Chapter 12

Flux Cored Arc Welding Equipment, Setup, and Operation

Objectives

- Explain the FCA welding process
- Describe what equipment is needed for FCA welding
- List the advantages of FCA welding, and explain its limitations
- Tell how electrodes are manufactured and explain the purpose of the electrode cast and helix
- Discuss what flux can provide to the weld and how fluxes are classified

Objectives (cont'd.)

- Explain what each of the digits in a standard FCAW electrode identification number mean
- Describe the proper care and handling of FCAW electrodes
- List the common shielding gases used, and explain their benefits
- Explain how changing the welding gun angle affects the weld produced
- Identify the methods of metal transfer and describe each

Objectives (cont'd.)

- Explain the effect electrode extension has on FCA welding
- Tell what can cause weld porosity and how it can be prevented

Introduction

- Flux cored arc welding (FCAW)
  - Fusion welding process
    - Weld heating is produced from an arc between the work and a continuously fed filler metal electrode
  - Atmospheric shielding
    - Provided completely or in part by flux sealed within the tubular electrode
  - Rise in the in use of FCAW
    - Due to a number of factors

Principles of Operation

- FCA is similar to operation of GMA welding
  - Both use a constant-potential (CP) or constant-voltage (CV) power supply
- Flux inside electrode
  - Provides molten weld pool protection
  - Improves strength
  - Improves weld shape
- Major atmospheric contamination
  - Comes from oxygen and nitrogen

Principles of Operation (cont'd.)

- Carbon, chromium, and vanadium can be added to improve:
  - Hardness and strength
  - Creep and corrosion resistance
- Gas formers
  - Rapidly expand and push air away from molten weld pool
- Slag
  - Protects hot metal from atmosphere

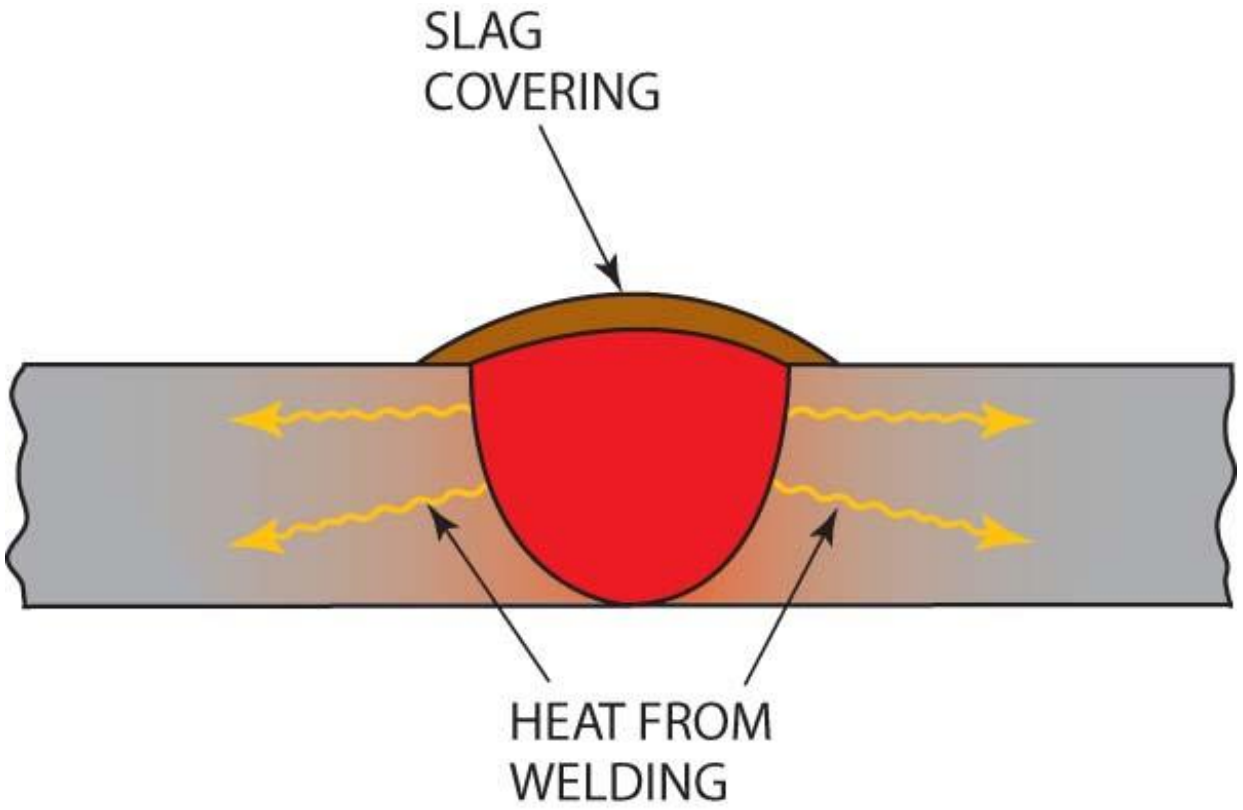


FIGURE 12-4 The slag covering keeps the welding heat from escaping quickly, thus slowing the cooling rate.

Equipment

- Same type required for GMAW
  - FCA welding guns
    - Available as water-cooled or air-cooled
  - Fume extraction nozzles
    - Vacuum pulls smoke back into a specially designed smoke extraction nozzle
  - Electrode feed systems
    - Similar to those used for GMAW

Advantages

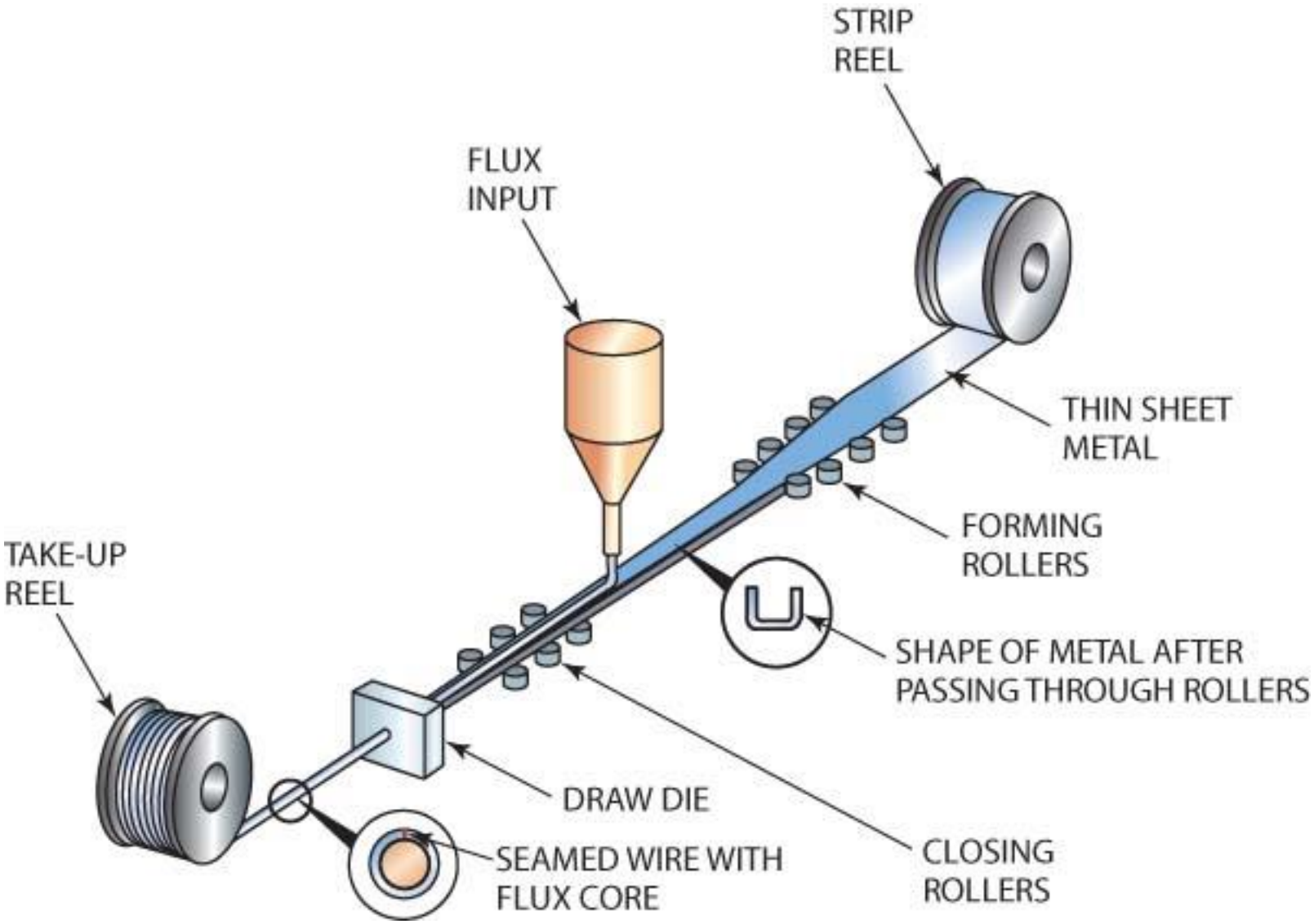
- Include:
  - High deposition rate is possible
  - Minimum electrode waste
  - Narrow groove angle can be used
  - Adding deoxidizers allows for minimum cleaning
  - All-position welding
  - Changes in power settings give flexibility
  - Addition of flux provides high quality welds
  - Excellent control of molten weld pool

Limitations

- Include:
  - Confined to ferrous metals and nickel-based alloys
  - Equipment and electrodes are more expensive
  - Removal of slag requires another production step
  - Increase in smoke and fume generation

FCAW Electrodes

- Manufacturing method
  - Form a thin sheet of metal into a U-shape
  - Pour in flux
  - Squeeze shut
  - Pass through a series of dies to size it
- Another method
  - Start with a seamless tube
  - Seal one end
  - Pour in flux



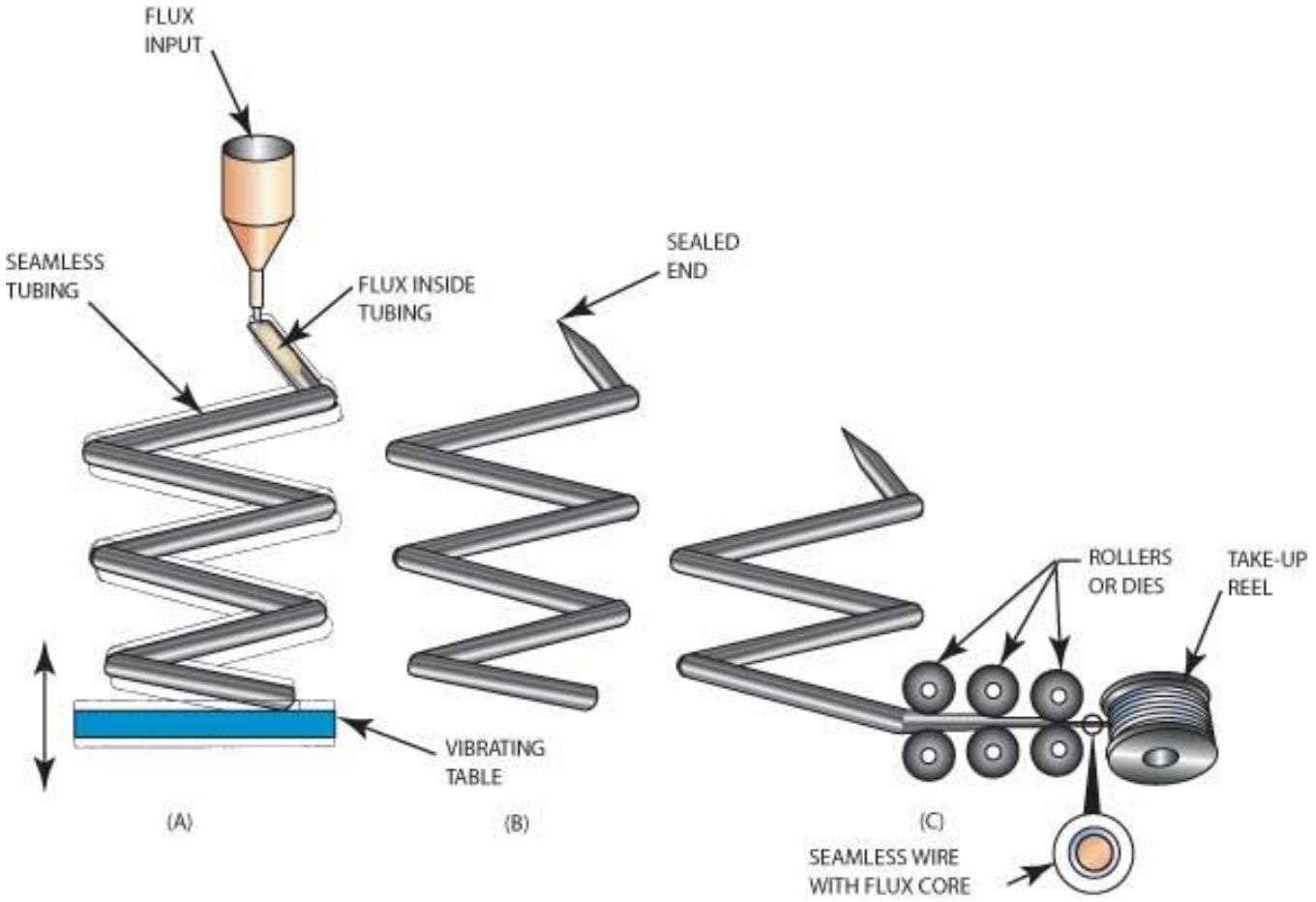


FIGURE 12-8 This shows one method of filling seamless FCA welding filler metal with flux. The vibration helps compact the granular flux inside the tube.
View Welding Video

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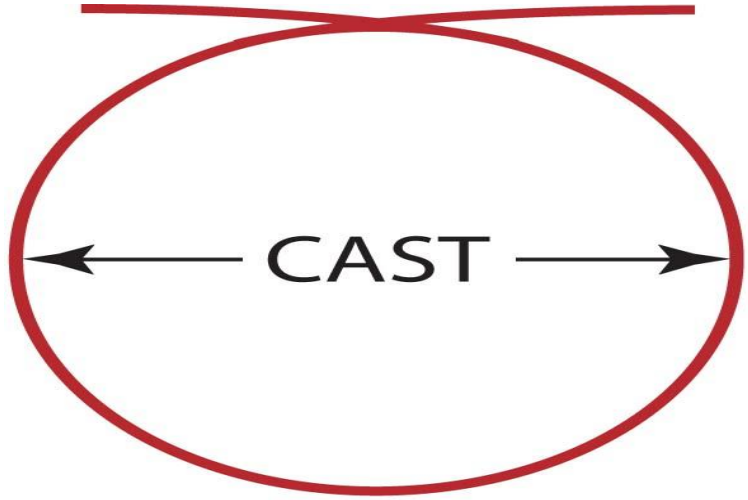
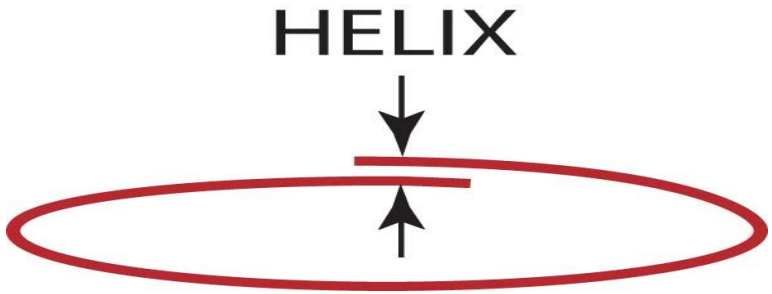
FCAW Electrodes (cont'd.)

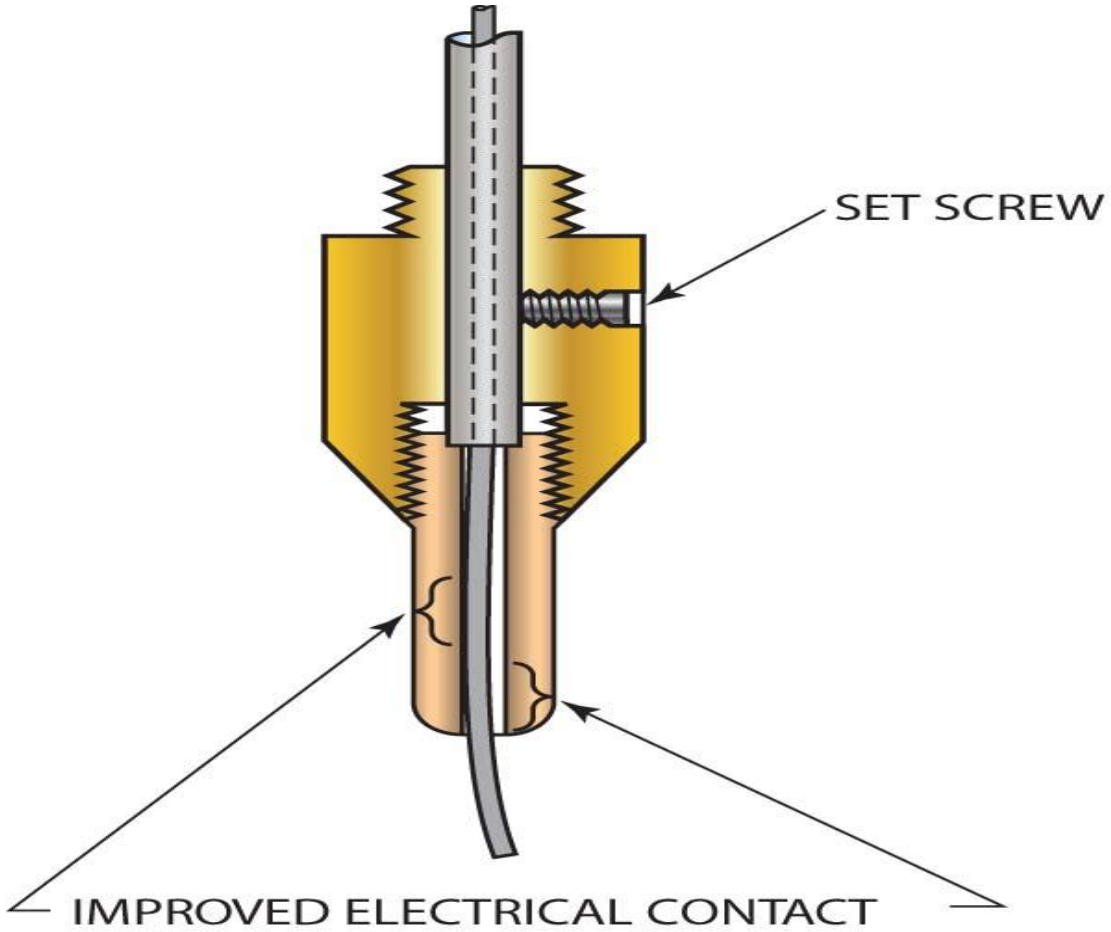
- Electrode cast and helix
  - Feed out some wire electrode and cut it off
  - Lay it on the floor and watch it form a circle
    - Diameter of circle is the cast
    - Wire electrodes do not lay flat
    - Height is the helix





FCAW Electrodes (cont'd.)

- Cast and helix cause the wire to rub on the contact tube



FCA Welding Electrode Flux

- Flux can provide all or part of the following:
  - Deoxidizers
  - Slag formers
  - Fluxing agents
  - Arc stabilizers
  - Alloying elements
  - Shielding gas (View Welding Video)

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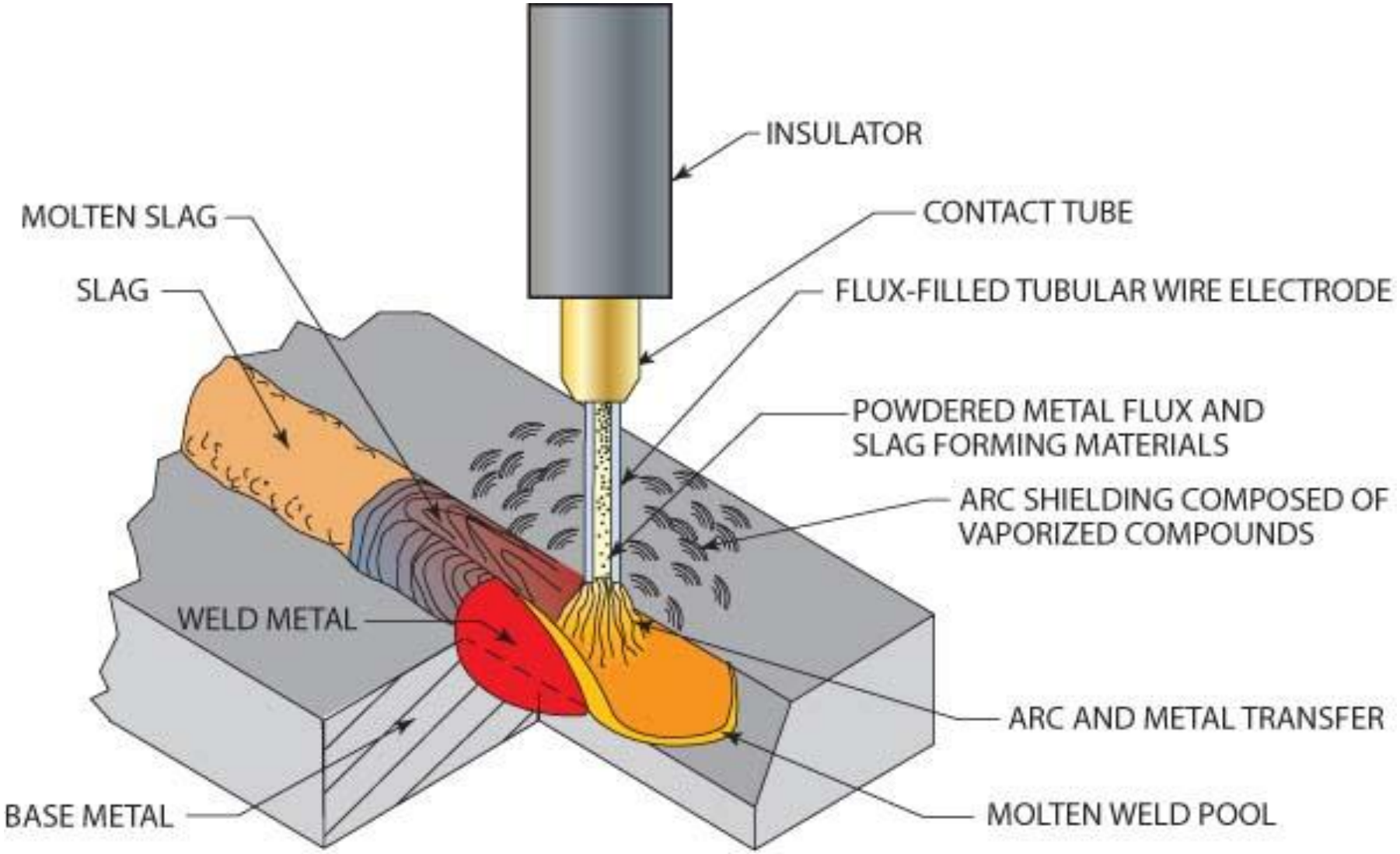
FCA Welding Electrode (cont'd.)

- Types of FCAW fluxes
  - Rutile-based flux are acidic
    - Produces a smooth, stable arc and a refractory high-temperature slag
    - Produces fine drop transfer and low fumes
    - Used for out-of-position welding
  - Lime-based fluxes are basic
    - Remove impurities
    - Undesirable for out-of-position welding



(A)

Mild Steel

- Electrode number *E70T-10* is used to explain the electrode classification system
  - *E*: electrode
  - *7*: tensile strength in units of ten thousand
  - *0*: used for flat and horizontal fillets only, and *1* is used for all position electrodes
  - *T*: tubular electrode
  - *10*: number ranges from *1* to *14*
    - Indicates electrode shielding gas and other welding characteristics

Mild Steel (cont'd.)

- Electrode *E70T-10* can have optional identifiers such as *E70T-10MJH8*
  - *M*: mixed gas, 75-80% Ar, balanced CO_2
  - *J*: Charpy V-notch impact test value
  - *H8*: residual hydrogen levels in the weld

Stainless Steel Electrodes

- AWS classification for stainless steel for FCAW electrodes starts with the letter *E*
  - Following the *E*: AISI three-digit stainless steel number is used
    - To the right of the number: dash and a suffix number indicating welding position

Metal Cored Steel Electrode Identification

- Addition of metal powders to flux produced a new classification
- Example: *E70C-3C*
  - *E*: electrode
  - *7*: tensile strength in units of 10,000 psi
  - *0*: flat and horizontal fillets only, and 1 for all positions
  - *C*: metal-cored electrode
  - *3*: used for a Charpy impact
  - *C*: indicates CO_2

Care of Flux Core Electrodes

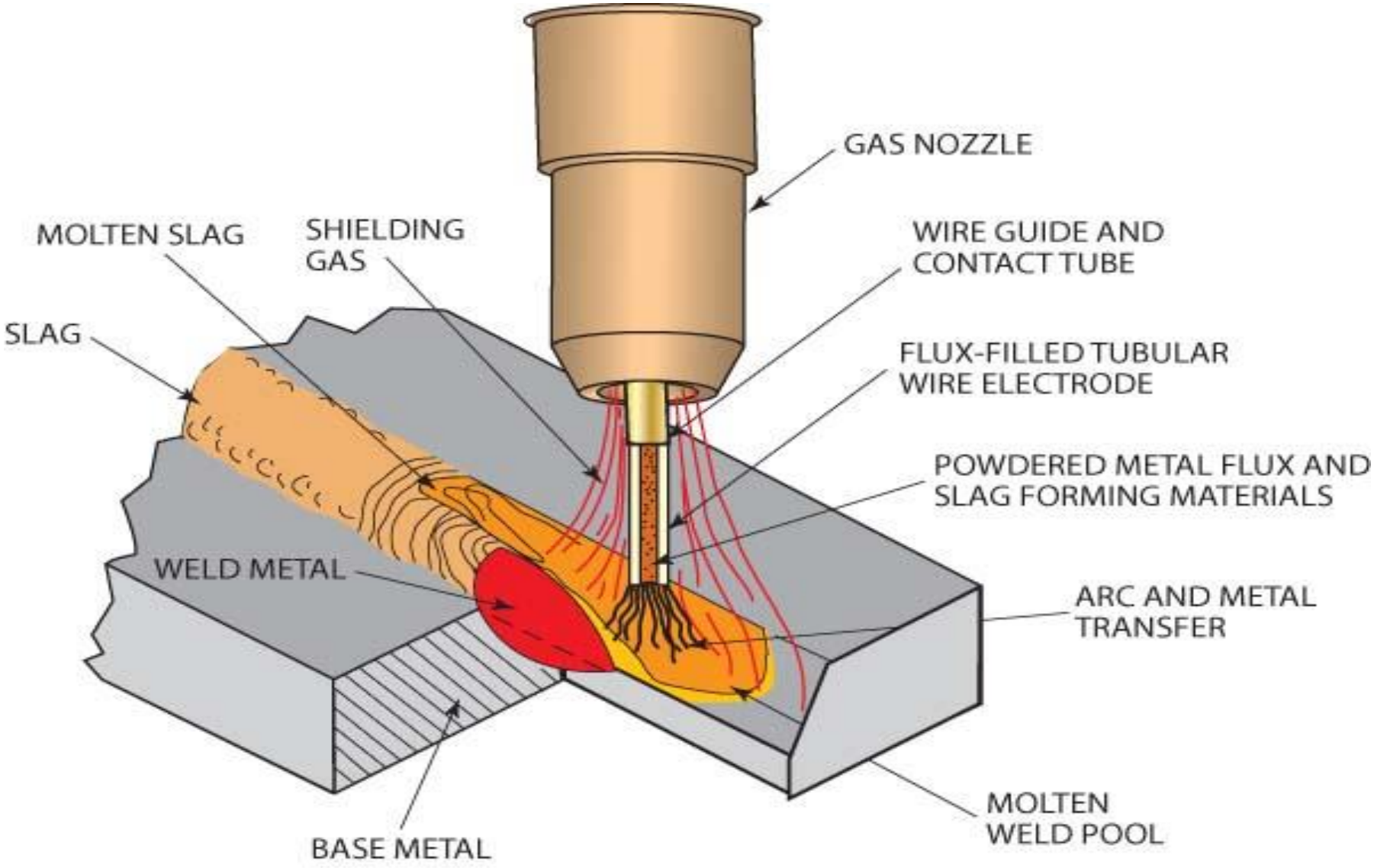
- Considerations
  - May be wrapped in sealed plastic bags or special paper
  - Some are shipped in cans or cardboard boxes
  - Crystal desiccant is sometimes placed in the shipping container
  - Some require storage in an electric rod oven
  - Weather conditions affect ability to make high quality welds
    - May be necessary to preheat base metal to drive out moisture

Shielding Gas

- Key terms
  - Self-shielding: electrode provides all shielding
  - Dual shield: shielding gas is added
- Care must be taken to use cored electrodes with the recommended gases
  - Selection effects arc and weld properties
- Shielding gas comes in high-pressure cylinders
  - Gases used for FCA welding: $C0_2$ and mixtures of argon and $C0_2$
    - Straight $C0_2$ can be used for some welding

Shielding Gas (cont'd.)

- Most FCA welding electrodes are:
  - Specifically designed to be used with or without shielding gas
    - For a specific shielding gas
    - For a percentage mixture
- Never use an FCA electrode with a non-designated shielding gas
  - Weld produced may be unsafe



(B)

Welding Techniques

- Gun angle, work angle, and travel angle
  - Refer to relation of gun to work surface (View Welding Video) Click here to view closed captioning
    - Gun angle can be used to control the weld pool
    - Changes in travel angle will affect weld bead shape and penetration
- FCAW electrodes have a mineral-based flux
  - These fluxes are refractory and become solid at a high temperature

Forehand/Perpendicular/Backhand Techniques

- Often used to describe gun angle as it relates to work and direction of travel
  - Forehand technique: pushing the weld bead
  - Backhand technique: pulling or dragging the weld bead
  - Perpendicular technique: gun angle is at approximately 90º to the work surface

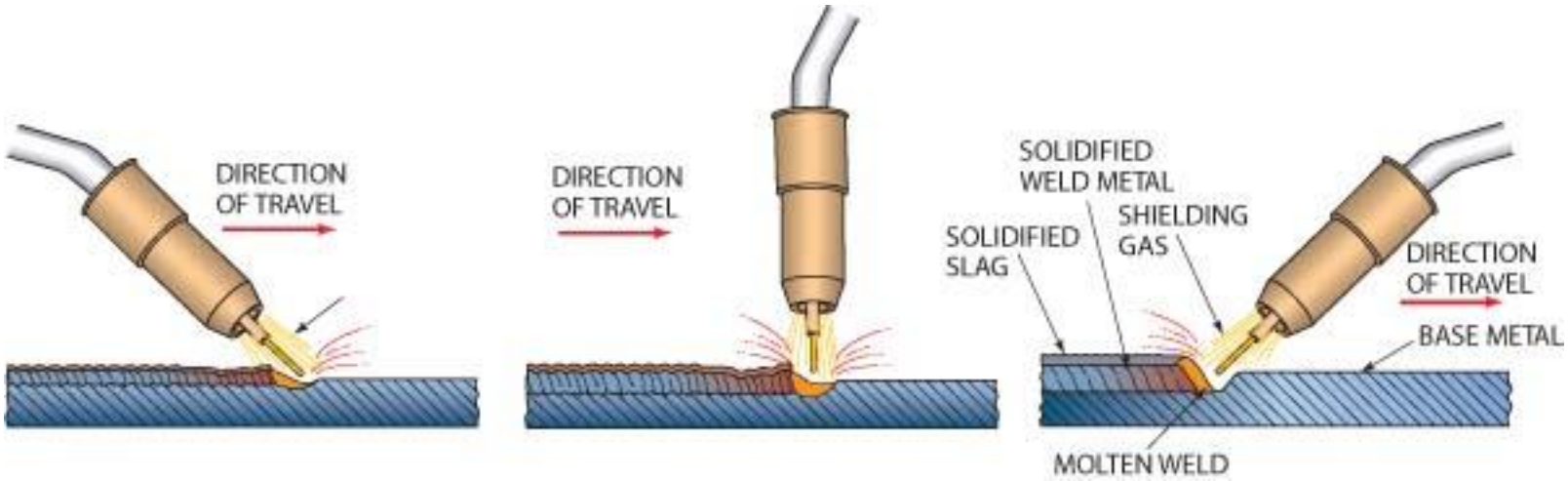


FIGURE 12-20 Changing the welding gun angle between forehand, perpendicular, or backhand angles will change the shape of the weld bead produced.

Advantages and Disadvantages of the Forehand Technique

- Advantages
  - Joint visibility
  - Electrode extension
  - Less weld penetration
  - Out-of-position welds
- Disadvantages
  - Weld thickness
  - Welding speed
  - Slag inclusions and spatter

Advantages and Disadvantages of the Perpendicular Technique

- Advantages
  - Machine and robotic welding
    - No need to change the gun angle
  - Uniform bead shape
    - Penetration and reinforcement are balanced
- Disadvantages
  - Limited visibility
    - Welding gun is directly over the weld
  - Weld spatter
    - Weld spatter can collect in the nozzle

Advantages and Disadvantages of the Backhand Technique

- Advantages
  - Weld bead visibility
  - Travel speed
  - Depth of fusion
- Disadvantages
  - Weld buildup
  - Post weld finishing
  - Joint following
  - Loss of penetration

Travel Speed

- Linear rate at which the arc is moved along the weld joint
  - Fast travel speeds deposit less filler metal
- Undercut
  - Occurs along edges or toes of the weld
- Preferred rate of travel for maximum penetration
  - Can stay within selected welding variables
  - Can control fluidity of weld pool

Mode of Metal Transfer

- Describes how molten weld metal is transferred across the arc to base metal
- Mode of transfer, weld shape, and depth of penetration depend on:
  - Welding power source
  - Wire electrode size
  - Type and thickness of material
  - Type of shielding gas
  - Best welding position

Spray Transfer – FCAW-G

- Most common process used with gas shielded FCAW
- FCAW-G can be used:
  - On thin or prepared thick sections of material
  - On a combination of thick to thin materials
  - With small or large electrode diameters
  - With a combination of shielded gases

Globular Transfer – FCAW-G

- Occurs when welding current is below transition current
  - Arc becomes unstable because of gravitational pull from large drops
- Electrode extension
  - Measured from end of electrode contact tube to the point the arc begins at the end of the electrode
- Porosity in the weld
  - Can be a constant problem

Troubleshooting FCA Welding

- Often a trial-and-error process
  - Make one adjustment or change at a time
  - Make a trial weld to see if the problem improved
  - Repeat until the problem is resolved
- Common causes of FCA welding problem
  - Equipment setup
  - Worn or dirty parts

Summary

- Flux cored arc welding
  - Produces more tons of welded fabrications that any other process
  - Wide variety of flux cored arc welding filler metals and shielding gas combinations are available
  - Very few differences in manipulation and setup among filler metals