

# Introduction to Welding

[http://upload.wikimedia.org/wikipedia/commons/a/a7/US\\_Navy\\_070517-N-9928E-009\\_Hull\\_Technician\\_Fireman\\_Zach\\_Carver\\_brazes\\_a\\_pipe\\_fitting\\_with\\_an\\_oxy-acetylene\\_torch\\_in\\_engineering\\_department%27s\\_welding\\_shop\\_aborad\\_Nimitz-class\\_aircraft\\_carrier\\_USS\\_John\\_C.\\_Stennis\\_%28CVN\\_74%29.jpg](http://upload.wikimedia.org/wikipedia/commons/a/a7/US_Navy_070517-N-9928E-009_Hull_Technician_Fireman_Zach_Carver_brazes_a_pipe_fitting_with_an_oxy-acetylene_torch_in_engineering_department%27s_welding_shop_aborad_Nimitz-class_aircraft_carrier_USS_John_C._Stennis_%28CVN_74%29.jpg)



<http://www.gooddirections.co.uk/mach/Mach%20Precision%20Engineering%20Images/Welding%20Metal%20Fabrication%20Home.jpg>

# Welding





- ▶ 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



# What is Welding?

Welding is the joining of metals. What welding does is join metals or other materials at their molecular level.



# Welding process?

The welding process works like this.

The metal gets heated to its melting point, at the same time there is some sort of shielding from the air to protecting it, and then a filler metal is added to the area that needs to be joined ultimately producing a single piece of metal.

## ARC Welding

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

There are three main types of arc welding commonly used today :

|      |                                       |
|------|---------------------------------------|
| MMA  | Manual Metal Arc (SMAW stick welding) |
| MIG  | Metal Inert Gas (GMAW)                |
| TIG  | Tungsten Inert (GTAW)                 |
| FCAW | Flux cored Welding                    |

<http://www.youtube.com/watch?v=5VBMAlljwhI>

<http://www.youtube.com/watch?v=BjRwPjJCFRM>

<http://www.youtube.com/watch?v=BjRwPjJCFRM>



# What is Arc Welding?

- ▶ 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



Steel Pipe – Tack  
Welded



Root Pass or  
“Stringer Bead”



Final weld after  
several beads are  
made

# Basic Steps of Arc Welding

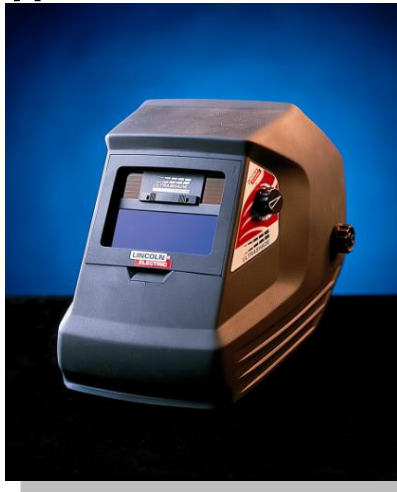
- ▶ Prepare the base materials: remove paint and rust
- ▶ Choose the right welding process
- ▶ Choose the right filler material
- ▶ Assess and comply with safety requirements
- ▶ Use proper welding techniques and be sure to protect the molten puddle from contaminants in the air
- ▶ Inspect the weld





# Arc Welding Safety

- ▶ Protect yourself and others from potential hazards including:
  - Fumes and Gases
  - Electric Shock
  - Arc Rays
  - Fire and Explosion Hazards
  - Noise
  - Hot objects



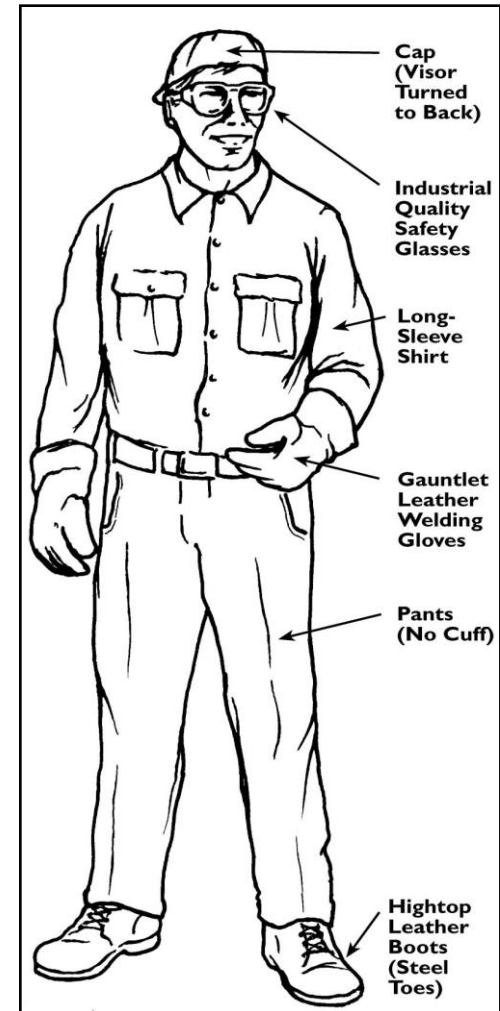
# Protective Clothing

## Welders must wear protective clothing for

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

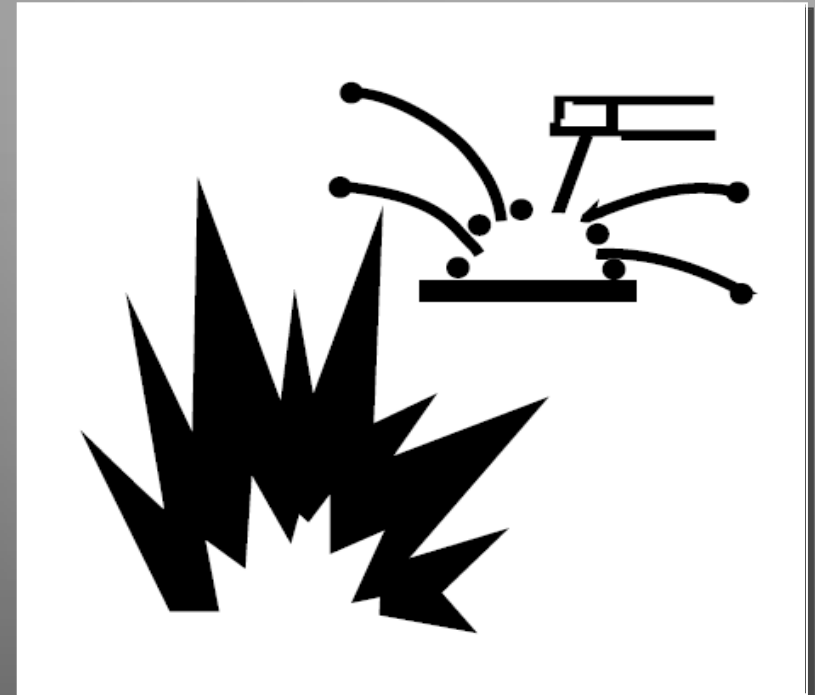
## ▶ Protective clothing includes ...

- 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



# Fire and Explosion Hazards

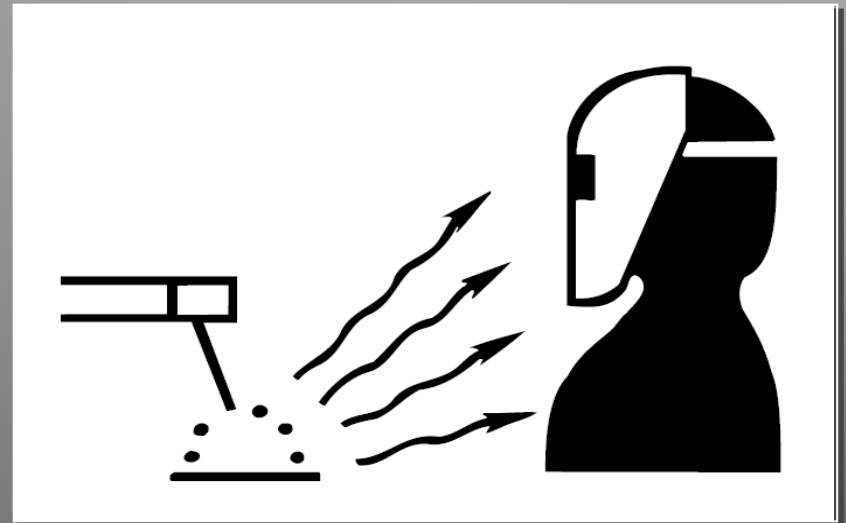
- ▶ Welding sparks can cause fires and explosions
- ▶ Sparks and spatter from the welding arc can spray up to 35 feet from your work
- ▶ Flammable materials should be removed from the welding area or shielded from sparks and spatter
- ▶ Have a fire extinguisher ready
- ▶ Inspect area for fires 30 minutes after welding





# Arc Rays

- ▶ *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*



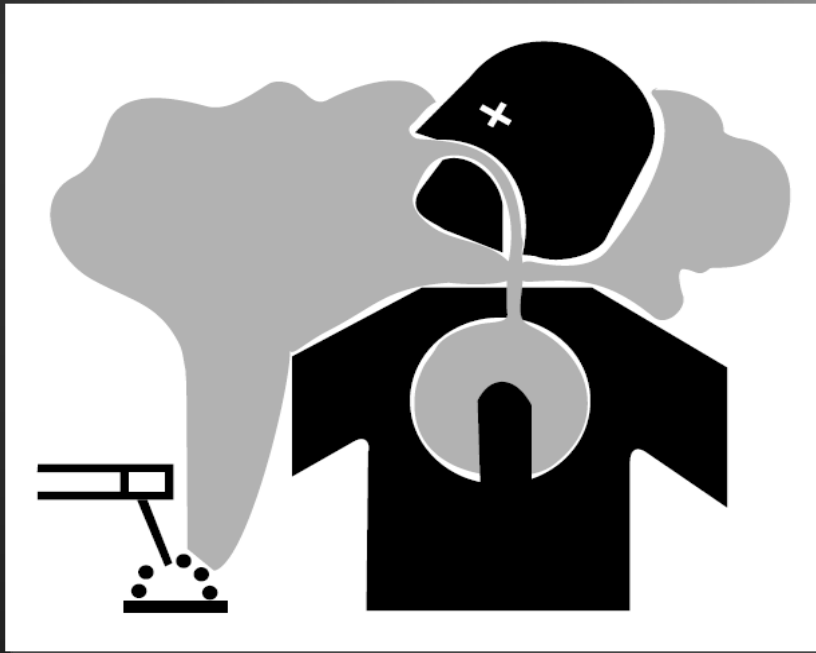
# Electric Shock

- ▶ 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!

# Fumes and Gases

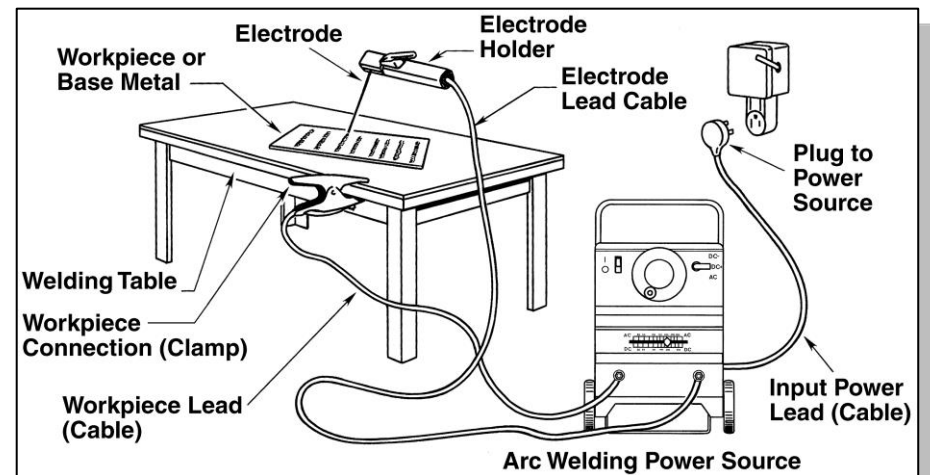


- ▶ Fumes and gases can be hazardous to your health
- ▶ Keep your head out of the fumes
- ▶ Use enough ventilation, exhaust at the arc, or both, to keep fumes and gases from your breathing zone and the general area
- ▶ See product labeling and MSDS for ventilation and respirator requirements



# SMAW Principles

- ▶ The American Welding Society defines SMAW as **Shielded Metal Arc Welding**
- ▶ SMAW:
  - Is commonly known as 'Stick' welding or manual arc welding
  - **Is the most widely used arc welding process in the world**
  - Can be used to weld most common metals and alloys



# SMAW Welding Circuit

- ▶ Current flows through the electrode cable, to the electrode holder, through the electrode, and across the arc
- ▶ On the work side of the arc, the current flows through the base material to the work clamp and back to the welding machine







# SMAW Safety

- ▶ **Fumes and Gases** can be dangerous
  - 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
  - The SMAW process can withstand wind and exhaust near the arc from ventilation equipment
- ▶ **Electric Shock** can kill – to receive a shock your body must touch the electrode and work or ground at the same time
  - Do not touch the electrode or metal parts of the electrode holder with skin or wet clothing
  - Keep dry insulation between your body and the metal being welded or ground
- ▶ **Arc Rays** can injure eyes and skin – Choose correct filter shade (See chart below)

| Operation                  | Electrode Size<br>1/32 in. (mm) | Arc Current<br>(A) | Minimum<br>Protective<br>Shade | Suggested*<br>Shade No.<br>(Comfort) |
|----------------------------|---------------------------------|--------------------|--------------------------------|--------------------------------------|
| Shielded metal arc welding | Less than 3 (2.5)               | Less than 60       | 7                              |                                      |
|                            | 3–5 (2.5–4)                     | 60–160             | 8                              | 10                                   |
|                            | 5–8 (4–6.4)                     | 160–250            | 10                             | 12                                   |
|                            | More than 8 (6.4)               | 250–550            | 11                             | 14                                   |

# GMAW ( MIG) Definition

- ▶ GMAW stands for **Gas Metal Arc Welding**
- ▶ GMAW is commonly referred to as MIG or Metal Inert Gas welding
- ▶ During the GMAW process, a solid metal wire is fed through a welding gun and becomes the filler material
- ▶ Instead of a flux, a shielding gas is used to protect the molten puddle from the atmosphere which results in a weld without slag



*GMAW is the most widely used arc welding process in the United States*

# GMAW Process Variables



What is the relationship between WFS and amperage?

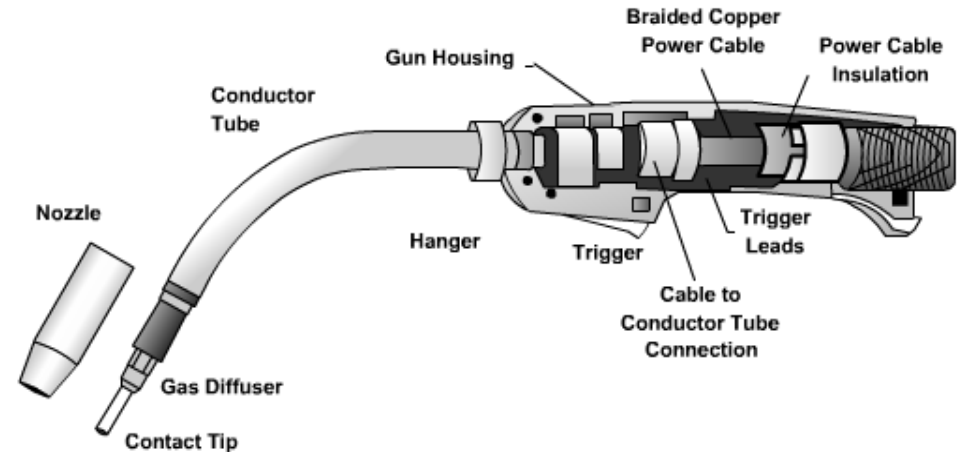
- ▶ Welding variables
  - Wire Feed Speed (WFS)
  - Voltage
- ▶ Operator controlled variables
  - Travel speed
  - Gun angles
  - Contact tip to work distance (CTWD)
  - Gas flow rate





# GMAW Circuit

- ▶ Three things happen when the GMAW gun trigger is pulled:
  - The wire electrode begins to feed
  - The circuit becomes electrically 'hot'



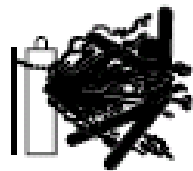
- Current flows from the power source through the gun cable, gun, contact tip to the wire and across the arc. On the other side of the arc, current flows through the base metal to the work cable and back to the power source
  - *Shielding gas flows through the gun and out the nozzle*

# GMAW Safety

- ▶ **REMEMBER** – Gas Cylinders require **SPECIAL** safety precautions
  - Cylinders must be secured in an upright position
  - Cylinders should be located in an area away from arc welding, cutting, heat, sparks, and flame
  - Refer to ‘Safety in Welding, Cutting, and Allied Processes’ (ANSI Z49.1) or Arc Welding Safety (E205) for more information on the handling of gas cylinders



## **WARNING**



**CYLINDER** may explode if damaged.

- Keep cylinder upright and chained to support.
- Never allow welding electrode to touch cylinder.

# TIG / Tungsten Inert Gas Welding

- ▶ Tungsten arc welding / TIG is a torch that has a gas flowing through it with a non consumable rod made of tungsten that heats the metal and the filler metal is held in the other hand and manually added when needed.

# Welding Polarity and Voltage Type

- ▶ Understanding welding polarity and voltage type is important. **Welding also uses different types of electricity depending on the welding process itself and what the welding filler material manufactures recommendations. There are two types of electricity used in welding D/C (direct current) like your car battery, and A/C (alternating current) like the power in your home. There are three types of welding polarity.**
- ▶ **D/C electrode positive** where the electrode is positive, the electricity flows from the metal to the welding rod.
- ▶ **D/C electrode negative** (the most common) when the electrode is negative and the electricity flows from the rod to the metal.
- ▶ **A/C alternating current** where the polarity changes from positive to negative many times in a second.



# Basic Electricity

**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)

# Lincoln Welding Simulation

- ▶ [http://www.youtube.com/watch?v=n9mNFpv\\_mdw&list=PL62018819A69595C1](http://www.youtube.com/watch?v=n9mNFpv_mdw&list=PL62018819A69595C1)



## 1.3 Personal Protective Equipment for gas welding work

Eye  
protection

<http://catalogue.3m.eu/pcimages/5373/fullsize.jpg>



<http://www.mackay.co.uk/images/product/SCAPPEGGAS.jpg>

Wear welding glasses or goggles to protect your eyes from intense light, radiation and sparks.

## Footwear



<http://1300apprentice.com.au/wp-content/uploads/2012/01/Spats-Final.jpg>



<http://espimages.biz/2386/1/331/90/7311RK.jpg>

Always wear leather boots or spats when welding to prevent sparks burning your feet.  
Safety boots should also be worn if you are lifting or moving heavy metal parts.



## Clothing

Wear a leather apron or flame protective suit and leather gauntlets (gloves) to prevent burning your hands or clothing.



<http://t0.gstatic.com/images?q=tbn:ANd9GcTQKqDRDBxkef-Z7Y8wCZDLi6Tir2Gfn6X7cBfkelkxaguEc>



[http://site.usweldingsupply.com/blog/wp-content/uploads/2012/02/yhst-49369779241392\\_2194\\_70073287.jpg](http://site.usweldingsupply.com/blog/wp-content/uploads/2012/02/yhst-49369779241392_2194_70073287.jpg)

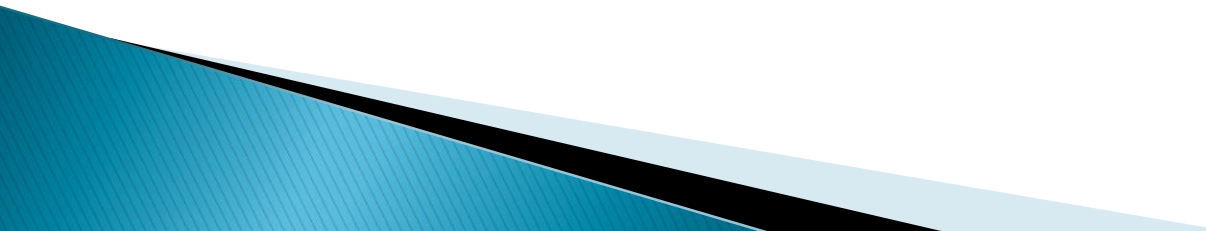
### Note

1. Never touch hot metal even when you are wearing gloves.
2. Never wear clothes made of synthetic material. – They can melt and burn you!

[http://web.tradekorea.com/upload\\_file2/sell/87/S00022387/leather\\_protective\\_clothing.jpg](http://web.tradekorea.com/upload_file2/sell/87/S00022387/leather_protective_clothing.jpg)



## 3.2 Safety rules for gas welding.

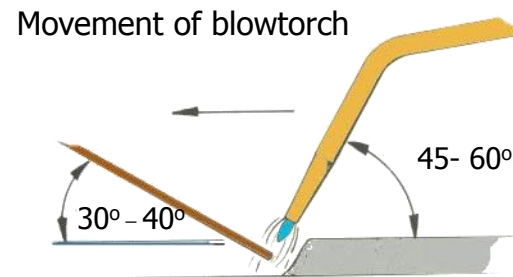
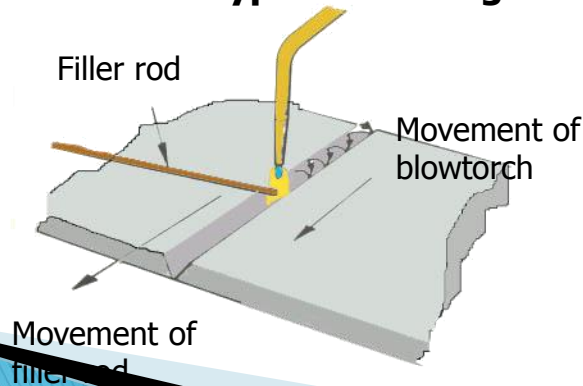
1. You must never allow oil or grease to touch any part of the oxygen equipment.
  2. You must not clean the equipment with **compressed air as it contains oil.**
  3. You must **never breathe** the oxygen from the cylinder because it is not pure oxygen.
  4. Always make sure that the welding area is **well ventilated.**
  5. Acetylene cylinders must **never be put on their side** when in use; they must be used in the upright position.
  6. Always ensure that there is **fire-fighting equipment** in the welding area.
  7. Always wear the **correct safety clothing** when welding.
  8. Always use the **correct safety equipment** when welding.
- 

## 3.7 Welding Techniques

In Oxy Acetylene welding the heat of the flame (3150°C) causes the metal being joined to melt and run together to form a weld pool. Filler rod of the same metal is added to make the joint stronger.

**To begin welding, have your goggles on and your flame adjusted appropriately.**

1. Place your welding tip approximately 2.5 cm from the steel that you are working on.(flame tip about 2-4 mm)
2. Form a weld puddle of molten metal.  
The torch should be held at a 45 - 60 degree angle above the metal. However, only practice will tell you the best angle to work at. Point the flame in the direction that you are forming the bead.
3. Move the tip along with a slight side to side motion. This is called fusion welding and melts two pieces of steel together.
4. Use filler rod to make the joint stronger. Place the filler rod in front of your flame dipping it into the pool of molten steel that you have made.
5. Gradually move your way along in the direction of the bead. This is called **Forehand** or **Leftward** welding. **(This is the most common type of welding used for plates under 5mm thick.)**

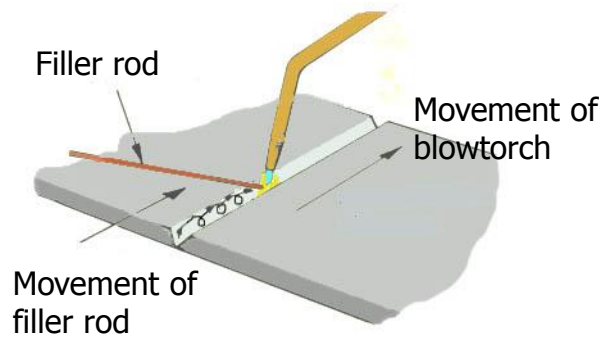


### **Leftward (or Forehand) welding**

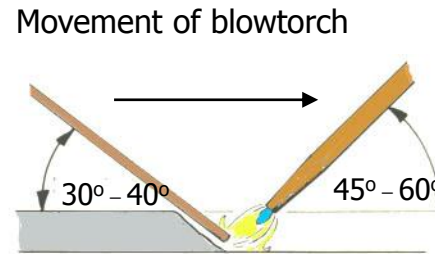
The blowtorch moves along the joint from right to left .

## Rightward or Backhand welding

You can weld in either direction and different situations may only allow you to move in one direction. Rightward or Backhand welding is used mainly for plates more than 5 mm thick. Here the blowtorch moves along the joint from left to right.

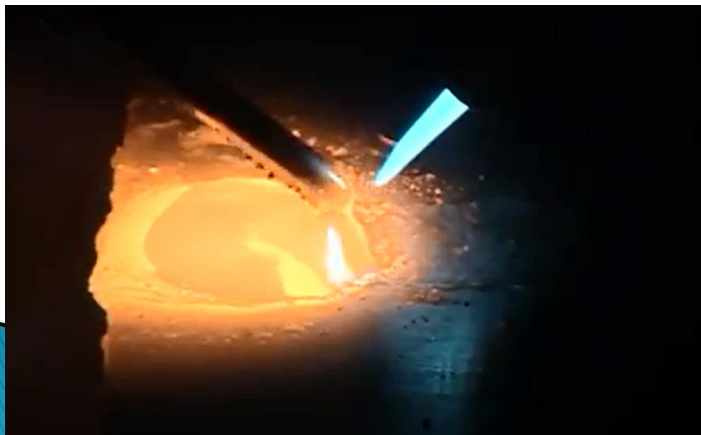


*Images from  
STS  
publication  
20/7/2011*



### Rightward or (Backhand) welding

The blowtorch moves along the joint from left to right.



### Rightward or (Backhand) welding video

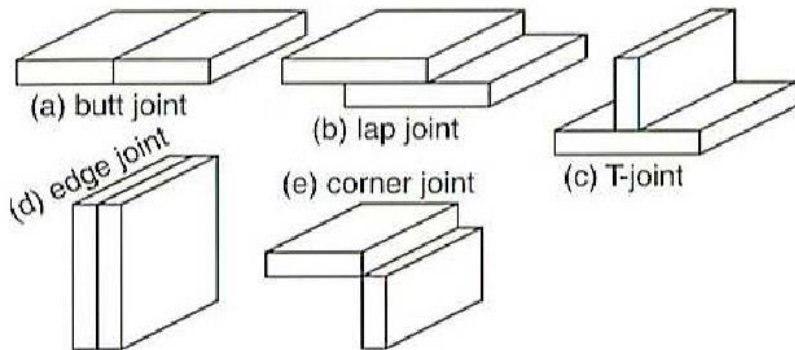
[http://www.youtube.com/watch?feature=player\\_detail\\_page&v=QEWEMCwSMuw](http://www.youtube.com/watch?feature=player_detail_page&v=QEWEMCwSMuw)

Time 0.44-1:16 with sound  
1:17-1:20 no sound



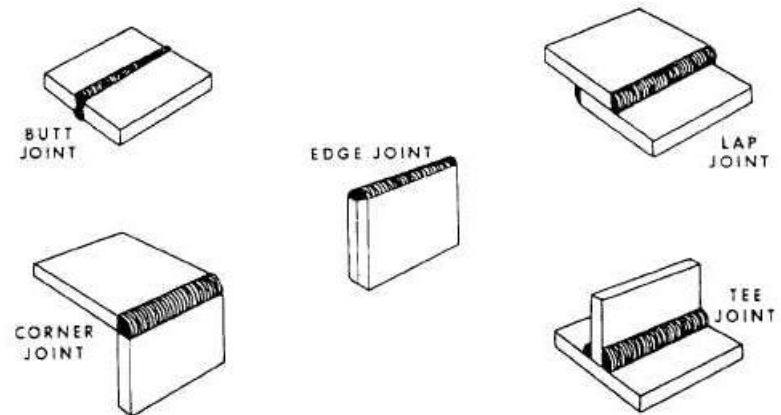
## Basic weld Joints

The following weld joints are common.



<http://dc228.4shared.com/doc/t5rnSnzu/prview007.png>

### Plate arrangement



[http://navyaviation.tpub.com/14018/img/14018\\_648\\_1.jpg](http://navyaviation.tpub.com/14018/img/14018_648_1.jpg)

### After welding

The two most common types of weld used in oxyacetylene welding are:

**Groove** - The groove weld is used mainly for the butt joint and can be used in the edge joint. Basically, you leave a space between your two pieces of metal that you are welding in a butt joint and fill it with a bead of weld.

**Fillet** - The fillet weld is generally a layer of weld to fill in corners created in joints. The weld looks like a triangular shape. It is most commonly used on lap, tee and corner joints.

*4-H Machine Series: Discovering  
Oxyacetylene  
Welding & Cutting, Manitoba 4-H Projects  
Manitoba Agriculture Food and Rural  
Initiatives*

## 3.8 Brazing

**Brazing** is a process for joining metals using a filler metal (usually a type of brass). This filler metal melts at a lower temperature than the metal being joined, (e.g. Brazing rod may melt at 850° C but steel does not melt until 1400° C) , however this process produces a very strong joint.

Brazing is the easiest way of joining metal with oxy acetylene equipment. It can be used to join steel, copper, brass and some types of aluminium. Brazing can also be used to join different types of metal together, for example, copper tube to steel plate.



[http://www.youtube.com/watch?feature=player\\_detailpage&v=GWzgg4G1QkM](http://www.youtube.com/watch?feature=player_detailpage&v=GWzgg4G1QkM)

Time: 3:56 – 5:05 with sound

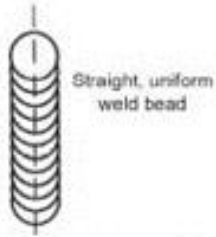


<http://3.bp.blogspot.com/-syBRfSqch8U/UJGYWTxW2jI/AAAAAAAAAF2E/-ow882YEM2g/s1600/Welded+Frame+Bronze+1.jpg>

Brazing is usually used in lap joints to join thin metal plate or tubes.

# 3.10 Inspection of welding and brazing

## Weld bead



**Good**

The weld bead should be uniform thickness and straight.



<http://image.thefabricator.com/a/articles/images/2176/welding-reducing-welds-weld-bead.jpg>

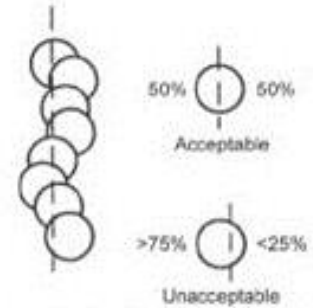


**Unacceptable**

If the thickness varies by more than 50%



<http://img580.imageshack.us/img580/2885/2013050514203>



**Unacceptable**

If the bead wanders more than 25%

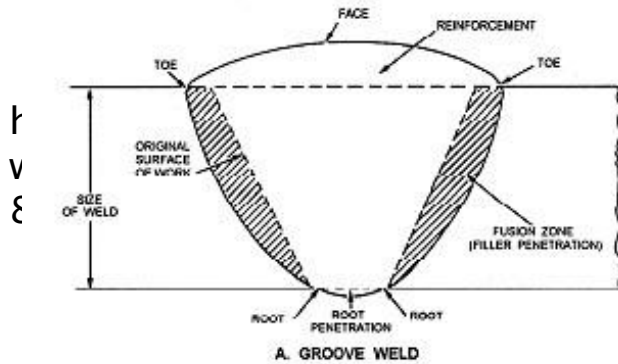


<http://t0.gstatic.com/images?q=tbn:ANd9GcQ5xO2hOtE04hY9HSn->

# 3.10 Inspection of welding and brazing

## Weld section

It is important that the weld goes completely through the metal and that the weld metal is as thick as the rest of the plate. Otherwise the weld will be weaker than the parts being welded.

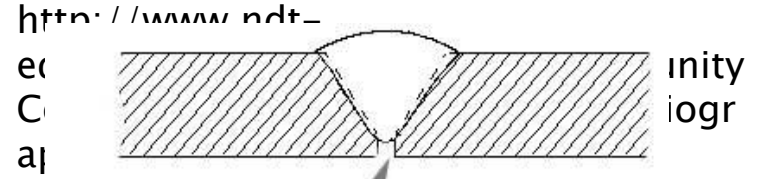


**Good**

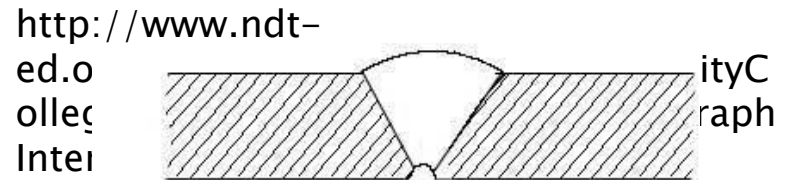
The weld fully penetrates the material



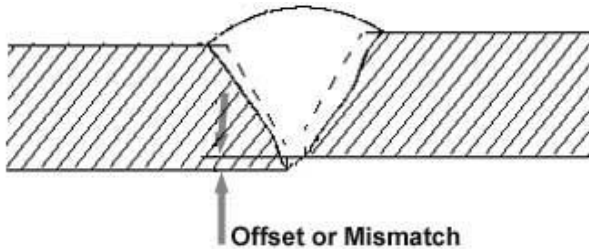
tid=1



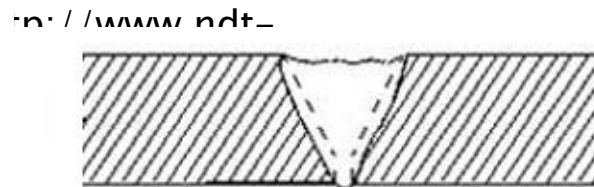
**Unacceptable (lack of penetration)**  
The weld does not go through the joint.



**Unacceptable (suck back)**  
The weld metal has contracted and does not go through the joint.



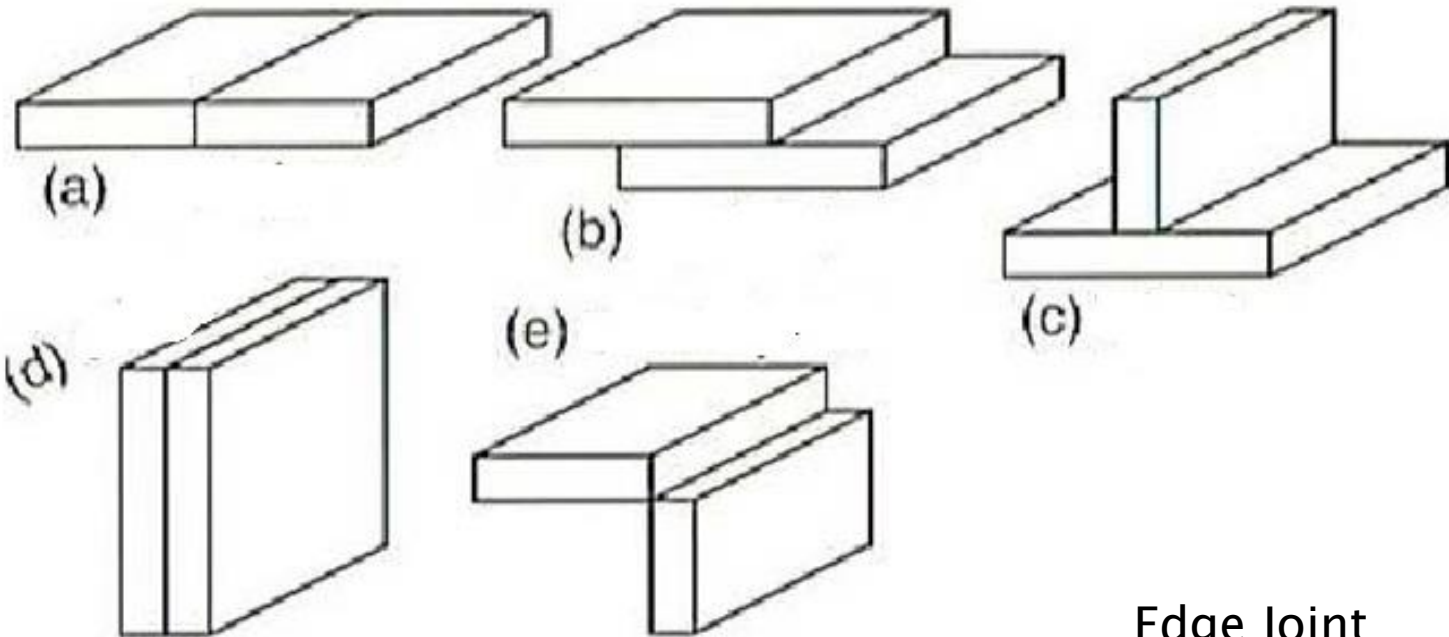
**Unacceptable (mismatch)**  
The welded plates do not align



**Unacceptable (Concavity)**  
The weld metal is not as thick as the plate.

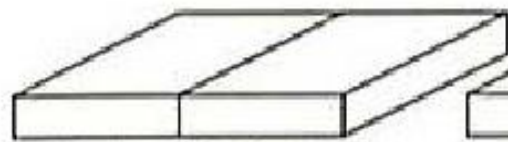


7. Give the correct names to the following weld joints

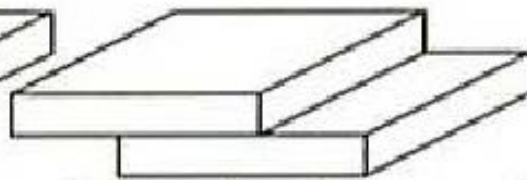


Edge Joint  
Butt Joint  
Corner Joint  
Lap Joint  
T Joint

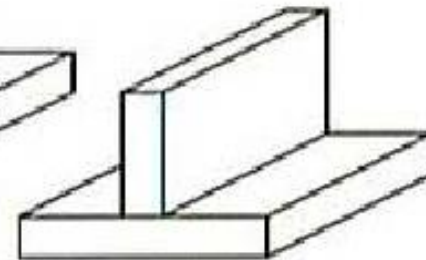
7. Give the correct names to the following weld joints



(a) butt joint

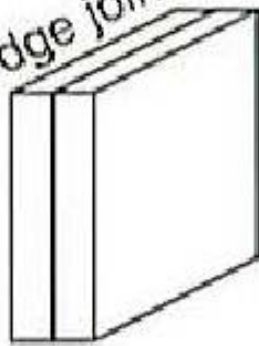


(b) lap joint



(c) T-joint

(d) edge joint



(e) corner joint

