



# HRP Training Aid: Welding Machines

DESCRIPTION	ECCN
Laser welding machines .....	2B999.c
Welders, MIG (GMAW) .....	2B999.d
Welders, oxy-acetylene .....	EAR99
Welders, resistance type spot .....	EAR99
Welders, stick (SMAW) .....	EAR99
Welders, TIG (GTAW) .....	EAR99
Welders, e-beam .....	2B999.e

## DEFINITIONS, ACRONYMS, AND HELPFUL TIPS

**Welding:** A process that creates permanent bonds between materials, most commonly metals, by applying intense heat to the materials, causing them to melt and intermix, forming a powerful connection (weld). This molten pool often incorporates a separate filler material, which melts alongside the base metals, further strengthening the joint as it cools and solidifies.

**Identification tip:** Look for the following acronyms related to types of welders/welding techniques frequently appearing on the equipment or on available paperwork:

- MIG (metal inert gas)
- GMAW (gas metal arc welding)
- SMAW (shielded metal arc welding)
- TIG (tungsten inert gas)
- GTAW (gas tungsten arc welding)
- Oxy-acetylene (oxygen-acetylene gas welding)

The **most common** type of welding machine is the MIG (metal inert gas) welder; this type of machine is known for its versatility, ease of use, and ability to create strong, clean welds. MIG welders are used on a wide range of metals, including steel, aluminum, and stainless steel.

The **least common**, or least frequently used, welding machine in general industrial settings is the oxy-acetylene welding machine, also known as gas welding. It is generally not as powerful or efficient for the structural welding and fabrication common in many industries compared to arc welding methods like MIG, TIG, or stick welding (shielded metal arc welding [SMAW]).

## INDUSTRIAL APPLICATIONS

- **Automotive:** Joining sheet metal components. MIG welding is a common choice.
- **Construction:** Building structures, bridges, and other infrastructure. Stick welding is widely used.
- **Manufacturing:** Assembling metal products; fabricating custom components.
- **Shipping:** Constructing and repairing ships using various welding processes used for different types of welds.
- **Other Industries:** Joining components in the oil and gas, aerospace, and fabrication (e.g., pipe welding, tank construction, structural repair) industries.

## WELDING MACHINES (LASER, MIG, E-BEAM)

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This ECCN controls specific processing equipment, not elsewhere specified (n.e.s), including items c, d, and e, as follows:

- c. Laser welding machines
- d. MIG welders
- e. E-beam welders

## LASER WELDING MACHINES

ECCN 2B999.C

### Description/features:

- Metal parts are joined with a high-intensity light beam that causes the materials to melt and fuse together when cool and dry; most materials can be welded with a laser welding machine, including base materials with extremely high melting points.
- Equipment is either a large stationary machine or a handheld machine (fiber laser) using a fiber-optic cable to transmit the laser beam directly to the weld.
- Extreme accuracy is the standout feature of the laser welding process (e.g., welding around delicate components or working with complex shapes).
- Laser welding works on a wide range of materials, including
  - metals (e.g., aluminum, copper, brass, steel, titanium, and nickel),
  - plastics (polycarbonate, nylon, and ABS),
  - ceramics (particularly alumina and zirconia),
  - welding magnetic base materials (since beam produced is not electrical),
  - welding metal parts to carbon fiber composites, and
  - welding materials with differing thicknesses and properties together.

- Typical power output:
  - 1,000–1,500 W for light fabrication or stainless steel
  - 2,000–3,000 W+ for thicker metals and heavy industrial use
  - Some CO<sub>2</sub> laser welding machines can exceed 25,000 W
- Equipment is more expensive than electrical or traditional thermal welding machinery.

## KEY COMPONENTS

- **Laser source:** Generates the laser beam. Common types include fiber lasers, solid-state lasers (e.g., Nd:YAG), and CO<sub>2</sub> lasers.
  - Fiber lasers are efficient, durable, and have lower operating costs, making them ideal for metal welding.
  - CO<sub>2</sub> lasers are better for nonmetal materials and cost less, but they require more maintenance.
  - YAG lasers have good precision, but they use more power and require more upkeep.
- **Beam delivery system:** Guides the laser beam to the workpiece. This may include mirrors, lenses, and potentially a scanner for precise beam positioning.
- **Focusing optics:** Focuses the laser beam to a small spot on the workpiece, creating a high-intensity energy concentration for melting the material.
- **Workpiece holding and positioning system:** Holds the parts to be joined and precisely moves them relative to the laser beam. This can include CNC tables, robots, or manual positioning systems.
- **Control System:** Regulates laser power, beam parameters (like spot size and scan pattern), and movement of the workpiece.
- **Cooling System:** Removes excess heat generated during the welding process.
- **Shielding gas system:** Provides a protective atmosphere (e.g., argon) to prevent oxidation of the molten weld pool.

- **Types of laser welding machines and price range (2025 USD). From left to right:**

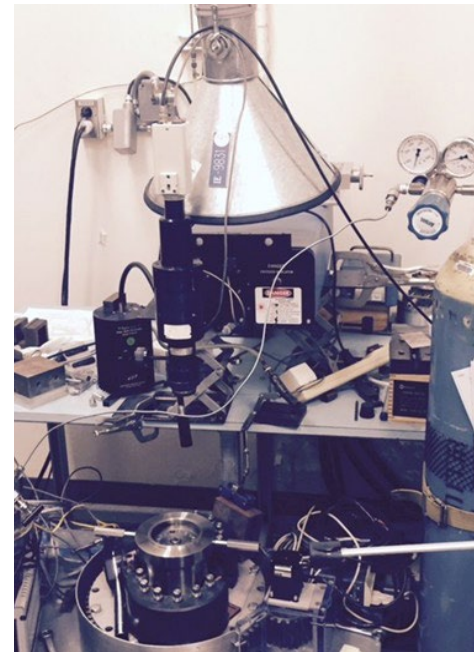
- Handheld fiber laser welder, \$6,000-\$15,000
- Benchtop laser welder, \$10,000-\$25,000
- Fiber laser welding system (CNC), \$30,000-\$100,000+
- CO<sub>2</sub> laser welder, \$8,000-\$20,000
- YAG laser welding machine, \$20,000-\$50,000



- All types: **ECCN 2B999.c**



Miller OptX 2 kW hand-held laser welding system. **ECCN: 2B999.c**



Neodymium YAG solid crystal laser welder. **ECCN: 2B999.c**



Large external power supply for laser welding machine. **ECCN: 2B999.c**



CO<sub>2</sub> laser welding machine setup with power supply. **ECCN: 2B999.c**

## MIG (METAL INERT GAS) WELDERS

ECCN 2B999.D

- Technically called **gas metal arc welding (GMAW)**

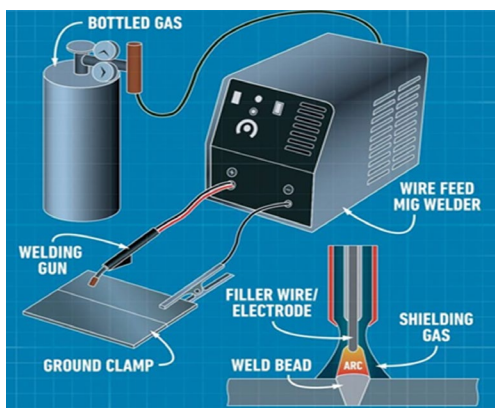
## DESCRIPTION/LOOK FOR THE FOLLOWING:

### Main components:

- **Power source:** Stand-alone unit or integrated into the wire feeder; usually 250–500 A.
- **Wire feed unit:** Continuously feeds the consumable wire electrode into the welding arc, acting as the filler metal.
- **Welding gun:** Handheld device housing the wire feed unit, the contact tip (through which the wire passes), and the nozzle for shielding gas, which functions as a welder's primary interface with the workpiece.
- **Stand-alone gas system:** Gas cylinders, regulators, and flow meters delivering the inert or active gas.
  - Argon and helium are the two most common inert gases used.
  - Mixtures of gases, such as 95% argon and 5% hydrogen, can also be used.

### Other features:

- **Cooling System:** Air-cooled or water-cooled, depending on the power output.
- **Welding wire:** A solid wire electrode, which can be made of various materials.
- **Control panel:** Settings for voltage, wire speed, and gas flow.
- **Portability:** Can range from small, portable units to large, industrial machines, with some models incorporating wheels or handles for easy movement.
- **Operation:** Process can be completely automatic, semiautomatic, or done solely by hand.



Components of MIG Welding.



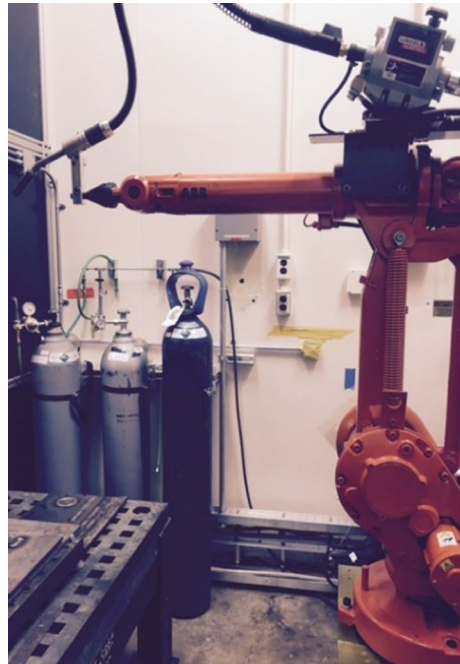
Filling material wire protruding from arc torch.



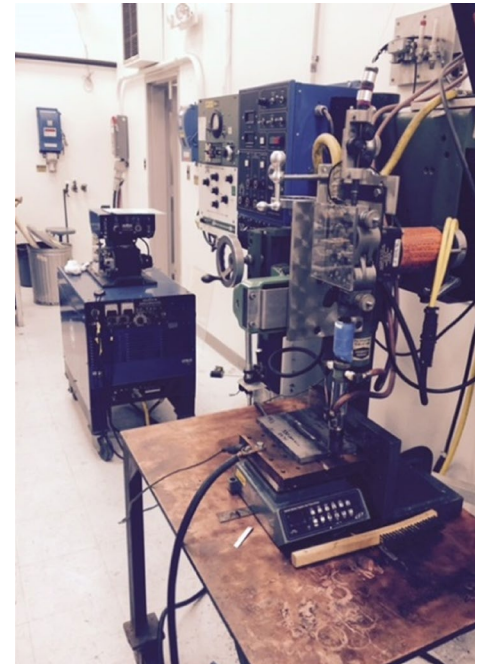
Portable, manually operated MIG welders. **ECCN: 2B999.d**



Portable, manually operated MIG welders. **ECCN: 2B999.d**



Fully automated gas metal arc welding machine: Note gas cylinders. **ECCN: 2B999.d**



Semiautomatic gas metal arc welding machine: Note adjacent power supply. **ECCN: 2B999.d**

## ELECTRON BEAM (E-BEAM) WELDERS ECCN 2B999.E

### Description:

- Electromagnetic fields focus accelerated electrons at a base material; thermal energy produced upon contact makes extremely deep welds possible
- The most versatile welding machine with high accuracy
  - Nearly any size and shape needed to join the base materials can be produced by using different beam patterns.
  - The level of heat input can also be controlled to allow increased versatility with both welding speed and the types of materials that can be welded.
  - Especially suited for performing welds on specific materials prone to cracking.
  - Not suited for use with magnetic materials

### Key identifying features:

- Large vacuum (size: several square meters up to one hundred square meters).
- Stationary electron beam gun (located outside of the vacuum).
- Radiation (X-rays) produced during operation (look for yellow and magenta radiation trefoil signage or stickers).
- Physically much larger and more expensive than other welding equipment.



Electron beam welding machine with electron "gun" located outside of vacuum:  
 Note vacuum pump (top left) and trefoil radiation sign (top center). **ECCN: 2B999.e**



Large vacuum where welding must occur to prevent electron dissipation.  
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## OXY-ACETYLENE WELDERS

### Key Points:

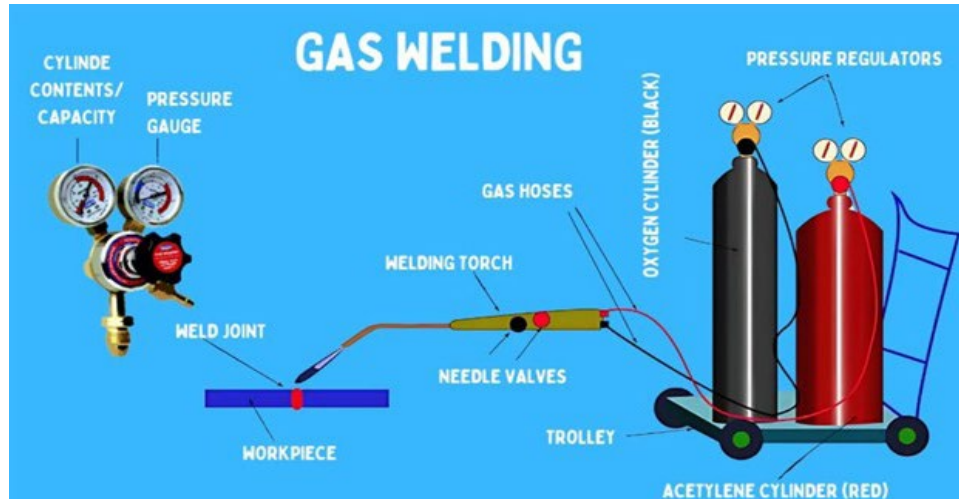
- Also known as gas welding—A torch mixes oxygen and fuel gas (usually acetylene) to produce a high-temperature flame to melt and fuse metals. In some cases, a filler rod is added to the molten pool to provide additional material for the weld.
- Versatile—Particularly useful for small-scale and emergency repair work on a wide range of metals, including low-alloy steel, stainless steel, wrought iron, cast iron, and nonferrous metals like copper and brass.
- Portable—Equipment is relatively compact and portable; thus suitable for on-site repairs and field work.
- Limitations—Generally slower and less efficient than modern arc welding processes; not ideal for thick materials.
- Applications—Widely used for repairing damaged machinery, pipes, and tanks.

### Main Components:

- **Fuel cylinder:** A sealed cylinder made of heavy gauge steel and usually colored yellowish brown or red.
- **Oxygen cylinder:** A sealed cylinder made of heavy gauge steel and usually, but not always, painted black.
- **Pressure regulator:** Equipment that reduces the high pressure fuel and oxygen gases to a safe, constant pressure during the welding process.
- **Control valves:** Used to control the amount of gas released from each cylinder and to control the ratio of fuel and oxygen.
- **Welding torch:** Includes a nozzle and control valves where a mixture of fuel and oxygen is burned together to facilitate the work of the welder.



Oxygen acetylene welding set.

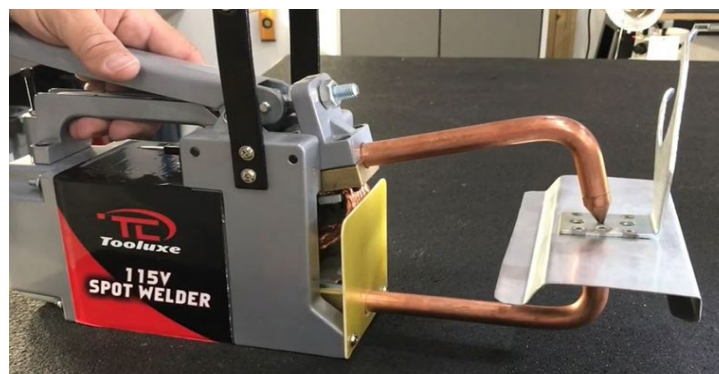


Components of gas welding.

## RESISTANCE TYPE SPOT WELDERS

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- Used to join two overlapping pieces of metal using heat and pressure applied to the joint. Spot welding is quick, efficient, and extremely easy to perform.
- A filling material is not required as it simply utilizes the base material to form the weld.
- Electrode tips (typically copper based alloys) are positioned on opposite sides of the base materials.
  - **Identification Tip:** the positioning of the opposing electrode tips allows the resistance spot welding machine to be easily identified, since other welding methods do not utilize two opposing electrodes.
- Large external power supply with supplied amperage up to 500 A.



Opposing electrodes on general purpose resistance type spot welding machines. **EAR99**



Oposing electrodes on general purpose resistance type spot welding machines. **EAR99**



Spot welds commonly performed by automobile manufacturers.



Amada Weld Tech resistance welding power supply: For micro spot welding applications, Output: 5-500 A, Weight: 49 lb, Size: 8.4 in. (W) x 15 in. (D) x 12 in. (H). **EAR99**

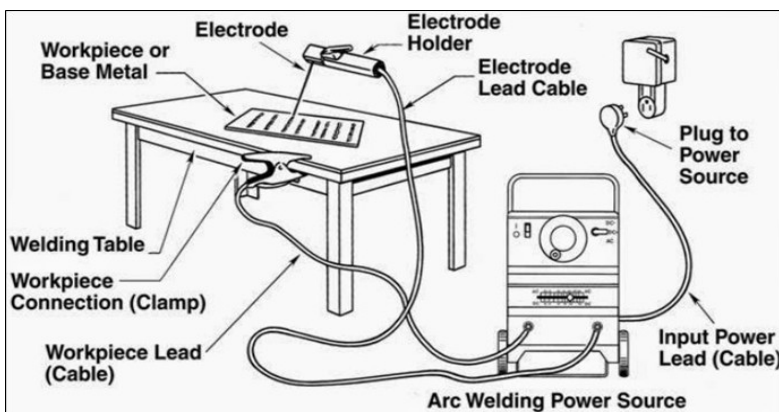
## STICK WELDER

### Key points:

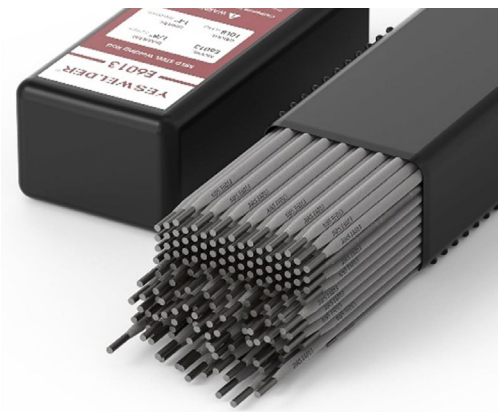
- Technically called **shielded metal arc welding (SMAW)**. Other names include manual metal arc (MMA), and flux shielded arc welding.
- Widely used because of its simplicity and versatility; can be used on a variety of metals, including steel, cast iron, aluminum; popular choice for construction and repair work.
- Process involves using a consumable electrode (also known as a welding rod) coated in flux. When an electric current passes through the electrode, it creates an arc between the electrode and the metal, melting both to form a weld. The flux coating on the electrode produces a gas that shields the weld from contaminants.
- Stick welding does not require shielding gases, which makes it ideal for working outside or under nonideal weather conditions.
- Stick welding can use AC (alternating current) or DC (direct current)
  - DC welding can be either electrode positive (DCEP) or electrode negative (DCEN).
  - Polarity notations can be found on the power source and the electrodes

### Main Components:

- **Power source:** Provides the electrical current needed to create the welding arc.
- **Electrode holder:** Holds the consumable electrode and connects it to the welding circuit.
- **Ground clamp:** Connects the welding machine to the workpiece, completing the circuit.
- **Consumable electrode:** Melts during welding, providing filler metal and shielding gas. Electrodes are classified by a code (e.g., E6013, E7018) that indicates their tensile strength, welding position, and flux type.



Stick welding machine schematic



Type E6013 1/8 in. carbon steel stick electrodes (also known as welding rods).



### AC225 stick welder

- Compact stick welder for welding a wide variety of materials including carbon, low alloy, stainless steels, and cast iron.
- Rated output: 225 A
- Dimensions: 24 in. (H) × 17.25 in. (W) × 12 in. (D)
- Weight: 96 lb
- Rates output: 225 A
- **EAR99**



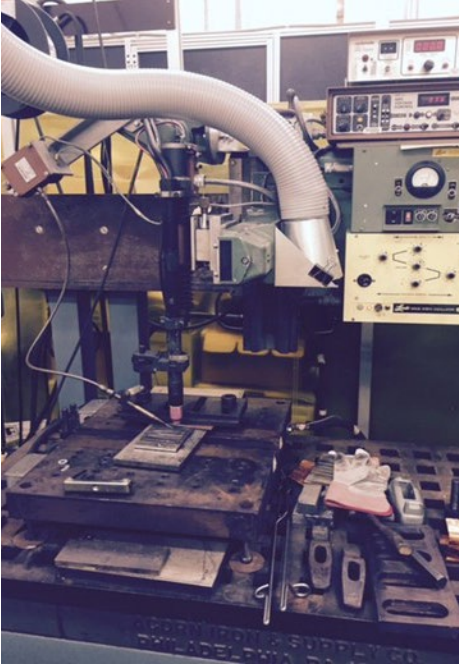
### Miller 90772 Thunderbolt 210 stick welder

- Applications: Maintenance, repair, light production-line work, shipyard install/repair, construction work.
- Input power: 240 V, 50/60 Hz
- Rated output: 210 A
- Weight: 15.5 lb
- **EAR99**

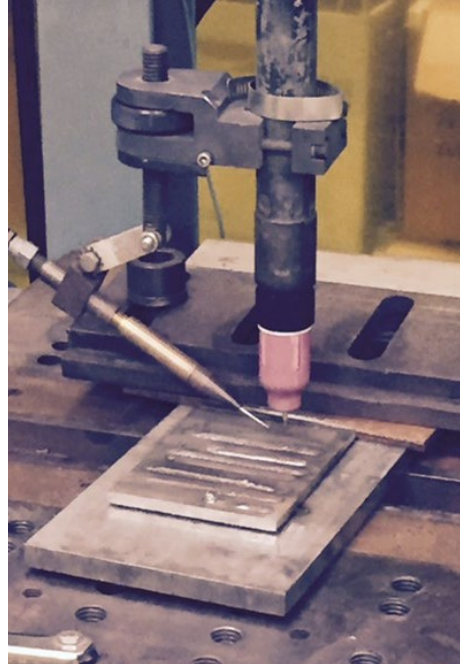
## TIG (TUNGSTEN INERT GAS) WELDERS

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- TIG welders are technically called gas tungsten arc welding (GTAW) and can be identified by filler material wire (like MIG welders) used in the weld.
- Filler material wire is not fed through an arc torch electrode like MIG welders but instead is applied by hand. This is more time-consuming than MIG welding, but it provides the user more control over the welding process and a high degree of precision.
- Commonly used for welding thin metals and intricate designs.
- Uses a nonconsumable tungsten electrode that delivers the current to the welding arc.
- Typical current: Up to 500 A.
- An inert gas, typically argon or helium, protects the weld from oxides that could potentially damage the weld.
- These welding machines can be operated manually or semiautomatically.



Semiautomatic gas tungsten arc welding machine setup. **EAR99**



Tungsten electrode and externally applied filling material wire. **EAR99**



Miller® Maxstar® 400 TIG welder: 208-600 V input, 400 A max output. **EAR99**



ARCCAPTAIN TIG welder AC/DC 200 A. **EAR99**



TIG welder using an electric torch as filling material is hand fed into a molten pool.