
  - Electric Shock
  - Arc Rays
  - Fire and Explosion Hazards
  - Noise
  - Hot objects
Fumes and Gases

- Fumes and gases can be hazardous to your health
- Keep your head out of the fumes
- Use enough ventilation, exhaust at the arc, or both, to keep fumes and gases from your breathing zone and the general area
- See product labeling and MSDS for ventilation and respirator requirements
Electric Shock

- Electric shock can kill
- Do not touch live electrical parts
  - Primary Voltage – 230, 460 volt input power
  - Secondary Voltage – 6 to 100 volts for welding
- Insulate yourself from work and ground
- Follow all warnings on welding equipment

Do not make repairs yourself, alert your instructor immediately!
• **Arc rays can injure eyes and burn skin**

• **The welding arc is brighter than the sun**

• **Precaution must be taken to protect your eyes and skin from UV radiation**

• **Wear correct eye and body protection**
• Welding sparks can cause fires and explosions
• Sparks and spatter from the welding arc can spray up to 35 feet from your work
• Flammable materials should be removed from the welding area or shielded from sparks and spatter
• Have a fire extinguisher ready
• Inspect area for fires 30 minutes after welding
Protective Clothing

Welders must wear protective clothing for

- Protection from sparks, spatter and UV radiation
- Insulation from electric shock

- Protective clothing includes …
  - Fire-proof clothing without rolled sleeves, cuffs or frays
  - Work boots
  - Welding gloves, jackets, bibs, and fire-proof pants
  - Welding cap, helmet and safety glasses
  - Ear protection – ear plugs and muffs
Basic Electricity and Welding
• The electricity flows from the power source, through the electrode and across the arc, through the base material to the work lead and back to the power source.
• Voltage – The electrical potential or pressure that causes current to flow
  – *Measured in Volts*
• Current – The movement of charged particles in a specific direction
  – *Measured in Amps*
• Polarity
  – **DC-** (Direct Current Electrode Negative)
  – **DC+** (Direct Current Electrode Positive)
  – **AC** (Alternating Current)
Can All Metals Be Welded?

- Most metals can be welded, but not all
- The three most common weldable metals include:
  - *Mild Steel* - inexpensive and strong
  - *Stainless Steel* – does not rust
  - *Aluminum* – does not rust and is light weight

Mild steel  |  Stainless Steel  |  Aluminum
• Material thickness is sometimes measured by gauge from 36 (.004 in) to 3 (.2391 in)
  – For example, steel gauge and measurement in inches:

  16 gauge = .051”  14 gauge = .064”  12 gauge = .081”  10 gauge = .102”

PLEASE NOTE: As the gauge number gets smaller … the material thickness gets larger.
Types of Joints
There are 5 types of joints …

- Butt
- Lap
- Tee
- Corner
- Edge
Parts of a Weld
Parts of a Weld

Fillet Weld Terminology

Groove Weld Terminology

Heat Affected Zone
Joint and Weld

Face
Toe
Throat

Leg

Reinforcement

Face
Toe

Heat Affected Zone
Joint Root

Weld Root

Joint Root

Root Opening
Fillet and Groove Welds

- Groove and fillet welds can be made on many types of joints

<table>
<thead>
<tr>
<th></th>
<th>Fillet</th>
<th>Groove</th>
</tr>
</thead>
<tbody>
<tr>
<td>Butt</td>
<td>N.A.</td>
<td></td>
</tr>
<tr>
<td>Tee</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Corner</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lap</td>
<td></td>
<td>N.A.</td>
</tr>
</tbody>
</table>
Fillet welds should:
- Have a flat to slightly convex face
- Be uniform in appearance
- Have equal leg size
- Have good wash-in into base materials

This is an example of a good fillet weld:
Welding Positions
What are Welding Positions?

- There are various positions that a weld can be made in:

- **Flat Position**
  - Throat of Weld Vertical
  - Axis of Weld Horizontal
  - **1F**

- **Horizontal Position**
  - Vertical Plate
  - Axis of Weld Horizontal
  - **2F**

- **Vertical Position**
  - Axis of Weld Vertical
  - Vertical Plate
  - **3F**

- **Overhead Position**
  - Axis of Weld Horizontal
  - Horizontal Plate
  - **4F**

- **Groove Weld**
  - Plates and Axis of Pipe Horizontal
  - **1G**
  - Pipe shall be rolled while welding

- **2G**
  - Plates and Axis of Pipe Vertical

- **3G**
  - Plates Vertical

- **4G**
  - Plates Horizontal

- **4G**
  - Inclined Position (45°)

- **5G**
  - Pipe shall not be turned or rolled while welding

- **6G**

---

Lincoln Electric
Classifications of Electrodes
Classifications of Electrodes

• Classified according to filler metal specifications by AWS and ASTM (American Society for Testing Materials)
  – Lincoln, AIRCO, Hobart, etc. will all be the same

• Based upon four factors:
  – Minimum tensile strength of the as-welded deposited weld metal
  – Type of covering
  – Welding position
  – Type of welding current (AC, DC+, DC-)
Classifications

- Electrode designated by “E” followed by a 4- or 5- digit number
- First two or three digits - minimum tensile strength as-welded deposited weld metal expressed in thousands of pounds per square inch (1000psi)
  - E-60xx - 60,000psi TS
  - E-120xx - 120,000 psi TS
• Third or fourth digit refers to the welding position.
  – E-xx1x - all positions
  – E-xx2x - flat and horizontal fillet positions
  – E-xx3x - flat position only
• The fourth or fifth and last digit indicates the type of welding current and the type of flux covering
  – \textit{E-xx10 - DC reverse polarity (electrode positive) only (cellulose sodium).}
  – \textit{E-xx11 - AC or DC reverse polarity (cellulose potassium) Fast freeze, cutting}
  – \textit{E-xx13 - AC or DC straight polarity (titania potassium)}
Selecting an Electrode
Selecting an electrode

- Type of metal to be welded
- Thickness of metal
- Position of weld
- Type of power (DC or AC)
- Cleanliness of metal
- Weld bead appearance desired
Selecting an electrode

- **Fast-Freeze-electrodes** - deposits a weld that solidifies or freezes rapidly - E6010, E6011.
- **Fast-Fill** - deposits metal rapidly - E7018, E6024, E6027.
- **Fill-Freeze** - characteristics between fast-freeze and fast-fill - E6012, E6013, E6014.