POWER TOOLS AND EQUIPMENT

Portable Fans

Portable fans provide the fire service a vehicle for achieving one of several critical elements of any firefighting effort: timely and effective ventilation of an affected structure. Whether carried out as part of a well-coordinated fire attack, or during overhaul operations, the ability to rapidly remove smoke and heat from an structure is paramount to any successful firefighting operation. Observable reductions in property damage, more tenable firefighting conditions, and overall improvements in firefighter health and safety are tangible benefits which occur with the use of portable ventilation fans.

Various manufacturers produce fire department ventilation fans. As such, several varieties of fan models and styles exist. Fan sizes may range from small (often electric or water-powered) to larger gasoline-powered blowers. In some instances, personnel may have the availability of much larger, trailer-mounted exhaust fans, similar to those in use by airboats. Regardless, each fan has specific applications and limitations. As such, the Rescue Squad driver/operator must be knowledgeable of the various types and specific operating characteristics of all fans carried on his/her unit.

Power Source(s)

The type of fan employed on the fireground is largely driven by the nature and availability of specific power sources. Until the early 1990’s, the fire service utilized electric “smoke ejectors” for all ventilation applications. This resulted from the fact gasoline-powered fans had yet to be introduced to the fire service.

The electric powered fan is powered by a large industrial electric motor, ranging from ½ to 1½ horsepower. These motors are more often deemed “intrinsically safe.” This term is commonly used to describe a device which is safe for operation in a hazardous/explosive atmosphere. These fans operate via extension cords which may be connected to power sources such as fire apparatus generators, or buildings whose electrical power remains unaffected. More often, these fans are encased in either a steel or aluminum housing.

The introduction of gasoline-powered portable fans drastically altered the “standard” of fireground ventilation. These fans consist of a small, frame-mounted, 4-cycle motor which is connected to a multiple-prop blade. Gasoline-powered fans offer the versatility of compactness and mobility, while simultaneously producing enormous volumes of air.

One of the major drawbacks of the gasoline powered portable fans is the large amount of carbon monoxide produced by the motor that is then drawn into the fan an forced into the building or area being ventilated. To counteract this effect most fan companies offer exhaust extensions that quickly attach to the exhaust port on the motor and discharge the harmful gases away from the fans air intake.

In an effort to eliminate all potential ignition sources during ventilation operations, several manufacturers offer water-powered fans. Often referred to as “hydro-powered,” these fans possess a motor or drive device which consists of a hydro-driven impeller connected to the blade’s shaft. The water supply intake for these fans is NST 1 ½” thread.

Size/Capabilities

The specifics of fire service ventilation fans vary greatly from manufacturer to manufacturer. The information listed below is a composite of the average capabilities and capacities for various sized fans. Detailed information regarding a fan’s specifications can be found within the manufacturer’s instruction manual.

Electric-powered

Size	Motor (hp)	RPM	CFM	Weight (lbs)
12”	½	3,400	3,700	40
16”	1/3	1,700	5,200	45
20”	1	1,700	12,000	75
36”	1	1,700	13,000	95

Gas-powered

Size	Motor (hp)	RPM	CFM	Weight (lbs)
18”	5.5	3,700	14,000	80
24”	8	3,300	21,000	115
30”	13	2,000	26,000	160

Hydro-powered

Size	Motor (hp)	RPM	CFM	Weight (lbs)
16”	4 hp @ 70 gpm @ 250 psi		18,000	54
21”	22hp @ 250 gpm @ 200 psi	2,000	30,000	75
30”	10hp @ 175 gpm @ 200 psi	3,600	14,000	30

Maintenance

Fans require considerable maintenance and cleaning in order to maintain operational readiness. Important factors to consider include:

- Electric motors must be kept clean to allow for proper ventilation of internal components and related circuitry.
- Shrouds must be securely fastened to prevent vibration and the introduction of particles into the airstream.
- Foot mounts or skids must be in place to ensure the fan operates without unnecessary vibration.
- Fuel tanks must be kept full to ensure uninterrupted operations during incidents.
- Oil levels must be maintained within an acceptable range in order to limit wear and tear on engine components.
- An exhaust hose, if so equipped, must be free of cuts and crimps.
- Fan blades/propellers must be free of dents, nicks, cracks, or other defects. Warning: Damaged blades could fail during operation and lead to serious firefighter injuries or death!
- The fan blade/propeller must be installed with the pitch in the correct direction. The blade/propeller should have an arrow or indicator to identify which side should face forward.

Portable Saws

Portable gasoline-fueled saws, operated by the fire service, are the "workhorse" of ventilation and forcible entry operations. These saws are light enough to be carried by one firefighter yet, given the appropriate blade, are powerful enough to quickly cut through most materials. A primary consideration when operating these saws is operator safety. These saws are capable of producing deafening noise, generating sparks, ejecting debris when cutting, and producing considerable torque and kick-back.

When operating these saws, a firefighter must wear proper personal protective equipment (PPE). Proper PPE must include adequate hearing protection, approved eye protection, turnout gear (when appropriate), and leather work/firefighting gloves.

Cut-off

The "Cut-off Saw" is a larger version of the carpenter's circular saw. While the fire service utilizes gasoline-powered units, those who work in an industrial or construction capacity rely on hydraulic and electric-powered versions, in addition to gasoline-powered units. The Cut-off Saw consists of several major components including:

Not in Photo

- belt tensioner

Saws operate on two-cycle fuel, which will be discussed later. When carrying a saw, the cutting wheel should be pointed behind the user, and the muffler facing away from the operator.

Blade Type

The type of blade installed on a Cut-off Saw will dictate the material which can be cut.

Composition	Material	Material To Cut
Composite /Abrasive	*Aluminum Oxide*	*Metal*
This blade type can be used to cut all ferrous metals. Ferrous metals include mild steel, stainless steel, rebar, and metal pipes.		
Composite /Abrasive	*Silicon Carbide*	*Stone Cutting*
This blade type can be used to cut concrete, masonry, and brick.		
Continuous Rim	*Dry Diamond*	*Stone*
This blade type can be used to cut concrete, masonry, and brick.		
Composite	*Wood Cutting/Toothed*	*Wood/Metal*
This blade type can be used to cut wood.		
Composite	*Carbide Chipped*	*Wood/Metal*
This blade type can be used to cut wood, light-gauge metal, and concrete.		

Manufacturers recommendations should be followed when considering the application of water on a cutting wheel (saw blade). Some manufacturers recommend the application of water on masonry (Silicon Carbide) blades. This increases wheel life while cutting down the production of dust. Applying water to a metal (Aluminum Oxide) will decrease the cutting performance and potentially could cause catastrophic blade failure.

Blade Inspection

Prior to each use, and as required during regular apparatus maintenance, the Cut-off Saw blade should be inspected for signs of deterioration and damage. Personnel should also verify that each saw is operating at the appropriate speed (i.e., revolutions per minute) for the blade.

Warning: Damaged blades could fail during operations and lead to serious firefighter injuries or death! Routine blade inspections should include an examination for:

- Appropriate blade diameter (no less than 8" in diameter);
- nicks or cracks;
- blade softness;
- exposure to corrosive fluids (e.g., hydrocarbon fuels);
- warping or wobble; and
- Arbor hole(s) which may be out of round.
- Missing teeth – no more that 2 continuously or a total of 4
- Reversal of blade – Some carbide chipped blades suggest reversing the direction of cut after a specified period of use.

Regulations Regarding Blade Use

The use of blades (cutting wheels) on cut-off saws (hand-powered tools) is regulated by manufacturer guidelines and various sections in the United States Code of Federal Regulations. When looking into the design, use, and application of cut-off saws one must first look at the each components' definitions.

The fire service cut-off saw is by regulation actually a portable abrasive machine. An abrasive wheel/blade is "a cutting tool consisting of abrasive grains held together by organic or inorganic bonds. (29CFR 19120.211(b)(14)" The use of cut-off saws with abrasive blades are governed by 29 CFR 1910.212, General Requirements for All Machines, subpart Machinery and Machine Guarding.

When using carbide tipped blades, be it regular tipped or clustered tipped like the D'ax or similar blades, the cut-off saw is now classified as a cutting saw. As such the cut-off saw must meet the requirements of 29 CFR 1926.309(b), General Requirements, subpart Tools – Hand and Power.

The D'ax blade or equivalent is actually "bonded steel fragments arranged in intermittent clusters around the periphery of a steel disc, approximately ¼" thick. OSHA Interpretation 6/22/1998" The use of a wood cutting blade will produce a surface feet-per-minute speed which may exceed the manufacturers design specifications. This is the primary reason that some saw manufacturers prohibit the use of wood cutting blades on their saws.

Saw Inspection

Prior to each use, and as required during regular apparatus maintenance, the Cut-off saw should be inspected for signs of damage. Routine saw inspections should ensure:

- the fuel reservoir is full and the fuel cap is secure;
- the blade guard is in place and positioned properly;
- the drive belt is secure, undamaged, and belt tension is appropriate*;
- the starter rope and housing are in place, and the rope is not frayed; and
- the cutting wheel is securely mounted and square against the arbor.

* Depress the belt with moderate thumb pressure, while ensuring the presence of no more than 3/8" of an inch depression.

Chain

As with many tools found in the fire service, the standard homeowners' or Lumberjacks' chain saw has been modified for firefighter applications. The Cutters Edge saw and Vent saw have been similarly customized for use in the fire service.

In general, chain saws possess several major components including a:

Not Shown in Photo
- chain brake;
- chain sprocket;
- chain tensioner;

Chain Oil

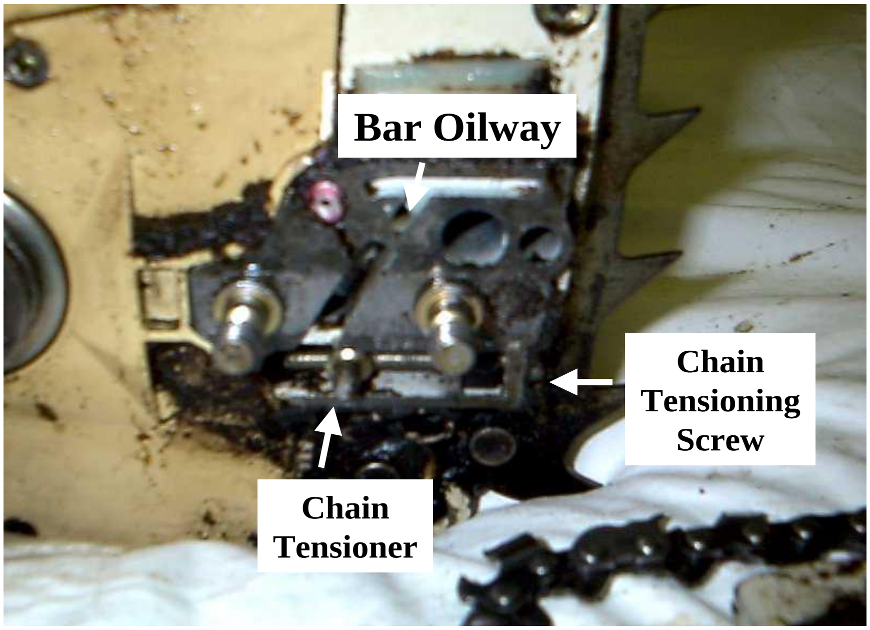
A critical component of safe and effective chain saw operation is that which relates to chain lubrication. The saw's chain and guide bar must be continuously lubricated during operation to protect them from abnormal wear. On most saws, the capacities of the oil and fuel tanks are balanced in such a manner that a small residual amount of oil always remains after consuming a tank of fuel. The chain oil reservoir should always be filled at the same time as the fuel tank. Although high-duty engine oil may be used in emergent cases, the appropriate brand chain oil should otherwise be utilized.

The chain oil reservoir is usually located below the front hand guard and just forward of the starter grip. The reservoir is pressurized by engine exhaust, thus forcing an appropriate amount of oil into the oil way. The oil way is located just above the bolts securing the guide bar. To ensure oil flows onto the bar and chain, the oil way in the crankcase must be aligned with the oil inlet located in the guide bar.

Once a cutting operation is complete, the chain oil reservoir cap should be opened to relieve built-up pressure inside the reservoir. Doing so will limit, if not prevent, the common occurrence of leaking chain oil onto compartment floors.

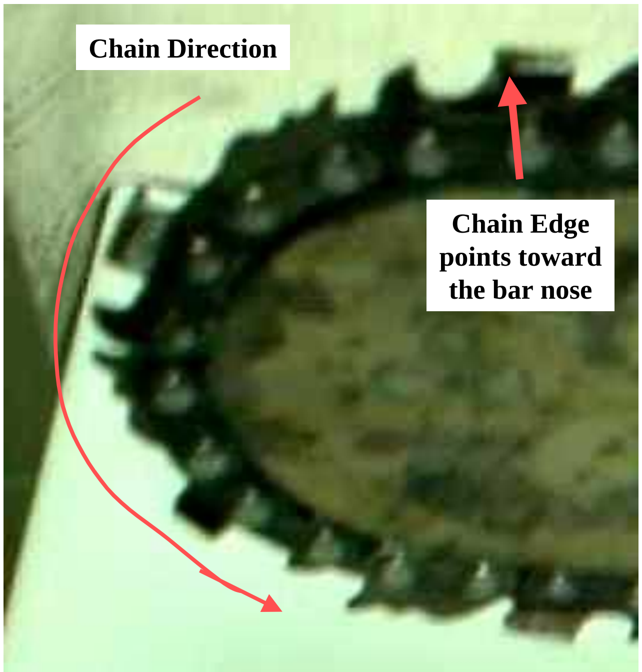
Chain Tension:

On occasion, the saw's chain may be removed for sharpening, replacement, or routine saw maintenance. Once the guide bar, chain, and depth gauge attachment (if applicable) have been properly re-installed, and prior to the saw's return to service, the chain must be tensioned. Note, however, that tensioning is occasionally required during prolonged cutting operations. Furthermore, it is a practice dictated by normal apparatus maintenance schedules.



Although each brand of chain saw has specific instructions regarding proper adjustment of chain tension, several guidelines can be universally applied.

1) Remove the chain/sprocket cover.
2) Adjust the chain tensioner to the rear-most position, thus posing the least possible tension on the chain.
3) Place the chain on the guide bar with the chain's cutting edges (i.e., teeth) facing towards the guide bar's nose.



4) Hold the guide bar and chain up to the bar studs, while placing the chain over the sprocket.
5) Ensure the tensioner peg is engaged in the guide bar's locating hole.
6) Turn the tensioning adjusting device until the chain is snug against the guide bar.
7) Place the chain and sprocket cover on the studs and using one's fingers, thread on the stud nuts.
8) While holding the tip of the guide bar in an upward position, tighten the stud nuts.

A properly tensioned chain should fit snugly against the underside of the bar, while still capable of being easily pulled along the bar by a gloved hand. Manufacturer guidelines are likely to recommend an acceptable gap of 1/8" to 1/4" between the guide and the bottom of the chain links.

Fuel Mixture

The fire service uses a combination of 2-cycle and 4-cycle combustion engines. Occasionally, these engines are referred to as "two-stroke" or "four-stroke" engines. The terms are fully interchangeable. The two engines can be differentiated on the basis of the type of fuel utilized. Two-stroke engines utilize 2-cycle fuel; a mixture of oil additive and gasoline. Four-stroke units operate on straight gasoline. The two engines can be further differentiated by the fact that 2-cycle units do not possess a separate oil reservoir. Since these engines operate on fuel possessing an oil additive, a separate mechanism for engine lubrication is unnecessary. On the other hand, 4-cycle units possess separate oil and fuel reservoirs.

Four-stroke engines commonly comprise the power plants found on such fire service equipment as ventilation fans and hydraulic rescue system pumps. Two-stroke engines comprise the power plants on all small saws.

The 2-cycle engine affords several advantages over its 4-cycle counterpart. First and foremost, 2-cycle units afford a smaller, more powerful, engine which is more tolerant of adverse (e.g., oxygen deficient) atmospheres. It is also less likely to sputter or backfire when placed in an inverted position. Conversely care should be taken to ensure that 4-cycle engines are placed on flat and level ground for best operation. In addition, two-cycle engines "pack" almost twice the power as that of an equal size four-cycle. Lastly, a 2-cycle engine utilizes a fuel/oil mixture to provide simultaneous cylinder combustion and crankcase lubrication.

Despite its inherent advantages, a 2-cycle engine also poses significant drawbacks for fire service personnel. First, these units exhibit wear and fatigue much more rapidly than 4-cyles. This phenomenon is largely due to 2-cycle units not possessing a dedicated lubrication system. Secondly, 2-cycle engines tend to produce large amounts of pollution.

The mixture of oil additives and gasoline required to effectively power 2-cycle engines is a delicate process. Mixtures must be measured precisely to ensure proper engine lubrication. Each manufacturer establishes a specific fuel mixture ratio for their specific brand or model of equipment. Simply put, this ratio indicates how many parts oil must be mixed with a specified quantity of gasoline. More common ratios include 50:1, 40:1, and 25:1.

Operational Checks

Within the fire service a great separation exists as to the proper procedure to perform operational checks on small motor driven equipment. Some will say that the tool needs to be started every day to ensure that it will operate when needed on the next emergency incident. While others say that starting saws, pumps, and fans daily cause more harm than good.

The answer will depend on the manufacturers instructions and guidance. The owner's manual will outline the proper procedure to be used to perform a service check on the unit. A sample check out procedure is outlined below:

1. Remove the tool/unit from the apparatus and inspect it for damage and/or leaks. If found notify the unit/station officer immediately.
2. Check the level of all fluids. (Oil, hydraulic, fuel)
3. Start the tool/unit and let it idle for 2 to 3 minutes.
4. Depress /slide the throttle halfway and hold it there until the tool/unit has reached its operating temperature.
5. **Never run a tool/unit at full throttle without a load on it.**
6. Release/return the throttle to the idle position.
7. Let the tool/unit idle for several minutes to allow for the tool/unit to cool down.
8. Shut the tool/unit off. Allow the tool/unit to further cool off before placing it in a compartment or storage case.

TORCHES

Types of Torches

The use of torches in the fire service is very limited but must be considered as a tool in the rescue squad's arsenal. The skill of operating a torch is learned from hours of practice and is an art as much as it is science. One can not expect to pickup a torch and to be instantly proficient in its operation.

The three main type of torches in use by the fire service today are the exothermic, oxygen/acetylene, and the plasma arc. The primary difference between the three is the type of reaction occurring at the torch tip.

Exothermic

The exothermic cutting torch uses a combination of gas and fuel to create an exothermic reaction. This heat is used to burn, melt, or vaporize metallic or non-metallic material.

Fuel & Gas Source

The exothermic torch uses a combination of a gas source, usually oxygen, and a fuel source, most often a rod of rolled metal to burn and create the exothermic reaction. Some units use a plastic coated cable as the fuel source in place of the rods. The temperature at the end of the rod/cable can be in excess of 10,000° F.

The fuel rods from one brand of exothermic torch will most often not be compatible with another brand of torch. These torches most often use a hand held “pistol” like grip unit to control the gas flow and to secure the fuel rod. A trigger like lever controls the flow of gas (oxygen), while the rod is secured by a collet and locking collar.

The collet is a thin slotted cylinder, that when squeezed clamps onto the fuel rod and secures it in place. The locking collar applies the pressure to the collet. A small spark arrestor is located inside the torch handle assembly behind the collet.

Oxygen/Acetylene

The oxygen/acetylene torch uses a stream of pure oxygen to literally burn a slot in material being cut. The torch preheats the metal to its ‘ignition’ or kindling temperature and then a high-pressure jet of pure oxygen is delivered to the center of the preheated area.

The ignition or kindling temperature of steel is in excess of 1500° F. The jet of oxygen burns the metal and produces molten metal and slag. The molten metal it used to preheat the next section to be cut while the slag, the ember like spray of metal, is forced out of the cut.

Torches are effective in cutting a wide range of thicknesses. Thin material, thinner than ¼”, are hard to cut with a torch due to the materials tendency to melt the edges together instead of cutting a clean kerf. The torch can be used to cut mild and low alloy steels, but they can not cut aluminum and stainless steel. A general rule is that if the metal can rust, it can be cut with a torch.

Gas Source

While most people believe that torches use oxygen as their gas source, the other gas is actually the fuel. Most torches use acetylene for its high flame temperature and good flame quality but it is also the most dangerous fuel gas to use. On its own acetylene will explode at pressures over 15 psi.! The inside of an acetylene cylinder is actually a honeycomb material that holds a mixture of liquid acetone and acetylene. The liquid acetone is used to stabilize the acetylene. **ACETYLENE CYLINDERS MUST NEVER BE USED IMMEDIATELY AFTER OR WHILE THE CYLINDER IS LYING ON ITS SIDE**. This situation will cause liquid acetylene to be discharged. The cylinder should be placed upright and allowed to sit for at least 30-minutes prior to use.

Other gases used in torch operations are propane, methylacetylene-propadiene (MPS), natural gas, and propylene. A variation of MPS is MAPP. MAPP is actually a mixture of MPS that is sold by Airco Inc.

Oxygen/Acetylene Torch Handles

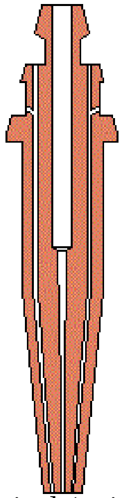
The business end of the torch consists of two valves that regulate the preheated oxygen and the fuel gas, while a third valve and a quick acting poppet valve attached to a lever handle controls the “pure” cutting oxygen. The third valve may be omitted on some torch heads, as it is not necessary to regulate the flow of the cutting oxygen.

At the base of the torch handle, at the fuel and oxygen inlet ports, one-way check valves are used to prevent the back flowing of gas into the supply hose. If these valves are missing an explosive hazard can be created by the back flow of gas.

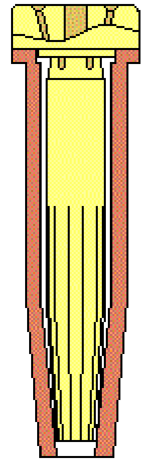
Torch Tips

The size of the torch tip will dictate the type and size of material to be cut. The tip must be compatible to the type of fuel gas being used and the style of torch seat. Some torch heads accept one or two piece tips as well as conical or flat seat tips. Using the wrong tip will create the dangerous situation.

The tip consists of an external ring of small holes that feeds the preheated oxygen and fuel gas. A larger hole in the center of the tip feeds the cutting oxygen. Acetylene torches must use a one-piece tip as the fuel gas is too aggressive for two-piece tips.



Typical 1-piece
tip with 3 seats



2-piece tip
with 2 seat flat

Torch tips are most often made from copper because of its excellent ability to conduct heat. If the tip gets too hot, the gas mixture inside can backfire. If a backfire occurs, shut the gasses off immediately and let the torch cool down. Backfiring can also occur if the flow the burning fuel mixture is blocked, such as by touching the tip down on a piece of metal or from slag blocking the ports.

The cutting torch can also be used as a welding torch, depending on the type of tip used. Welding tips have only one orifice while the cutting tips will have many. Tips are numbered like electrical cords. The larger the tip number the smaller the orifice. For example a number 5 tip has a smaller orifice than a number 3 tip.

Torch tips require continuous maintenance to prevent backfires or poor flame production. All slag must be removed from the tip. These little pieces of slag can clog some of the holes in the tip and cause additional turbulence. The fine holes in the torch tip should be cleaned with the specially designed cleaners found in tip cleaning kits. These tips are actually fine pieces of ribbed wires that clean the inside of the tip holes. Tips with any signs of damage should be removed from service and inspected and or replaced.

Torch Operations

- To prevent the accidental connection of the wrong gas to the regulator the threads on the acetylene cylinder are left-hand while the threads on an oxygen cylinder are right-hand threads.
- Always use an adjustable wrench or a torch wrench to secure fittings. **NEVER USE PLIERS**
- Before attaching regulators to the cylinder, open the tank valve slightly and release a small amount of gas. This is called "cracking." This will remove any dirt or oil/grease

that has fallen into the valve opening. Cracking should not be performed if the released gas could find a possible source of ignition.

- Open the cylinder valve partly to pressurize the regulator and then open the valve fully.
- Always start with regulator crossbars screwed all the way out, thus lowering the regulated pressure to zero.
- The normal operating pressures for torch operations are
  - Acetylene 10 psi and Oxygen 10 to 150 psi

Plasma Arc

The cutting action of a plasma arc torch is the powerful constricted electric arc in combination with a high velocity gas. The electric arc actually blasts the metal into fine particles. As opposed to the torch, a plasma arc cutter can work on very thin metals, but is limited to roughly 6" in thickness. Portable plasma arc cutters require 110-volt or 220-volt power and a large volume high-pressure air supply. Nitrogen is often used in industrial applications in place of the high-pressure air. Most plasma arc cutters carried on fire department apparatus have a cutting capacity of between ½" and ¾".

Electric Source

While the type of gas source is limited, the source of electrical power varies greatly. Some cutting torches use 110/220 volt AC current while others us a 12-volt battery connected to a striker, while still others use a 9-volt battery and a wad of steel wool. The old reliable source of "electricity" or spark is the flint lighter used with the oxygen/acetylene torch.

The application of the striker or ignition source to the torches tip is a very dangerous procedure. If after several attempts to light the torch fail, the operator should stop the flow of oxygen/gas and wait several minutes until the gas buildup has dissipated. Torches should not be lighted with matches, cigarette lighters or other sources of open flame.

Torch Safety

The use of torches falls under the OSHA definition of "Hot Work." In Title 29 of the Code of Federal Regulations, standard 1917.152 defines "Hot Work" as the "(act) of riveting, welding, flame cutting, or other fire or spark-producing operation". The standard also requires that "all necessary precautions be taken to confine the heat, sparks, and slag so that they cannot contact flammable or combustible material. (1917.152(c)(2)"

The standard goes further and outlines the fact that "fire extinguishing equipment must be immediately available (1917.152(c)(3)" During fire service use of cutting torches we must ensure that a charged hoseline is in place prior to starting operations. If the location and circumstances do not permit the hoseline, a dry chemical fire extinguisher may be used in its place.

- Always keep oil and grease away from torch fittings, hoses or valves.
- Do not operate cylinder valves with oily hands or gloves.
- Oxygen under pressure will explode when combine with oil or grease.

Torch PPE

Any person operating a torch or near a torch must have on the following protective items:

- Glasses with side shields or face shield.
  - The type/level of protection will vary depending on the type of torch being used. A # 3 shade is appropriate for oxygen/acetylene work but a # 5 shade is needed for work with the Arc Air.

- Flame resistant clothing.
  - The standard station uniform does not provide enough protection for using a torch. At the very least the torch operator should wear a flame resistant shirt/coat with full length sleeves.
  - PBI turnout gear is adequate protection while Nomex IS NOT.
  - Work boots and “cuffless” pants should also be worn.

- Respirator
  - The respirator should be rated to protect against welding, torch cutting, soldering, and brazing.
  - This can range from dust (particulate) mask to half-face piece, to full-face piece.

Additional Readings

STP – P.P.V. Discussion Guide – 1991
OSHA Interpretation and Compliance Letter 11/15/1999 to Jeff Haenisch of Avoca Village Sales
OSHA Interpretation and Compliance Letter 06/22/1998 to Gabriel Gillotti of the Office of Voluntary Programs and Outreach.
29 CFR 1926.300 – General Requirements – Tools Hand and Power
29 CFR 1910.243 – Guarding of Portable Powered Tools
29 CFR 1910.211 – Definitions – Machinery and Machine Guarding
29 CFR 1910.212 – General Requirements - Machinery and Machine Guarding
29 CFR 1910.213 – Woodworking Machinery Requirements - Machinery and Machine Guarding
29 CFR 1910.215 – Abrasive Wheel Machinery - Machinery and Machine Guarding