



## STUDENT MANUAL

### HEAVY EQUIPMENT & RIGGING SPECIALIST TRAINING

#### MODULE 1-3 :

#### METAL BURN CUTTING

#### Unit Objectives

The Student will understand the capabilities and limitations of all the types of burning equipment that can be used in US&R operations, and

Understand how to efficiently and safely cut and remove multiple pieces of steel from a debris pile

#### Acknowledgements


The majority of the information in this manual was provided by Robert Tooker, Captain, California Department of Forestry and CATF-3 Lead Metal Cutting Instructor, plus James Walker, Seattle Fire Department Special Operations, WATF-1, Lead Metal Cutting Instr.

#### Enabling Objectives

We will:

- Discuss how to conduct a site hazard analysis
  - Select appropriate PPE
  - Select the most efficient metal burning equipment, based on needs of an incident
- Discuss safety practices associated with the different metal burning equipment
- Identify hazardous situations found when cutting and burning on a debris pile
  - Understand how to minimize risk to rescuers
- Discuss the use & setup of the various types of metal burning equipment based on safety, material type & thickness
- Identify special issues involved with
  - Compressed gas cylinders
  - Oxy / acetylene—use and safety
  - Gasoline / oxygen operation
- Discuss proper breakdown, storage and shipping methods for the metal burning equipment in FEMA US&R Cache

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#### Enabling Objectives

- Discuss how to conduct a site hazard analysis
  - Select appropriate PPE
  - Select the most efficient metal burning equipment based on needs of an incident
- Discuss safety practices associated with the different metal burning equipment
- Identify hazardous situations found when cutting and burning on a debris pile
  - Understand the safety practices to minimize risk to rescuers.

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#### Enabling Objectives

- Discuss the use & setup of the various types of metal burning equipment based on safety, material type & thickness
- Identify special issues involved with
  - Compressed gas cylinders
  - Oxy / acetylene—use and safety
  - Gasoline / oxygen operation
- Discuss proper breakdown, storage and shipping methods for the metal burning equipment in FEMA US&R Cache

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### I. Introduction & Topics to be discussed

We will discuss the following topics:

- Safety and the Oxy/Fuel Process
- Personal Protective Equipment that is required for metal cutting
- Types of Metal Cutting Equipment
  - Oxy/Acetylene
  - Oxy/Gasoline
  - Exothermic/Oxygen Lance
  - Plasma Arc
- Area Method for calculating the weight of steel objects of various shapes
- Storage and Shipping Methods

#### The Oxy/Fuel Process


Cutting with a torch is the process of burning metal with oxygen to effect separation. Wrought iron, steel, and cast iron are the metals cut by this process. Aluminum, brass, bronze, nickel, monel, and the other non-ferrous metals and alloys cannot at present be cut by the torch process. In oxyacetylene cutting of iron, steel, and cast iron, the metal is heated to the ignition temperature with preheating flames burning at the end of the tip. The preheating flames, usually four, are spaced around the cutting orifice in the center of the tip.

When the metal to be cut is heated to a bright red, the high-pressure oxygen jet is turned on, and the metal in the path is cut or burned away. Progressive movement of the torch results in cutting a narrow kerf similar to that made by a metal saw.

Acetylene is the most common fuel gas for the preheating flame, and oxygen is required both to burn the acetylene in the preheating flames and to effect cutting. However, the recently developed Petrogen System uses gasoline as the fuel gas, in combination with oxygen.

Both these cutting systems will be discussed in this manual

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#### Topics to be discussed

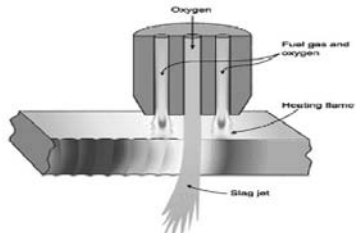
- Oxy/Fuel process & Safety
- Personal Protective Equipment
- Types of Metal Burning Equipment
  - Oxy/Acetylene
  - Oxy/Gasoline
  - Exothermic/Oxygen Lance
  - Plasma Arc
- Storage & shipping methods

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#### Oxy Fuel Process



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## II. Safety

Metal burning operations require strict compliance to safety guidelines.

The two major causes of injury during burning operations are burns caused from hot materials or ultraviolet rays and injuries caused from breathing toxic materials and gases that can attack internal organs or the respiratory tract.

Full Personal Protective Equipment (PPE) must be worn at all times.

Respirators and air handling equipment should always be used in confined spaces or when material surface finishes such as paint or plating have been applied to metal.

Whenever possible, two-person teams should be assigned to burning assignments. One person should operate the burning equipment while a second person tends hoses and equipment. It is the second person's responsibility to look out for potential hazards and make sure the burner is aware of them.

Always pay strict attention to where the burn cutting is directed. (into or through) Flammable or explosive material or victims may be on the other side.

Always inspect cutting and burning equipment for leaks and proper setup before use.

Re-hydrate often. Because of the heavy protective clothing and the heat generated from the equipment and hot material, burning operations can be very hot work.


A pressurized or hand pump water extinguisher shall be on site at all times.

In order to minimize chance for injury, it is imperative to deploy a Safety Person that will have no other responsibility than the area where metal burn cutting is taking place.

This individual should watch for fires, and other hazards that may be created, and be aware of any other equipment that may be working in the area

The Metal Burning Team should be a minimum of Two persons, so that there is a second pair of eyes that are focused on the immediately surrounding area. The second person would observe the progress of the cut, and anticipate when and where to cut piece or pieces will fall

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### General Safety Guidelines

- **Metal burning requires strict compliance with all manufacturer's safety guidelines**
- **Biggest causes of injury**
  - Burns from hot material or ultraviolet rays
  - Breathing toxic materials
- **Wear full PPE at ALL TIMES**
  - Wear UV rated eye protection
  - Use proper respiratory protection
- **Work in 2 person teams**

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### General Safety Guidelines (contin.)

- **Inspect all equipment prior to use for damage and leaks**
- **Have a fire extinguisher or small hose line available for spot fires**
- **Hydrate often**
- **Consider the reaction of your actions before and while cutting a piece of steel or cable**

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### Safety During Operations

- **Have a safety person watch the area for fire and other hazards**
  - Be aware of heavy equipment and other people working above and below
- **Two Person Team**
  - The tender is the burner's second set of eyes because the person burning is focused on the progress of the cut

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### Use of Proper PPE

In addition to “normal” US&R PPE, the metal cutting personnel must wear additional protection. This may vary, depending on what type of metal is being cut, but in most all cases one should be protected from the metal burning process. (listed in adjacent slide)

Coatings such as paint and galvanizing can create harmful gasses from which one needs protection.

### Personal Accessory Equipment

Metal burn cutting requires specialty equipment and a tool belt to carry them.

Most of this equipment is listed on the adjacent slide

Extinguishing and ventilation equipment may be provided for an entire area of cutting operations, but should be immediately available for all that are involved .

### Special Cautions involved with Metal Burning

Do not operate welding or cutting equipment in the vicinity of chlorinated solvents or hydrocarbons.

The heat or arc rays can react with the chlorinated hydrocarbons to form phosgene or hydrogen chloride, which are highly toxic irritant gases.

### CAUTION! Using Painted or Plated Metals

- Always inspect metal for protective surface finishes such as paint or plating before cutting.
- Metals that have been painted may contain lead or cadmium.
- Metals that have been plated may contain zinc (galvanize) or cadmium.
- Stainless steel contains nickel and chromium.
- Welding, cutting, and heating operations that involve or generate any of the substances listed at the right, require proper respiratory protection.


### Internet Safety Articles

[www.cdc.gov/elcosh/docs/hazard/chemical\\_metals.html](http://www.cdc.gov/elcosh/docs/hazard/chemical_metals.html)

[www.cdc.gov/elcosh/docs/hazard/chemical\\_welding.html](http://www.cdc.gov/elcosh/docs/hazard/chemical_welding.html)

[www.ccohs.ca/oshanswers/safety\\_haz/welding/fumes.html](http://www.ccohs.ca/oshanswers/safety_haz/welding/fumes.html)

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### Proper PPE

- Tinted eye protection
- Respirator (organic vapor)
  - Consider PAPR
- Helmet
- Leather gauntlet gloves
- Long sleeves
- Leather or heavy fire resistive jacket and chaps if needed

*Level of protection will depend on Situation and type of Metal to be cut*

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### Personal Equipment

- Crescent wrench
- Striker/spare flint
- Tool belt, Tape Measure & Soapstone
- Spare Tips & Tip cleaners
- Marking paint
- Side cutter pliers
- Water extinguisher
- Exhaust and ventilation equipment if needed

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### CAUTION!

- Using chlorinated solvents
- Using painted or plated metals
- Wear respiratory protection

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Arsenic	Beryllium
Chromium	Cobalt
Copper	Lead
Manganese	Mercury
Nickel	Ozone
Selenium	Silver
Vanadium	Zinc



### III. Oxygen/Acetylene Burning Equipment

Oxygen/acetylene has been the most widely used metal burning technology in the industry for many years. It is very versatile and can be used for brazing, welding, and cutting carbon steel.

**Benefits:** There are a wide range of torches, accessories, and gasses available from most welding and gas suppliers.

- It is the industry standard used by most fabrication shops and at most construction or demolition sites.
- It can be used to weld items, unlike other systems that can only be used to cut.

**Disadvantages:** Acetylene has one of the widest flammable limits of any fuel gas (2.5 percent to 81 percent) and is extremely hazardous at pressures exceeding 15 psig.

- Acetylene gas requirements for proper handling, use, and storage must be followed at all times.
- The oxy/acetylene burning operation can create large amounts of molten slag when cutting thick steel.
  - ◆ This slag can fuse back into the cuts and cause problems for the burner if clean cuts are not made.
  - ◆ Slag will also ignite spot fires and can be a hazard to the burner.


#### Oxy/Acetylene Safety Practices

There are many safety practices to be followed, when using oxy/acetylene.

As listed on the adjacent slide, one must limit the pressure, limit the withdrawal rate, limit contaminants, use flashback arrestors and reverse flow valves, and perform checks for leaking components.

We will now discuss each of the components in this system

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#### Oxy/Acetylene

- **Benefits**
  - Commonly used in many industries
  - Wide variety of available accessory equipment
  - Industry standard for shops and field
- **Disadvantages**
  - Wide flammable limits
  - Limited to withdrawal rate of 1/7 per hour
  - Extremely hazardous above 15 psig
  - Requires proper handling and storage
  - Can create large amounts of molten slag

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#### Oxy-Acetylene - Safety Practices

- Do not operate Acetylene above 15 PSIG
- Do not withdraw more than 1/7 of the cylinder contents per hour
- Do not drain all of cylinder contents
- Keep components and area clear of grease, oil and other oxidizers/flammables
- Do not operate without Flashback Arrestors and reverse flow check valves
- Always perform a mechanical check for leaking components

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### Acetylene Fuel Gas Cylinders

Acetylene cylinders are considered to below pressure, 200 to 250 psi.

Acetylene is a compound of carbon and hydrogen (C<sub>2</sub>H<sub>2</sub>). It is produced when calcium carbide is submerged in water or from petrochemical processes.

Acetylene becomes unstable when compressed in its gaseous state above 15 psig.

Acetylene gas requires a special cylinder; it has a porous core that is saturated with liquid acetone.

- Acetylene gas is pumped into the cylinder and is absorbed by the acetone, which keeps the gas stable while under pressure.

Acetylene cylinders must always be stored and used in an upright position to keep the liquid acetone properly contained.

The maximum safe delivery pressure for acetylene is 15 psig. **Never exceed regulated pressures above 15 psig or the acetylene gas will become very unstable.**

Only 1/7th of the total capacity of an acetylene cylinder should be withdrawn per hour, this is controlled by the tip size being used and regulated fuel gas pressure.


- If more than 1/7th of the total capacity is withdrawn from the cylinder, it may also withdraw the liquid acetone.

When not in use or being transported in a vehicle, acetylene cylinders must be capped and secured.

Most cylinders are equipped with pressure relief devices to prevent rupture of a normally pressurized cylinder when it is inadvertently exposed to fire or high temperatures.

- Never completely drain all of the gas out of the cylinder.
- Always change out your cylinders before they are completely empty, leaving some measurable amount of gas product in the cylinder.
- If you completely drain the cylinder, you may run the risk of contaminating the cylinder with mixed gases.

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### Acetylene Gas Cylinders

- Open cylinder 1 to 1 ½ turns
- Acetylene cylinders are 200 to 250 psig
- Gas becomes unstable when compressed in gaseous state above 15 psig
- Requires special porous core cylinder
  - Acetylene gas is absorbed by acetone in cylinder core to keep it stable under pressure
  - Must be stored and used in upright position to keep liquid acetone contained
- Maximum delivery pressure is 15 psig

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### Oxy Acetylene Equipment

#### Acetylene cylinder



**POROUS FILLER 8% to 10%**  
The filler, which completely occupies the steel shell, is 90% to 92% composed of millions of interconnected pores.

**ACETONE 42%**  
Acetone equal to 42% of the internal volume is dispersed throughout the filler.

**ACETYLENE GAS 36%**  
The acetylene gas is uniformly absorbed by the acetone. The resulting mixture occupies 75% of the internal volume.

**RESERVE VOLUME AT 70° F. 10% to 12%**  
Since acetone and acetylene gas will expand as temperature rises, a safety reserve must be present even at 150° F.

**Must be stored & operated in upright position**

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### Example :

An acetylene cylinder with a total volume of 300 cubic ft may only be withdrawn at a rate of about 42 cubic ft per hour to not withdraw the acetone.



### Acetylene Fuel Gas Cylinders (continued)

- Completely draining the cylinder may allow gas to travel down through the hose into the mixing chamber of the torch and then back down through the other hose into the empty cylinder, thereby contaminating it.
- If this goes unnoticed by the welding gas supplier, the next time the tank is filled, the cylinder will contain mixed gases that may be explosive.

Friction generated during filling or opening the high-pressure cylinder may cause the cylinder to explode. This is the reason for using one-way check valves and flashback arrestors on the regulators and torch.

### Compressed Gas Oxygen Cylinders

Compressed gas oxygen cylinders are considered high pressure since they are rated at 2,250 psi.

They must be secured at all times; by law, they must be capped while being transported in a motor vehicle, or when not in use.

Grease and oil must never come in contact with any component of an oxygen system, cylinder, regulator, hose, or torch. They can combust and burn violently in the presence of pure oxygen.

### Liquid Oxygen Tanks (DEWARS)

Dewars are large cryogenic tanks.

For large jobs, these liquid oxygen tanks (called Dewars) will be used instead of compressed gas oxygen cylinders.


- One GP45 Dewar holds 4,500 cubic feet of product, and One k-size compressed gas cylinder holds 249 cubic feet of product.

A manifold can be attached to the Dewar that will supply oxygen to many torch sets.

- Attachment of the manifold can save a lot of time and energy that would be wasted moving and changing out compressed gas cylinders.
- Dewars must be secured and handled with caution; they are heavy, and if knocked over, can be damaged.

The adjacent slide shows a large, compressed oxygen trailer that was used at the World Trade Center incident

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### Compressed Gas Oxygen Cylinders

- High pressure—rated at 2,250 psi
- Must be secured at all times
  - By law must be capped to transport in motor vehicle or not in use
- Grease and oil must not come in contact with component of oxygen system
  - They can combust and burn violently in presence of pure oxygen

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### Alternate Oxygen Sources (Liquid Oxygen - Dewars)

- GP45 Dewars can evaporate 4500 Cu. Ft. of gas from a liquid contained in cylinder
  - External evaporator may be needed
  - Must be kept in an upright position
- The Green, K-Style compressed gas cylinder holds about 250 cu ft of oxygen
- Both these tanks must be secured and handled with caution


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### Compressed Oxygen Trailer

- Used when a large Demand is needed
- A tube style Trailer Cannot be easily moved around a site
- May not be readily available



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### Oxy/Acetylene—Use and Safety

#### Equipment Set Up

- Oxygen/cylinder, hose, and torch threads are right hand.
- Acetylene/cylinder, hose, and torch threads are left hand.

#### Main Cylinder Valves


- Inspect the cylinder valve seating surfaces and threads for dirt or damage.
- If you notice the presence of oil or grease on the oxygen cylinder valve, do not use the cylinder; inform your gas supplier immediately.
- Always crack the valve before attaching a regulator; doing so helps remove any loose dirt or debris that might be in the valve.
  - ◆ Always stand to the side of the valve port and make sure nobody else is standing directly in front of the valve port when you crack it.

#### Regulators

The purpose of the regulator is to reduce the high pressure within the cylinder to a usable working pressure.

- Before attaching the regulator to the cylinder, inspect it for damaged threads, seating surfaces, dirty filter, or the presence of dirt, oil, or grease.
  - ◆ Regulators are attached to the cylinder or manifold by their inlet connections.
  - ◆ All inlet connections conform to specifications and standards set by the Compressed Gas Association (CGA) and are marked with an identifying CGA number.

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### Oxy/Acetylene – Use and Safety

- **Equipment setup**
  - Oxygen—cylinder, hose, and torch threads are **Right-Hand**
  - Acetylene—cylinder, hose, and torch threads are **Left-hand**
- **Main cylinder valves**
  - Regulates gas down to working pressure (15psi max.)
  - Inspect cylinder valve seating surfaces and threads for dirt and damage
  - Always crack valve before attaching regulator—helps remove any loose dirt or debris
  - Stand to side of valve port and make sure no one is standing in front of it when you crack it

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### Oxy/Acetylene – Regulators

- **Before attaching to cylinder, inspect for damaged threads and seating surfaces + dirty filter, dirt, oil, and grease**
- **Before opening cylinder, release tension on regulator diaphragm by turning screw counterclockwise until it turns freely—places regulator valve seat in closed position**
  - Stand to side of regulator and gauges to avoid injury
  - Components of regulator usually fail while opening cylinder valve, thereby releasing high-pressure gas
  - Start opening oxygen cylinder valve by slowly cracking it until max pressure is indicated on high-pressure gauge, then continue opening valve until it is opened completely

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- Before opening the cylinder, release the tension on the regulator diaphragm by turning the pressure adjustment screw counter clockwise until it turns freely. This places the valve seat of the regulator in a closed position.
  - ◆ When opening the tank cylinder valve, always stand to the side of the regulator and gauges to avoid injury.
  - ◆ If a gauge or other components of the regulator should malfunction or fail, they will usually do so while opening the cylinder valve and thereby release the high-pressure gas.

Start opening the oxygen cylinder valve by slowly cracking it until maximum pressure is indicated on the high-pressure gauge, then continue opening the valve until it is opened completely.

### Fuel Gas Cylinder Valves

- Do the same procedure with the **fuel gas cylinder valve**, but only open the cylinder valve a maximum of 1 to 1 1/2 turns.
  - ◆ Some acetylene cylinders use a regular hand wheel knob to open the cylinder and others use a special removable wrench or key.
  - ◆ If a removable wrench or key is used to open the valve, leave it attached to the cylinder valve so the fuel gas can be shut off quickly in the case of fire or other problems with the system.

### Check Valves

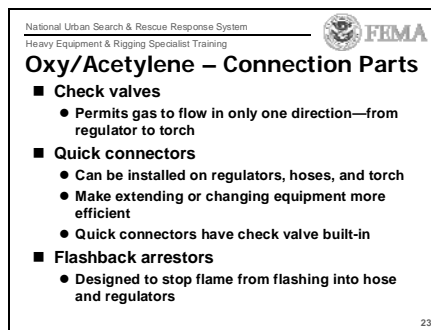
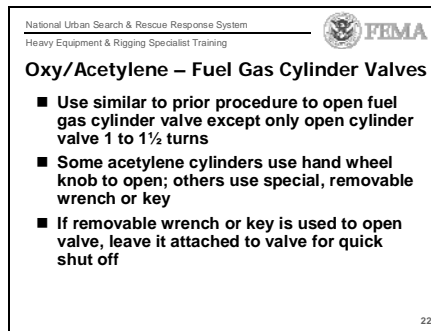
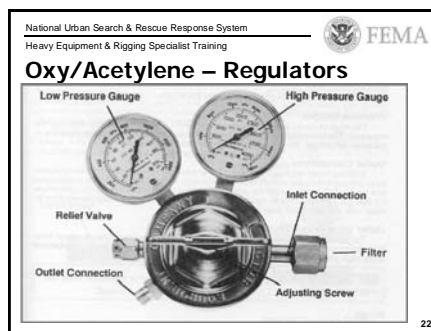
- Check valves permit the gas to flow in only one direction—from the regulator to the torch.

### Quick Connections

- Quick connections can be installed on regulators, hoses, and torches.
- They make setup plus extending and/or changing equipment more efficient.
- Each quick connect has a check valve built into it.

### Flashback Arrestors

- Flashback arrestors are designed to prevent the flame from flashing into the hose and regulators.





### Hoses

Make sure the hoses are rated for the fuel gas being used and that they are large enough to deliver the required volume for the tip size that has been selected.

- Welding hoses are often exposed to severe abuse and must be inspected for cracks, crushed areas, burns, cuts, and other damage.
- They must be kept clean and free of oil or grease and should be repaired or replaced if found to be damaged.
- The hoses are color-coded and threaded differently:
  - ◆ (Oxygen—green with right-hand threads),
  - ◆ (Fuel gas—red with left-hand threads),
  - ◆ The fuel gas hose nuts also have a V groove on the outside to indicate left-hand threads.
- Purge both hoses at about 3 psi to clear any foreign objects before attaching torch.

### Torches

- Torches come in a variety of brands, models, and sizes.
  - ◆ There are 1-piece and universal 2-piece styles.
- Long torches work well when the burner needs extended reach or is burning thick steel with a large size tip and needs extra distance from the heat.
- Long torches can be very awkward and heavy, which cause additional fatigue to the operator.
- Short torches are lighter and more maneuverable, especially in confined spaces.
- Remember, the size of the tip determines the thickness of the steel that can be burned, not the size of the torch.
- Some newer style torches have anti-reverse-flow check valves built into the main torch body; as such, additional accessory check valves may not be necessary.
  - ◆ The valves are marked OC or FC with an arrow to indicate the direction of flow.
  - ◆ If you are using an older style torch or a brand not having one-way check valves, you should install them.

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**Oxy/Acetylene – Hoses**

- Hoses are color-coded and threaded differently
  - Oxygen is green with **Right-Hand** threads
  - Fuel gas is red with **Left-Hand** threads
  - Fuel gas hose nuts have a **V-Groove** on outside to indicate **Left-Hand** threads
- Make sure rated for gas being used and tip size
- Hoses often exposed to abuse and must be inspected for cracks, burns, etc.
- Keep clean and free from oil or grease
- Purge both hoses at about 3 psi to clear any foreign objects before attaching torch

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**Oxy/Acetylene - Torches**

- Many models and sizes
- Long ones work well for extended reach and when cutting thick steel
  - May be awkward and cause operator fatigue
  - Size of tip determines thickness that may be cut
- Some newer torches have anti-reverse flow check valves built-in to main torch body
  - Marked OC or FC with arrow to indicate flow direction

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**Cutting Tip**

Cutting tips are available in a wide variety of configurations and sizes. Cutting tips keep the preheat gas mixture and cutting oxygen stream separated and provide flame characteristics needed for a particular cutting application. Tips are sized according to the thickness of metal they can cut. For instance, a number 00 tip is designed to cut metal 1/16" to 1/8" in thickness, and a number 00 tip will cut metal 1/8" to 1/4" in thickness. Charts are available to assist operator with tip selection.

**CAUTION:** Always make sure your equipment is rated for the size tip you have selected. A tip with too much capacity for the equipment can starve or choke the tip. This causes overheating of the head and a flashback may result. Use only genuine VICTOR tips, welding nozzles and multi-flame nozzles to ensure leak-free connections and balanced equipment.

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## Cutting Torch Tips

- Cutting tips are available in a wide variety of configurations and sizes.
- Cutting tips keep the preheat gas mixture and cutting oxygen stream separated and provide flame characteristics needed for a particular cutting application.
- Select the proper size torch tip to match the make and model torch you are using and the thickness of the material you will be burning.

Selection of the proper size tip can be aided by using a tip chart.

- Remember, you can only withdraw 1/7th of the total volume of an acetylene cylinder per hour.
- If you are using a small acetylene cylinder, the size of the tank will dictate or limit the cutting tip size that can be used.

## Brass Fittings and Attachments

- All gas-welding components use **brass** compression type fittings.
- When assembling welding components, remember not to over tighten them, or you will destroy the brass seating surfaces and threads.
  - ◆ You should only have to tighten them snugly with a short wrench.
  - ◆ If they leak after being tightened with moderate pressure, check for damage or defects and repair or replace.
- Always inspect O-rings before assembling welding and cutting attachments (welding tips, cutting attachment and/or heating attachment, multi-flame or rose bud).
  - ◆ If damaged O-Rings are found, do not use the torch until they are replaced.
- When mating attachments to the main torch body, only tighten them hand tight.
  - ◆ Over tightening with a wrench will only damage the O-rings and cause them to fail.



### Oxy/Acetylene - Cutting Torch Tips

- Available in many configurations and sizes
- Tips keep preheat mixture and cutting oxygen stream separated
- Select tip to match torch make and model as well as thickness of material to be cut
- Can only withdraw 1/7th of volume of acetylene cylinder per hour
  - Using small tank will limit cutting tip size

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TYPES 1-101, 3-1-1 & 5-101 (Oxy-Acetylene)

Metal Thickness	Tip Size	Cutting Oxygen		Pre-heat Oxygen PSIG	Acetylene		Speed FPM	Kerf Width
		Pressure*** PSIG	Flow*** SCFH		Pressure PSIG	Flow SCFH		
1/8"	000	20-25	20-25	3-5	3-5	6-11	20-30	.04
1/4"	00	20-25	30-35	3-5	3-5	6-11	20-28	.05
3/8"	0	25-30	35-40	3-5	3-5	6-11	18-26	.06
1/2"	0	30-35	40-45	3-6	3-5	9-10	16-22	.08
3/4"	1	30-35	80-85	4-7	3-5	8-13	15-20	.07
1"	2	35-40	140-160	4-8	3-6	10-18	13-18	.09
2"	3	40-45	210-240	5-10	4-8	14-24	10-12	.11
3"	4	40-50	280-320	5-10	5-11	18-28	10-12	.12
4"	5	45-55	300-450	6-12	6-11	22-30	6-9	.15
6"	6**	45-55	500-600	6-15	8-14	25-35	4-7	.15
10"	7**	45-55	700-850	6-20	10-15	25-35	3-5	.34
12"	8**	45-55	900-1050	7-25	10-15	25-35	3-4	.41

\*Applicable for 3-hose machine cutting torches only. With a two hose cutting torch, preheat pressure is set by the cutting oxygen.

\*\*For best results use ST 1600C-ST 1900C series torches and 3/8" hose using tip size 6 and larger.

\*\*\*All pressures are measured at the regulator using 25' x 1/4" hose through tip size 5, and 25' x 3/8" hose for tip size 6 and larger.

**WARNING** At no time should the withdrawal rate of an individual acetylene cylinder exceed 1/7 of the cylinder contents per hour. If additional flow capacity is required, use an acetylene manifold system of sufficient size to supply the necessary volume.

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### Oxy/Acetylene Brass Fittings & Attachments

- All gas welding and cutting components use brass fittings
- Do not over-tighten brass fittings
  - Destroys seating surfaces and threads
  - If leak after being tightened using moderate pressure, inspect and/or replace
- Inspect O-rings before assembling attachments
- Hand-tighten attachments to main torch body
  - Over tightening will damage O-rings



### Welding Cart

- The welding cart should be of sturdy construction and be well balanced.
- Pneumatic rubber tires 8" tall or larger with bearings or bushings should be used to ensure ease of movement on broken or uneven ground.
  - ◆ Small hard rubber or steel wheels will stop or bind when used on rough or rocky surfaces.
- The cart should be of the proper size to accommodate and contain cylinders safely.
- There should also be a place to store safety goggles, spark lighter, tip cleaners, a wrench, and extra torch attachments

### IV. Oxygen/Gasoline - Petrogen

The Petrogen gasoline/oxygen system operates somewhat differently from its oxy/acetylene cousin that most torch operators are accustomed to.

- It uses all of the same oxygen components and safety guidelines.
- The torch looks and operates in much the same way on the outside but is totally different on the inside.
- The gasoline stays liquid throughout the system until it reaches the cutting tip where it is heated and turned into a vapor in much the same way a Coleman stove or lantern does.

Petrogen system has many advantages as listed on the adjacent slide

#### Petrogen Disadvantages

As previously mentioned Oxy/Acetylene is used by many industries, including construction.

Petrogen's use is limited to cutting metal, and may not be available in many locations where disasters may occur.

The Petrogen Torches may look very similar to ones using Oxyacetylene, but all must remember that they operate differently



#### Oxy/Acetylene – Welding Cart

- Should be sturdy and well-balanced
- Use 8" minimum pneumatic tires and wheel bearings or bushings
- Need to safely contain cylinders
- Need place to store goggles, lighter, tip cleaners, wrench, and extra torch attachments

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#### Oxy/Gasoline - Petrogen

- Has been available for many years
- Similar to oxy/acetylene, but only for burning
- Benefits
  - Can cut steel up to 14" thick
  - Will cut through various sized air gaps
  - Less likely to fuse itself back together
  - Burns cleaner and with little slag
  - Not limited by fuel cylinder size
  - Gasoline is readily available and is safer
  - Can be used under water with special tips

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#### Oxy-Gasoline - Petrogen

- Disadvantages:
  - Equipment is not available locally
  - Rescuers must understand that the Petrogen torch setup, tuning and usage is different than the oxy-acetylene setup
  - Failing to understand the differences will produce poor cutting results

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## Petrogen Safety Practices

As with all burn cutting, the use of Petrogen equipment entails significant and special risks.

Fuel leaks are critical

- Perform leak checks after assembly and prior to lighting
- Look for liquid fuel on the ground and at couplings
- Secure fuel tank in the upright position, since the fuel cannot flow with tank on its side
- A flashback arrestor should be used on the oxygen line, but one is not required for the fuel line

**The 2.5-gallon ASTM certified Petrogen fuel tank** is equivalent to a 250-cubic foot acetylene tank.


- It has a fast-flow check valve located inside the tank shut-off valve that is designed to shut off the fuel in the event that the fuel hose is ever cut or severed.
- For the fast-flow check valve to operate properly, the pressure in the gasoline fuel tank should never be allowed to drop below 10 psig.
- The tank shutoff valve should be opened slowly when setting up the torch for operation so that the fast-flow check valve will not engage and shut off the fuel.
- The tank pressure should normally be between 10 to 20 psig during normal operations when using the hand pump.
- Higher pressures may be used when using the optional compressed air carry tank.

## Petrogen Torches

Torches come in various configurations

- Torches are available in 14", 20", 27", 36," and 48" lengths.
- Available head angles are 75, 90 and, 180 degrees.
- The size of the tip, and not the torch length determines the thickness of the cut

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### Petrogen Safety Practices

- Always perform a check for leaks
- When checking for a fuel leak look for liquid fuel on the ground and couplings
- Secure fuel tank in the upright position  
Fuel cannot flow with tank on its side
- A flashback arrestor should be used on the oxygen line.
  - One is not required for the fuel line
- Do not operate fuel tank below 10 psi

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### Petrogen Equipment – Fuel Tank

- 2.5 gal ASTM-certified tank is equiv to 250 c.f. acetylene tank
  - Has fast-flow, check valve inside tank shut-off valve
    - ◆ Designed to shut off fuel if hose is cut
    - ◆ For valve to operate, tank pressure should not drop below 10 psi
    - ◆ Shut-off valve should be opened slowly so fast-flow check valve will not engage
  - Keep tank pressure between 10 and 20 psi when using hand pump
    - ◆ Higher pressure may be used when using optional compressed air carry tank
- Use freshest fuel available

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### Petrogen Equipment - Torches

- Various lengths/styles and head angles
- The size of the tip not the torch length determines the thickness of the cut

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### Petrogen Torch Tips

The tip is a 2-piece assembly, with an inner brass core and an outer copper shell. The liquid fuel is vaporized, directed down to the base of the core, and then re-directed out the tip through the flutes of the core.

- As gasoline changes from liquid to vapor, its volume increases almost 200 times. This rapid expansion provides a large force to the pre-heat flame.
- Because gasoline vaporizes inside the tip, and evaporation is a cooling process, the tip runs cool.

### Petrogen Tip Chart

The chart shows the cutting range of each tip, and suggests gasoline and oxygen pressures.

- The range of each tip is extended by higher pressures, but the quality may be reduced.
- The best combination of tip and pressures depends on operator technique, type and size of steel, desired cutting speed, and quality of cut

### Lighting the Torch

- Lighting the torch is done by first turning on the oxygen and the gasoline tank valves and setting the proper pressures.
- Open the pre-heat oxygen valve at the torch until a light flow is established.
- Next, open the gasoline valve until you see a very light mist.
- Using a spark lighter, light the torch and adjust the flame.
- Place the torch tip against the steel to heat the tip. Then re-adjust and you are ready to burn.

### To Shut Down the Torch

- First, shut off the gasoline, then the oxygen at the torch.
- Close the valves at the tanks and back off the oxygen regulator pressure adjustment.
- The tips are sized a little differently from oxy/acetylene tips.

Refer to the gasoline/oxygen tip chart that is posted on the side of the fuel tank or in the operators manual



### Petrogen Equipment Torch Tips

- Tip has two pieces
- Fuel enters the tip as a mist /atomized gasoline oxygen mixture
- Has oxygen and pre heat ports similar to Oxy-Acetylene
- If tuned properly, fuel entering tip should keep tip cool as it vaporizes



### Petrogen Equipment Tip Chart

- Serves as a basic starting point
- Settings will depend on operator experience
- You are not limited by the 1/7 per hour rule
- Tip does not need to be as clean as for oxy-acetylene tip

INCHES STEEL	TIP NO.	POUNDS/SQ INCH	
		GASOLINE	OXYGEN
0-1/4	0	10-20	12-17
1/4-1	1 & 81	10-20	17-25
1-2	2	10-20	25-35
2-4	3 & 83	10-20	35-40
4-6	4	12-20	40-50
6-8	5	14-20	50-60
8-10	6	16-20	70-80
10-12	7	18-20	80-100
12-14	8	20	120+



### Oxy-Gasoline - Petrogen

- Lighting the torch
  - Turn on oxygen and gas tank valves and set proper pressure
  - Then open pre-heat oxygen valve until light flow established
  - Next open gas valve until you see a very light mist
  - Light torch using spark lighter and place torch tip against steel to heat tip before adjusting flame



### Gasoline/Oxygen Operation (continued)

- Shutting down the torch
  - First shut off gasoline at torch
  - Next shut off oxygen at torch
  - Close valves at tanks
  - Back off oxygen regulator pressure adjustment
- Tips are sized differently than oxygen/acetylene
  - Refer to gasoline/oxygen tip chart in Operators Manual



### Petrogen – Poor Practice

The adjacent slide shows the damage to torch tips that can be caused by operator error.

- This type of damage is usually caused by having the coupling distance too short, or
- By turning the torch too lean
- One should start with a coupling distance of 1/2”

### Petrogen Operation

To summarize, Petrogen operates very similar to Oxy/Acetylene.

- One needs to use the same oxygen components and guidelines
- The torches look the same but they are different inside.
- The gasoline stays in liquid for until it reaches the cutting tip. Liquid gasoline is NOT flammable

## V. Other Metal Burning Tools

### Exothermic

The exothermic technology came to us from the U.S. Navy. They designed this equipment for burning through bulkheads in submarines.

This technology uses oxygen pushed through consumable alloy rods, which burn at a very high temperature.

The arc is started by shorting out the consumable rod, which is attached to a gel-cell battery and to a grounding plate (or by using a burning punk).

**Benefits:** This system can burn through almost anything, including:

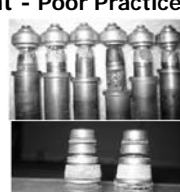
- Ferrous and nonferrous metals,
  - Stainless steel,
  - Concrete,
  - Glass,
  - Cast iron, or
- (Just about anything else you can think of).

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### Petrogen Equipment - Poor Practice

- Operator Error caused this overheated equipment
- Typically caused by too close of a coupling distance or tuning the torch too lean
- A coupling distance of 1/2” is a good safe starting point



Heat transferred from Tip & overheated mixer

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### Gasoline/Oxygen Operation

- Operates similar to oxygen/acetylene
- Use all same oxygen components and safety guidelines
- Torch looks same but different on inside
  - Gasoline stays liquid throughout system until reaches cutting tip
  - Then heated and turned into vapor in similar way to Coleman stove

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### Exothermic

- Developed by U.S. Navy to burn through bulkheads
- Uses oxygen pushed through consumable alloy rods
- Benefit: can burn through almost anything
- Disadvantages
  - Potential for fire caused by molten metal
  - Operator must wear full protective clothing
  - Areas of work must be free from combustibles
  - Lead acid batteries should not be substituted for gel cell starter batteries due to off gassing of hydrogen

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**Disadvantages:** The main disadvantage is fire!

- This system throws large amounts of molten material.
- The operator must be wearing full PPE to prevent serious burns.
- The area where the work is performed must be free from combustible materials, and water extinguishers must be available at all times.
- Gel-cell starter batteries should not be substituted for lead acid automotive batteries because they may give off hydrogen gas and can explode.

### Oxygen Lance

The Oxygen Lance uses a carbon steel, consumable pipe, fed with oxygen to burn cut other substances.

The **Thermolance** uses a steel pipe that is packed with a combination of wire inserts, also fed with oxygen. It burns at a higher temperature than the Oxygen Lance, and will melt anything from concrete to stainless steel. It is, also, more effective and controllable

### Plasma Arc

This technology uses an electric arc in conjunction with compressed air. It works very well but is best suited for fabrication work.

**Benefits:** Plasma systems do an excellent job and can burn through both ferrous and nonferrous metals, including stainless steel.

- They are able to make very clean, precise cuts with very little slag and light sparks.

**Disadvantages:** Only small units that are limited to burning light gauge metals are portable.


- The larger systems that can burn thicker material are large, heavy and require 220 volts to operate.

### Basic Torch Handling

As with any physical task that will last for significant time, one needs to assume a reasonably comfortable position.

- One should use a longer torch rather than reaching with a shorter one.
- It is best to balance the torch on a pivot point like a pool cue.
- It is worth the time to set-up one's work space in order to remove stress from the arms and back.

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### Oxygen Lance

- Uses exothermic technology but uses a much thicker and longer consumable rod
- This allows the operator to be at a safer distance away from the material being cut

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### Plasma Arc

- Uses Electric arc in conjunction with Compressed air
- Benefits
  - Can burn through ferrous and non-ferrous metal including stainless steel
  - Clean burns, almost no slag and sparks
- Disadvantages
  - Portable units can only burn light gauge metals
  - Systems that can burn thicker material are large and heavy, plus they require 220 volts to operate

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### Basic Torch Handling Skills

- Make yourself as comfortable as possible
- Try to work the torch like a pool cue or pivot using your hand or material/debris as a pivot point

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## VI. Estimating the Weight of Steel

Often burning operations are needed when large steel beams and columns are present in a collapsed structure.

Since these heavy objects will need to be moved, some of the first things to consider are the lifting capability of the available equipment, based on the distance to the object's initial and final positions.

- The information regarding maximum lifting capacity will determine where to mark and cut the heavy steel members so that the weight requirements are met.
- Most metal suppliers offer booklets that give information about the weight of steel by thickness, shape, and dimension, usually on a per-foot basis.

There is an easy way to quickly estimate the weight of steel, by remembering that a one square foot, one inch thick steel plate weighs 40.8 pounds per square foot (psf).

The 40.8 psf is based on the fact that steel weighs 490 pounds per cubic foot (12"x 12"x12"). One may cut 12 – one inch slices, one square foot each, from a cubic foot.

**Therefore, 1" thick, sq ft plate weighs  $490/12=40.8$  lbs**

In order to easily remember, we round off to 40 and use the following weights for one sq ft steel plates:

- 1" thick = 40 psf
- $\frac{3}{4}$ " thick = 30 psf
- $\frac{1}{2}$ " thick = 20 psf
- $\frac{1}{4}$ " thick = 10 psf


One can easily calculate the weights of steel plates to the eight or sixteenth of an inch ( $3/8$ " = 15psf)

Note that this Area Method can be used to estimate the weight of concrete slabs.

Reinforced concrete weighs about 150 lbs per cubic ft, and we can use the following weights per sq foot

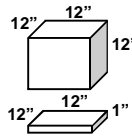
- 12" slab = 150 psf
- 8" slab = 100psf
- 6" slab = 75psf & 4" slab = 50psf

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### Estimating Steel Weight - Area Method

- Steel weighs 490 lbs per cubic ft
- Steel 1" thick weighs  $490\text{pcf} / 12" = 40.8$  psf
- For steel weight per square foot use:
  - 1" thick Use 40 lbs
  - $\frac{3}{4}$ " Use 30 lbs
  - $\frac{1}{2}$ " Use 20 lbs
  - $\frac{1}{4}$ " Use 10 lbs



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### Area Method Example 1

The weight of the steel “box section” shown in adjacent slide can be easily calculated by noting that a 2” thick plate would weigh 80psf.

- Since the total area of 2” plate is 8 sqft per ft, the section weighs  $8 \times 80 = 640$  pounds per foot (plf)
- Total weight if the section is 36ft long is 23,040 lbs
- This is only 2% less than the exact weight

### Area Method Example 2

The adjacent slide shows an additional example, using a built-up so called W shape.

- Again, the calculation is simple, and the error is the same 2%
- The 2% is just the difference between the exact 40.8 psf and the easier to remember 40 psf for the 1” x one square foot steel plate

### Area Method for Round Tube/Pipe Shapes

For round tubes, one may imagine a flat plate, made from cutting the tube length-wise and laying it flat.

- The width of this imaginary plate is the circumference of the round shape, which is the diameter x 3.14 (Phi).
- The easy to remember value is 3, which is about 5% less, but close enough.

### Area Method – Pipe & Tube Example

In the adjacent slide there is an example for estimating the weight for a 12” diameter x 1/2” steel pipe and a 8” square x 1/4” square tube, using the Area Method.

One can see that this method yields results that are within 5% of the actual weight in both cases

Additional methods for calculating weights of both concrete and steel will be presented in a later HERS Training Module. The student is encouraged to use whatever method is easiest for them to remember.

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**Area Method Example - 1**

- What is weight of this 36ft long steel section?
  - 2” Steel = 2 x 40 psf = 80 psf
  - Area per ft = 2 x 3 sq ft + 2 x 1 sq ft = 8 sq ft
  - Weight per ft = 8 x 80 = 640 plf
  - Total weight = 640 x 36 = 23,040 lbs
- Exact weight = 652.8 plf (only 2% off)

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**Area Method Example - 2**

- What is weight of this 20ft long steel section?
  - 2 Flanges 40 psf x 5” x 2 ft x 2 = 800 plf
  - Web 40psf x 3.5” = 140
  - Weight per ft = 800 + 140 = 940 plf
  - Total weight = 940 x 20 = 18,800 lbs
- Exact weight = 958.8 plf (only 2% off)

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**Area Method – Round Tube Shapes**

- Get area by: Circumference x Length
  - Either Measure distance around w/ tape or
  - Multiply Diameter x 3 (exact is 3.14)
  - Think - cut & unfold tube
- Weight per ft is 3 x Diameter x Wt, per sq ft
  - Wt. per sq ft depends on thickness
  - 1” thick Use 40 lbs
  - 3/4” Use 30 lbs
  - 1/2” Use 20 lbs
  - 1/4” Use 10 lbs

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**Area Method - Pipe & Tube Example**

- What is weight of this 16ft long steel pipe?
  - 12” Diameter x 1/2” thick
  - 1/2” Steel = 20 psf Area per ft = 3 x 1 = 3 sq ft
  - Weight per ft = 3 sf x 20 = 60 plf, Total = 960 lb
  - Exact weight = 61.4 plf (only 2% off)
- For Sq Tube use 4 x Size x Wt per sq ft
  - For 8” Sq. x 1/4” thick x 16ft (10psf for 1/4”)
    - Wt per ft = 4 x 8”/12” x 10psf = 26.7 plf, 427lb
    - From AISC Hbk = 25.8 plf (only 4% off)

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### Other Clues of Steel Weight

In order to identify steel sections and aid with erection, the steel mill, and/or shop may paint-on indications of the section/s weight.

The standard method is:

- First numbers are the section depth
- Second number is the weight per foot
- Third number is the approximate length in feet

One may or may not be able to find these numbers for any specific piece, since it may be cut from something longer, and/or may be covered by some sort of primer or finish paint/coating

### Shipping & Storage Methods

To be stored, all torches & hoses must be completely purged of fuel. In order to do this, one must remove quick disconnects.

Acetylene torches should may be stored in a oil free, hard case

Petrogen torches, hoses, and fuel tanks must be stored in ventilated shipping boxes

Since regulators are relatively fragile, they should be stored and/or shipped in oil free, padded hard cases.

Refer to IATA and local guidelines for shipping compressed gas

### Cylinder Safety

Cylinders must be secured and capped during transport and when not in use


- Since most cylinders are equipped with pressure relief devices, there is little chance of rupture, due to high temperature.
- One should never drain all gas out of a cylinder due to the risk of contaminating it

### Review Unit Objectives

The Student will understand the capabilities and limitations of all the types of burning equipment that can be used in US&R operations, and

Understand how to efficiently and safely cut and remove multiple pieces of steel from a debris pile

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#### Other clues for Steel Weight

- Numbers painted on steel at the Mill/Shop
  - First number is Depth in Inches
  - Second is Weight Per Foot in Pounds
  - Third is Length in Feet
- Usually located near the end
  - May be covered with other paint

**24X76X46**

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#### Shipping & Storage Methods

- All torches & hoses purged of combustible fuel
- Remove quick disconnects if used to completely remove fuel
- Store Petrogen torches, hoses & fuel tanks in a ventilated shipping box
- Regulators are fragile and should be stored in protective oil free hard case
- Refer to IATA and local guidelines for shipping compressed gases
- Acetylene torches can be stored in a oil free hard case

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#### Oxy/Acetylene – Cylinder Safety

- Secure at all times and cap during transport or when not in use
- Most cylinders are equipped with pressure relief devices to prevent rupture if exposed to high temperatures
- Never drain all gas out of cylinder
  - Risk of contaminating cylinder
  - Reason to use one-way check valves and flashback arrestors on regulators and torch

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