MODULE 1d. TOOL LAB

Unit One Tool Assessment
Unit Two Tool Maintenance
Unit Three Electricity and Tool Use

Lecture time: 1 Hour
Practical time: 3 Hours

Materials: Power point system
Screen

Terminal Objectives:

At the conclusion of this section, the
Student shall demonstrate proficiency in the inspection of, operation of, maintenance of and the safe use of all power tools.

Enabling Objectives:

- Understand the operator's influence on tool performance
- Understand Electrical power sources, the electrical loads, and tool safety
- Understand the tool assessment criteria
- Be able to perform a pre use inspection of all gas and electric power tools
- Be able to demonstrate the proper procedure in mounting and/or changing the cutting/breaking device to the tool
- Be able to demonstrate the procedure for the field maintenance of all power tools
- Be able to demonstrate the proper operation of all power tools

UNIT: 1 — TOOLS ASSESSMENT

MODULE 1d. TOOL LAB

The Urban Search and Rescue Response system is a young and evolving program. Part of the evolutionary process is a constant evaluation of tools and equipment. As Rescue Specialists, who better to evaluate the tools and equipment in the cache.

When assessing the tools' effectiveness, it is important to draw your opinions when the tools are being operated in a manner for which it was designed. Often times in a rush to complete a rescue, we tend to operate our equipment outside the parameters for which they were designed. This would not produce an accurate assessment of the tools' true effectiveness.

Operators Influence on Tool Performance

- No other factor will influence the tools' performance more than the level of training and experience of the operator.
  - Cutting large sections of concrete, with new equipment and equipment that we just don't use every day is a relatively recent addition to the fire service.
  - As a result, operators are inexperienced and tools are not being properly operated. The result is poor performance and increased maintenance.
  - Proper assessments must take this into account and resist the tendency to black ball a piece of equipment due to operator inexperience.

Assessment Criteria

The following is a list of equipment evaluation criteria that will assist in the assessment process.

- Does the tool perform in field situations as well as in training.

- Weight
  - Does the weight of the equipment restrict its transportability when compared to like equipment? Is the equipment too heavy to operate in confining spaces or on a footing?

MODULE 1d. TOOL LAB

UNIT: ONE — TOOLS ASSESSMENT

Assessment Criteria (continued)

- Power source
  - The power sources can be anything from battery powered equipment to propane, gasoline, etc.
  - Batteries should be assessed on duration, rechargability and availability.
  - Fuel should be assessed on type, capacity, and transportability. Does the fuel type restrict locations where the tool can operate and is that a hindrance?

- On scene maintenance
  - Can the equipment be serviced and maintained on the rescue site?
  - How often does maintenance need to be performed?
  - Is special equipment required to perform the maintenance?

- Operating conditions - Can be any other condition which may affect tool performance or how the tool impacts on the operator:
  - Environmental
  - Hazards
  - Confined space
  - CO
  - Noise
  - Fire
  - Atmosphere
  - User interface
  - Ease of operation
  - Day/night
  - Number of personnel required to operate
  - Technical skill required to operate
  - Specialized training
  - Certification

- The only way to improve the task force cache is with feed back from the users. Make notes on tool and operator performance during incidents and training activities. After the incident is over, put these notes in memo form to be given to your Task Force Leader.

MODULE 1d. TOOL LAB

UNIT: TWO — TOOLS MAINTENANCE

INTRODUCTION

- The key to any successful US&R operations is a through knowledge of the tools in the task force's cache. The Rescue Specialist must not only be able to select the appropriate tool to accomplish the task quickly and safely, but to trouble shoot minor tool problems and make the necessary on site repairs.
- Unfortunately, the US&R task force is not overly abundant with tools, small tool mechanics, or personnel to shuttle tools back and forth from the work site to the Base of Ops. This requires the Rescue Specialist to pick up the slack and make the minor tool repairs.

2-CYCLE ENGINES

- The predominant engine used for most gasoline powered rescue tools is the 2-cycle engine. The 2-cycle engine has many advantages over the conventional 4-cycle engine for rescue work but requires distinct starting and maintenance considerations.

- By understanding the operating characteristics of a 2-cycle engine, the Rescue Specialist can better prepare for and trouble shoot maintenance issues.
    - The 2-cycle engines have no oil sump. The gasoline oil mixture provides the fuel and lubricating oil. This allows the 2-cycle engine to be operated at almost any angle without loss of lubrication. It is therefore important to mix and maintain the proper fuel/oil mixture. A 2-cycle engine run on a fuel/oil mixture too rich in oil may end up fouling the spark plug and smoke excessively when operated. But an engine run on too lean an oil mixture can permanently damage the engine.
    - Two cycle engines operate at an higher RPM than 4-cycle engines. The higher Rpm’s generate higher operating temperatures. After periods of running under load and at high RPM, the engine should be allow to cool before shutting off. Allow the engine to run for 10 to 15 seconds at idle. This slows cooling reducing the chance of mechanical damage.

MODULE 1d. TOOL LAB

UNIT: TWO — TOOLS MAINTENANCE

2-CYCLE ENGINES (continued)

- With every down stroke of the piston, the fuel/oil mixture is drawn into the cylinder. This makes the 2-cycle engine more susceptible to flooding than the 4-cycle engine. To start a 2-cycle engine and reduce the possibility of flooding, the following guidelines should be used when starting a cold engine.
  - Turn the on/off switch to the on position and close the choke. Pull the starter cord briskly until the engine starts. If the engine fires but will not start, open the choke and attempt to start again.

- If after repeated attempts to start have failed, the engine is probably flooded. Remove the spark plug and dry. Replace and repeat the above procedure. If the engine still fails to start check the maintenance items listed below.

- The maintenance and trouble shooting of all 2-cycle engines no matter what the application is are very similar. The three areas the Collapse Technician may be required to perform maintenance are replacing air filters, spark plugs and fuel systems.
  - clogged airs filter can result in loss of power and prevent starting. Air filters should be checked after every tank full of fuel or more often in dusty conditions. Before removing any air filter, always close the choke. This will reduce the possibility of dirt getting into the engine and causing damage.
  - Spark plugs can become fouled from a too rich an oil mixture or when the engine idles to long. If an engine fails to start or during operation quits, check to see if the spark plug has fouled.
  - The fuel tank on 2-cycle engines is most often vented with a one-way valve to let air in and prevent fuel from leaking when operated at different angles. If after starting, the engine runs only to stall 10 or 15 seconds later, the one-way valve may have become clogged. Open the fuel tank cap slowly and listen for a rush of air to enter. This is a tell-tale sign of no fuel tank venting.

MODULE 1d. TOOL LAB

UNIT: TWO — TOOLS MAINTENANCE

GASOLINE POWERED CHAIN SAWS

- The chain saw is one of the most frequently used tools in the task force's cache and maybe one of the most dangerous to operate. The large exposed cutting surface requires the operators to be skilled at using a chain saw, for their safety as well as the victim's safety. It is therefore important to know not only about the maintenance aspects of the saw but the possible reactive forces involved in cutting.

- Before every use, the chain saw should be inspected for fuel, chain oil, chain tightness and operation of the chain brake. Most chain saws will allow for the fuel tank to run dry before the chain oil reservoir is emptied. For this reason don't be fooled into thinking that because chain oil remains in the reservoir after a tank of fuel the chain oil does not need to be added. Always refill your chain oil reservoir after each tank of fuel.

- Before beginning work check to make sure the chain is receiving oil. Point the tip of the chain saw towards the ground and run the engine at half to three quarters throttle. You should begin to observe a darkening of the ground underneath the tip of the guide bar. This indicates the chain is receiving lubrication and cutting can begin. The absence of chain lubrication can destroy the guide bar and chain.

- If no oil appears on the ground check the chain oil reservoir to make sure the reservoir has not run dry. If that is not the problem, next check the oily in the crankcase and the oil inlet hole in the guide bar for blockage.

- The chain brake should be checked by running the saw at an idle. Engage the chain brake by pushing the hand guard forward then squeeze the trigger for no longer than a few seconds. The chain should not rotate.

MODULE 1d. TOOL LAB

UNIT: TWO — TOOLS MAINTENANCE

GASOLINE POWERED CHAIN SAWS (continued)

- There are three main reactive forces the operator may encounter during cutting. They are push-back, pull-in and a kickback.
  - A push-back occurs when the chain on top of the guide bar gets pinched which suddenly stops the chain movement. The saw will tend to push-back towards the operator.
  - The opposite of this is a pull-in in which the chain on the bottom of the guide bar get pinched and the saw is pulled into the work.
  - Lastly, the kickback occurs when the upper tip of the bar comes in contact with a solid object. Kickback can happen in an instant with explosive force.

- When cutting wood that may be under stress, a relief cut should first cut be made in the area of the wood which is under compression. The deepness of the cut depends on the thickness of the material to be cut. For example, a 2x4 may just have to be nicked and a large log may require a cut of several inches. In either case, you do not want the wood to begin to flex from this cut. Your next cut will then be on the tension side of the material completing the cut.

- Working in areas of blown down trees or in collapsed structures is very dangerous. Always work in pairs, plan your cuts and keep the nose of the guide bar away from solid objects.

- There is three main maintenance or repair items the rescuer may be required to complete on site. They are:
  - inspecting and changing of the air filter
  - inspecting and replacing the chain and or guide bar
  - tensioning the chain

MODULE 1d. TOOL LAB

UNIT: TWO — TOOLS MAINTENANCE

GASOLINE POWERED CHAIN SAWS (continued)

- A clogged air filter can reduce engine performance and increase fuel consumption. Most chain saws have two sets of filters. A prefilter to remove the larger dirt and wood chips and a fine filter.
  - The prefilter should be cleaned after ever tank full of fuel. This is accomplished by either brushing away the dirt with a small brush or by blowing the filter clean with a stream of air.
  - The fine filter can either be a mesh material or a paper filter similar to that found in automobiles. The mesh type filter may be reused after cleaning so long as there are no holes in the filter material. The paper type filters should be discarded when dirty. Mesh filters should be cleaned at least once a day and more often in dusty areas. For this reason, spare filters should accompany the saw to any cutting site.

- Although the methods for replacing air filters vary according to the brand of saw, all recommend that before the fine filter is removed, brush away any dirt near the carburetor and close the choke to prevent dirt from entering the engine.

MODULE 1d. TOOL LAB

UNIT: TWO - TOOLS MAINTENANCE

GASOLINE POWERED CHAIN SAWS (continued)

- Chain saw chains should be replaced or sharpened when the operator must force the saw to cut or the wood begins to smoke when cutting. A dull chain increases fatigue on the operator and increases the risk of kickback. Since sharpening the chain is time consuming and can involve complex angles, the Rescue Specialist should plan to replace the chain on site.
  - To do this remove the side cover covering the chain sprocket. Relieve the tension on the chain. Once the chain tension is released, remove the chain from the tip of the guide bar. The chain and guide bar can then be removed.
  - Once the guide bar is removed, examine the ridges on which the chain rides for uneven wear. If one side of the ridge is higher than the other, a file must be used to level the ridges. During the course of normal operation, the nose and underside of the guide bar will wear faster than the top. For this reason, every time the saw chain is sharpened or replaced, turn the guide bar over.
  - Reverse the removal procedure when reinstalling the guide bar and chain but only finger tighten nuts holding the sprocket cover in place.

- Now that the chain has been replaced, pull the guide bar nose up and out at the same time as turning the tensioning nut. The chain is properly tensioned when the chain is resting on the underside of the guide bar and can be easily pulled along the bar. Run the saw for two or three minutes then readjust the chain tension as necessary.
  - Chains that are overly tight will increase guide bar ware and engine strain. Chains that are too loose, run the risk of being thrown off the guide bar and injuring the operator.

MODULE 1d. TOOL LAB

UNIT: TWO — TOOLS MAINTENANCE

CUTOFF SAW

- The rotary blade power saw goes by many names, cutoff saw, K-12, or Cutquik, but what ever you call it, these saws all have circular blades driven by a V-belt attached to a 2-cycle engine. These saws can be used to cut wood, concrete or steel depending on the type cutting wheel attached to the saw.

- Before using, check the cutting wheel for any nicks, cracks or missing segments that could cause the blade to be out of balance and shatter during use. Check the V-belt tension.

- Always place the wheel guard in a position to protect the operator.

- Operators should always stand to the left of the cut to protect themselves in the event of cutting wheel failure or being hit by thrown material.

- During wet concrete cutting, the slurry created can cause slick footing. Make sure you have a stable base and work in pairs.

- The following are general guidelines the Collapse Technician can used when replacing the cutting wheel. Refer to your owner's manual for specific details.
  - To replace the cutting wheel switch the engine off and prevent the cutting wheel from turning by placing the locking pin through the spoke in the V-belt pulley.
  - Remove the nut holding the thrust washer in place and remove the thrust washer. The cutting wheel can now be removed.
  - Reverse the sequence when installing the new cutting wheel. Always make sure blade rotation corresponds to the rotation arrow on the cutting wheel.

MODULE 1d. TOOL LAB

UNIT TWO – TOOLS MAINTENANCE

CUTOFF SAW (continued)

- The items that the rescuer may be required to repair or maintain in the field would be cleaning and replacing of the air filter, and replacing and tensioning of the V-belt.
  - Filters for rotary blade power saws are similar to that of chain saws. There is a pre-filter that is usually a reusable foam filter and a fine filter of mesh or paper. The pre-filter should be cleaned after every tank full of fuel. This element can be cleaned by with a soft brush or by blowing the filter clean with air. The filter should be cleaned daily or more often in dirty and dusty conditions such as in cutting concrete. Non-reusable paper filters should be discarded when dirty.

- Remember to close the choke and wipe away any dirt near the filter housing before removing any filter.

- The V-belt or drive belt should be inspected before every use. Look for fraying or any damage to the belt that could cause it to break.

- Most V-belts are replaced in a similar manner. Unscrew the screws hold the arbor bearing and wheel guard in place. Next remove the screws holding the drive arm in place. Place the new V-belt on the drive pulley and reassemble.

- To tension the V-belt, loosen the screws holding the arbor bearing/guard in place. Either tighten the eccentric adjuster or turn the tensioning screw (depending on the manufacturer) until the V-belt can be depressed slightly. Over- tightening of the V-belt may cause premature arbor bearing failure.

MODULE 1d. TOOL LAB

CUTTING WHEELS

- The term cutting wheel is a generic term for any number of cutting blades whether they are diamond blades, abrasive blades or carbide tip blades. These blades can be grouped according to the material they are designed to cut. Concrete or masonry blades can be either diamond or abrasive cutting blades. The concrete abrasive blades are composed of an silicon oxide matrix. Metal cutting blades are almost exclusively the abrasive types composed of an aluminum oxide. Lastly, wood cutting blades are steel and may or may not be carbide tipped.

- Abrasive cutting blades no matter what the material they are designed to cut are subject to the same type of wear and use considerations.

- Abrasive blades are particularly susceptible to chipping and cracking.
  - For this reason, blades should not be transported attached to the saw.

- Before using an abrasive blade, inspect the blade for chips cracks and uneven ware. If any are found, replace and discard the damaged blade.
  - Uneven blade wear is characterized by a thinning of the blade towards the outer edge.

- If water is to be used during cutting, make sure the blade is compatible for use with water.
  - Not all blades are designed for wet cutting and the application of water could result in blade failure.

- Wet cutting has several advantages over dry cutting.
  - Water helps keep the blade cool which will prolong the blade life.
  - Water will reduce the air borne by-products of cutting which can clog air filters and breathing respirators.

MODULE 1d. TOOL LAB

UNIT: TWO — TOOLS MAINTENANCE

CUTTING WHEELS (continued)

- When using water, make sure both sides of the blade receive near equal amounts. Unequal water coverage can result in greater wear on one side of the blade resulting in thinning and eventual blade failure.

- After completing your cut, shut the water off first allowing the abrasive blade to spin removing excess water.

- Abrasive blades should only be stressed radially and never torsionally by twisting or bending.
  - This could result in sudden blade failure seriously injuring the operator.

- The diamond-cutting wheel is composed of a steel wheel, called a core on which a diamond and steel cutting matrix, called a segment, is welded. Although diamond blades are not as susceptible to chipping and cracking as abrasive blades, other problems can arise with diamond blades which when recognized and corrected, will help to extend blade life and shorten cutting time.

- The first and most important step to prolong blade life is selection of the proper wheel.
  - Wheel segments (the diamond and steel matrix) vary in hardness according to the material they are designed to cut. Some blades are designed for cutting cured concrete while others may be designed to cut asphalt or lightweight concrete. The blades we should be primarily concern with are those design to cut cured concrete.

- After the proper blade is selected, the blade must be broken-in on the material being cut.
  - Allow the blade to begin cutting with only slight pressure. This exposes the cutting diamonds without generating excessive heat. Cutting can now begin using the back and forth motion. This cools the blade by exposing it to air.

MODULE 1d. TOOL LAB

UNIT: TWO — TOOLS MAINTENANCE UNIT:

CUTTING WHEELS continued

- During cutting operations, periodically examine the cutting wheel for the following problems.
  - Cracked or missing segments can occur due to stresses from twisting or jamming of the blade in the cut or by blade overheating. A telltale sign of segment loss due to overheating will be a discoloration of the core just underneath the missing segment. To prevent overheating, expose the blade to air more frequently, cool with water.
  - Check for glazing.

- Glazing appears as a shiny smooth surface on the segment. The first sign that glazing has occurred, is lack of cutting progress. Glazing can occur at anytime during the cutting process from contact with rebar, overheating or cutting a material to hard for the diamond segment. Once glazing has occurred, cutting progress will be slowed and overheating will result until the blade is reconditioned.
  - To recondition or dress a diamond blade, the operator must find a material softer than the material being cut. Operate the saw in the softer material as you would for the break-in period with light pressure.

- Just as abrasive blades can have uneven wear, diamond segments can also wear unevenly. The most common cause of uneven segment wear is lack of adequate water coverage to one side of the segment, which results in one side of the segment wearing faster than the other.

- The last blade we should be familiar with is the carbide tipped cutting blade. Designed to cut primarily wood, the main advantage of a carbide tipped blade is the long life of the cutting edge when compared to conventional blades. The blades work best at high RPM. Slower Rpm’s can result in carbide tip loss.

MODULE 1d. TOOL LAB

UNIT: TWO — TOOLS MAINTENANCE

PNEUMATIC AIR GUNS

- Pneumatic air guns require very little field maintenance. The main field maintenance of air guns is to maintain constant internal lubrication. Lubrication is supplied by oilers attached to the air inlet hose or by placing a few drops of oil directly into the air gun.
  - A misting of oil should be noticeable at the exhaust ports of the air gun during operation.

- Only operate the air gun when the bit is firmly against an object.
  - When operated without pressure against the bit, the piston can become jammed or the bit may become a projectile.

- Always treat the air gun as a loaded weapon.
  - Never point the air gun at other personnel.

MODULE 1d. TOOL LAB
UNIT: THREE — ELECTRICITY AND TOOL USE

ELECTRICITY

Definition

- "WEBSTER Collegiate dictionary" — A fundamental entity of nature consisting of negative and positive kinds composed respectively of electrons and protons or possibly of electrons and positrons observable in attraction and repulsion's of bodies electrified by friction and in natural phenomena utilized in the form of electric currents.

- Electrical current

  - Is essentially a mass movement of electrons through a conducting material such as wire. Until the essential nature of electricity was understood, however, no one was sure in which direction the electrons moved.

  - It was thought that electrical current flowed from the positive (+) side of the source to the negative (-) side.

  - Actually it flows from the negative (-) side to the positive (+) side, but it was too late to change all of the books that had been published on electricity. Old and new theories on the flow of electrons could not be reconciled because there was too much old-theory equipment in use and re-labeling the terminals would cause confusion.

  - Technical publications compromise by saying that Electrical current flows from the positive side to the negative side (+ -), and that Electrons flow from the negative side to the positive side(- +).

MODULE 1d. TOOL LAB

ELECTRICITY

- Generators do not create electrical energy, they convert mechanical energy to produce electricity.

- To produce electricity either the loop or the magnets must be rotated relative to one another. The energy for this rotation can be provided by a variety of sources.

- In some sources water is converted to steam, which is used to drive turbines that operate generators. The energy to boil the water and convert it to steam can be from;
  - Coal
  - Oil
  - Wind
  - Hydroelectric
  - Natural gas
  - Nuclear reactors.

- It is the energy not charge, that flows from the electrical outlet. The electric charges that move in a lamp are already in the lamp.

- A kilowatt is a unit of power, or energy consumed per time.

- Electrical power is the relationship between, potential difference in volts, and current in amperes is. Power = voltage x amperes.

MODULE 1d. TOOL LAB

UNIT: THREE — ELECTRICITY AND TOOL USE

ELECTRICITY

Electricity (continued)

- AC circuits obey OHM'S LAW, E=IR, when R consists of purely resistive elements.
- When reactive elements (see REACTANCE) are present in the circuit, Ohm's law becomes E=IZ, where Z is the IMPEDANCE.
- The formula for power—which, in DC circuits, is P=EI — becomes P=EI cos phi, and the term cos phi is known as the combination of capacitors, inductors, and resistors in the circuit.
- Doubling the current means four times the power loss. If the voltage is too low, there may be insufficient electrical energy to power tools or appliances.

ELECTRICAL CURRENT

Direct Current (DC)

- The most common source is battery power. A battery:
  - The voltage per cell in is usually low, between 1 and 2 volts.
  - Connecting cells in series produces higher voltages.
- A simple example of "Direct Current" is the flow in a circuit using a battery as the power source. The direction of current flow is always the same.
- DC is sometimes used for very long-distance power transmission .
- More than 500 miles or power transmission and very high voltages greater than 500,000 volts.

MODULE 1d. TOOL LAB

UNIT: — ELECTRICITY AND TOOL USE

ELECTRICAL CURRENT

Direct Current (DC) (continued)

- Thyristors, or silicon-controlled rectifiers convert high-voltage 3-phase to DC, which is then transmitted along power lines. At the other end thyristors in an inverter circuit convert the DC back to 3-phase AC.

Alternating Current (AC)

- Voltage is generated when a wire passes through a magnetic field.
  - When the magnet (rotor) rotates 180^{o}, the direction of the magnetic flux is reversed and the current flows in the opposite direction.
  - Each 180^{o} rotation of the magnet, the magnetic flux passing through the stator coil collapses and is then reestablished in the opposite direction and current flow in the circuit is changed accordingly. This is termed "Alternating Current" or "AC".

United States Electricity

- Utilizes "Alternating Current" (AC).
  - Frequency of 60 cycles (Hertz) per minute

- Modern plant can generate from 500 to 4,000 megawatts or millions of watts.
  - There are about 3,500 individual power systems in the United States. They are comprised of investor-owned public utilities, cooperatives, government-owned systems and manufacturing industries.
  - Electric companies bill their customers not for electrons but for electrical energy.
  - The charges on the electric bill are based on kilowatt-hours.

MODULE 1d. TOOL LAB

UNIT: THREE — ELECTRICITY AND TOOL USE

ELECTRICAL CURRENT

United States Electricity (continued)

- Transmission Lines
  - High voltage, 50 to 1,000 KV (KV means kilovolt or 1,000 volts) is carried from generator source to substations or receiving (switching) stations.
  - High voltage can kill or injure at a considerable distance from ground fault location.
  - High voltage, 2,300 to 20 KV is delivered power from substations to areas of use.
  - Downed power lines may become re-energized due to automatic re-closer or remote controls.
  - Re-energizes at least twice before locking out.
  - A high fire hazard can exist if combustibles are in the area of a fault or downed line.

- Low voltage, 110 to 500 volts is delivered power from distribution transformer to the user. This includes lines from pole to pole as well as service lines to buildings.
  - This voltage range is the highest cause of electric contact injuries and electrocutions because of complacency and easy access.
  - Voltages of 2 to 80 volts normally have little electric contact injury potential.
  - However all wires may come in contact with higher voltage systems and should be treated with caution.

Motors vs Generators

- A DC generator is a motor working in reverse:
  - A motor changes electrical energy into mechanical energy.
  - A generator produces electrical energy from mechanical energy.
  - In a motor, electric current is fed into the loop that can rotate in a magnetic field, resulting in rotation of the loop.
  - In a generator, the loop is rotated, resulting in the production of electric current in the loop.

MODULE 1d. TOOL LAB

UNIT: THREE — ELECTRICITY AND TOOL USE

ELECTRICAL CURRENT

Motors vs Generators (continued)

- For 180^{o} degrees of the rotation, electron deflection produces and electric current in the loop that moves in one direction.
  - In the next 180^{O} the electron deflection is reversed.
  - As the current leaves the loop to an external circuit, the current will be observed to move in one direction and then the other. This is called alternating current (AC).
  - For a generator to generate direct current it is necessary to use a split-ring commutator at the point where the generator feeds current to the external circuit. The current in the loop is still alternating, but it is direct in the external circuit.

- Electric motors consist of:
  - Two mechanical parts;
    - A stator, or stationary part.
    - A rotor, or revolving part
  - Two sets of electrical windings;
    - The field
    - The armature.

- Electromagnetic fields set up across the air gap between the stator and rotor interact with each other and produce the torque, or turning force, that rotates the motor.
  - The power output is dependent on the torque and rotational speed.
  - A motor is classified as DC or AC depending on its power source.

MODULE 1d. TOOL LAB

UNIT: THREE — ELECTRICITY AND TOOL USE

ELECTRICAL CURRENT

Generators (portable)

- A generator can have two separate main power producing circuits.
  - When two or more receptacles are used, prevent overloading by dividing the loads between the two lower circuits, or "BALANCE THE LOAD"
  - Do not exceed the rated capacity of any one receptacle. For all receptacles used, do not exceed the rated load capacity of the generator.

ELECTRICAL SAFETY

Contact Injuries

- Mild shocks can injure through, falls, etc.
- Electric shocks can kill.
  - Over 1,000 Americans die each year.
  - Electric contact injures can occur by a person becoming a part of the circuit;
- Ground fault; a short between energized conductors and ground or a conductor of ground potential.
- Multi conductor contact

MODULE 1d. TOOL LAB

UNIT: THREE — ELECTRICITY AND TOOL USE

ELECTRICAL SAFETY

Injury Factors

- Voltage is not the main factor, amperage through the body tissue determines the extent of injury.
  - Resistance of body ie...wet skin.
  - Resistance of ground contact - floors, shoes, etc.
  - Path of current flow through body .
  - Let-go current varies. approx. .010 amps (10 milliamps)
  - As little as .1 amp (100 milliamps) current flow through the body can be fatal.
  - Higher amperages can cause severe burns and muscle damage.
  - Victims may die from shock several days after contact.

Tools

- Tool failure can result if inadequate power is supplied to the tool.

- Examples of tool failure;
  - Damaged brushes
  - Armatures
  - Damaged switches
  - Windings.

- If sufficient electrical power is not delivered to the tool excess current flow and overheated wires could cause tool failure.

- Proper tool wiring insures a safe tool and safe operator. If the tool has a bad ground or broken wire in the cord the operator is susceptible to electric shock and injury.
  - Inspect all tools prior to use.

MODULE 1d. TOOL LAB

UNIT: THREE — ELECTRICITY AND TOOL USE

ELECTRICAL SAFETY

Prevention

- Double insulated devices.
- Ground fault circuit interrupters. Best protection
- Circuit breakers and fuses WILL NOT GIVE PROTECTION
- Three wire grounded systems provides a low resistance path to ground for fault current.
- Test tools for shorts.
- Protective devices,
  - Gloves
  - Overshoes,
- Safe work practices include;
  - Open switches
  - Lockout and tag
  - Ground circuits before considering them dead.

MODULE 1d. TOOL LAB

UNIT: THREE — ELECTRICITY AND TOOL USE

DEFINITIONS

- AMPERE (I)
  - A measure of the current or volume of electricity.
  - Determined by dividing the voltage by the resistance.
  - Similar to the volume (gallons) of water in a charged hose line.
  - Amps (I) = E/R.

- AUTOMATIC RECLOSING RELAY
  - Also known as the re-closer. A relay system that will cause a circuit breaker to close one or more times during a fault condition.

- CAPACITOR (bank)
  - A device used by the utility company for power factor correction.

- CIRCUIT BREAKER
  - A overcurrent protection device relying on mechanical means to interrupt the current flow by the heating of a bi-metal strip or the use of magnetic force.

- CLEARANCE
  - A term indicating that an electrical circuit is de-energized and safe to work on. Includes isolating, testing, installing "short and grounds" and a written record.
  - Clearance must be released before line can be re-energized.

- CODE
  - National Electric Code, NFPA, 1978 edition.

- CURRENT
  - The volume of electricity flowing, measured in amperes.

- DEAD
  - Refers to a condition of an electrical circuit or line which is de-energized, tested and has "short and grounds installed".

MODULE 1d. TOOL LAB

UNIT: THREE — ELECTRICITY AND TOOL USE

DEFINITIONS (continued)

- DISCONNECT (noun)
  - A switch used to connect or isolate portions of a circuit. May be individually operated or connected together in a "gang-style".
  - Utility disconnects can be found on pole tops, in underground enclosures, entrances, power and lighting switches or controllers.

- DISTRIBUTION
  - The electrical system used to distribute the power in a local area.
  - The portion of the utilities system between the substations and the distribution transformers.

- DISTRIBUTION TRANSFORMER
  - Normally a potential transformer used to lower the primary voltage to a level usable by the customer.
  - The secondary voltage is normally below 500 volts.

- ELECTRIC CONTACT INJURY
  - An injury or shock caused by contact with an energized device or line.

- ELECTRODE
  - An electric conductor.

- E.M.F.
  - Electromotive force. (see volt)

- FAULT
  - An inadvertent contact between an energized (ungrounded) conductor and ground or another energized conductor of a different potential.

- FLASH BURN
  - Injury caused by the heat produced by electrical arcing and molten metal.

MODULE 1d. TOOL LAB

UNIT: THREE — ELECTRICITY AND TOOL USE

DEFINITIONS (continued)

- FUSE
  - A over current protection device which uses the melting of a metal to interrupt the flow of current.
  - Springs and arc quenching material to limit the electric arc.

- G.F.C.I. (or G.F.I.)
  - Ground fault circuit interrupter.
  - A current protection device that also gives protection against electric contact injuries by measuring the current flow in both legs of the circuit. If the return current in the neutral is not equal to the supply (indicating a fault in the circuit), the current flow is interrupted. See "Ground Fault". Designed to disconnect prior to injury.

- GROUND
  - Earth ground or any conductor having no difference of potential to earth ground.
  - The act of connecting a conductor or device to ground.

- GROUND FAULT
  - A fault or short circuit between an energized conductor and ground or a conductor of ground potential.

- GROUNDING CONDUCTOR
  - A conductor used in inside wiring to ground the equipment.
  - The green conductor.

- ISOLATE (ED)
  - The act of disconnecting a circuit or part of a circuit from possible sources of electrical current.

- IMPEDANCE
  - The apparent resistance in alternating current (AC) circuits that corresponds to true (ohmic) resistance in direct current (DC) circuits. Symbolized by the letter "Z", impedance is measured in ohms and is related to the voltage E and the current I by the relation "Z=E/I"

MODULE 1d. TOOL LAB

MODULE 1d. TOOL LAB

UNIT: THREE — ELECTRICITY AND TOOL USE

DEFINITIONS (continued)

- KILO
  - A prefix referring to 1000, such as kilowatts or kilovolts.

- KV
  - Short for kilovolts, see kilo. Written "KV".

- LOCK (ED) OUT
  - The condition of a circuit that is protected by automatic reclosing relays, has cycled through the reclosing settings, and has been unable to reset itself.
  - A fault that caused the first relay still exists.

- MEGA
  - A prefix referring to one million, such as megawatts or mega volts.
  - 20 megawatts would equal 20,000,000 watts.

- METER LOOP
  - The service entrance equipment including the meter can or box, the conduct riser to the roof or underground and attached equipment.
  - Also known as the service entrance, service entrance section (SES) or meter loop.

- NEUTRAL
  - A conductor, usually grounded, and used to return the power to the source in a dual voltage system.
  - A conductor used in inside wiring which is grounded at the source of feed.
  - Normally is a white conductor.

- OHMS (R)
  - The resistance of a circuit, the opposition to current flow.
  - Determined by dividing the voltage by the current.
  - Similar to friction loss in a flowing hose line.
  - Ohms (R) = E/I

MODULE 1d. TOOL LAB

UNIT: THREE — ELECTRICITY AND TOOL USE

DEFINITIONS (continued)

- PHASE
  - The relative time of change in values of current or E.M.F.
  - Refers to AC conductors with a potential between them and to ground.
  - A term used by field personnel of a utility to indicate a conductor. They may say that there is a "phase down" rather than a "primary conductor down.

- POLE RISER
  - A portion of a underground system where the underground conductors are brought up a pole and connected to the overhead system.

- POT
  - A potential transformer.

- POTENTIAL
  - Measured E.M.F. (voltage).

- POTENTIAL TRANSFORMER
  - A transformer connected between two conductors.

- RECEIVING STATION
  - A facility which converts very high transmission voltages to sub-transmission voltages. (500 KV to 66 KV)
  - Contains switch gear, circuit breakers, controls, and power transformers.

- SECONDARY
  - The voltage supplied to the customer.
  - The conductors downstream of the distribution transformer.
  - Normally less than 500 volts.

- SERVICE
  - The conductors delivering the power to the customer.
  - May be overhead or underground.

MODULE 1d. TOOL LAB

UNIT: THREE — ELECTRICITY AND TOOL USE

DEFINITIONS (continued)

- SHORT (Short Circuit)
  - A very low resistance connection between two conductors of different potential. Causes large current flow.

- STEP DOWN TRANSFORMER
  - A transformer connected to a circuit in such a manner as to decrease the voltage.

- STEP-UP TRANSFORMER
  - A transformer connected to a circuit that increases the voltage.

- SUBSTATION
  - The facility used to receive transmission voltage and reduce it to distribution voltage.
  - Includes the switch gear and circuit breakers and power transformer(s).
  - In some large industrial areas may be used to supply the customer direct without a distribution system.

- THREE PHASE
  - Term applied to circuits carrying three voltages, 120^{O} apart in phase.

- TRANSFORMER
  - A device used to raise or lower the voltage and amperage.

- TRANSMISSION
  - The portion of the electric system which carries the power from the generating stations to the areas of use.
  - Includes receiving stations, sub-transmission lines and ends at the distribution substations.

- UPSTREAM
  - Refers to the direction on a line or circuit toward the power source.

MODULE 1d. TOOL LAB

UNIT: THREE — ELECTRICITY AND TOOL USE

DEFINITIONS (continued)

- VOLT (E)
  - The electrical pressure or electromotive force (EMF) required to cause a current of 1 ampere to flow through a resistance of 1 ohm.
  - Determined by multiplying the current by the resistance.
  - Similar to the pressure in a charged hose line.
  - Volts (E) = IR

- WATTS (W)
  - The total power
  - Determined by multiplying the current by the voltage.
  - Similar to the gal/min fire flow through a hose line.
  - Watts (W) = EI
  - Since volts (E) = IR, Watts may also be expressed as: Watts (W) = I2R

- WEATHER HEAD
  - The cap on the top of the service entrance riser used to prevent rain from entering the conduct and meter loop.

MODULE 1d. TOOL LAB

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MODULE 1d. TOOL LAB

CUTTING TORCH SETUP

Description of Process

- Oxyfuel cutting is a process whereby a metal is heated to it's kindling temperature (temperature below the melting point) by an oxyfuel gas flame and then burned rapidly by a regulated jet of pure oxygen. Cutting torches, whether hand held or machine operated are used for this operation.

- The cutting process is a chemical reaction between iron and oxygen. When iron is heated to a temperature in excess of 1600 F(870 C) and then exposed to a stream of high purity oxygen, the iron oxidizes rapidly and produces a mixture of molten oxides and iron called slag. When cutting a narrow slot called the kerf is formed as a result of the loss of metal by the cutting oxygen jet.

- The oxyfuel cutting process is generally used on materials ranging from 1/32 in. to a thickness in excess of 100 in. The majority of oxyfuel cutting is done on materials ranging from ¼ in. to 2 in. in thickness.

Equipment and Supplies

- In order to perform oxyfuel flame cutting, the following equipment is required as a minimum:

  - Oxygen
  - Fuel gas(Acetylene, Propane, or MAPP gas)
  - Pressure regulators
  - Hoses and fittings
  - Torch
  - Cutting tips
  - Tip cleaners
  - Strikers
  - Protective clothing and safety equipment meeting ANSI-Z49.1

MODULE 1d. TOOL LAB

Oxygen

- Oxygen of high purity (99.5% Minimum) is required to perform the operation of oxyfuel flame cutting. This can be supplied in a variety of high-pressure cylinders and/or in bulk liquid tanks. CAUTION: Oxygen supports combustion! Improper use can result in fires or explosions. Never use oxygen in pneumatic tools, to clean equipment or parts, or to blow dust off clothing.

- Oxygen safety precautions

  - Do not permit smoking or open flames in area where oxygen is stored, handled or used.
  - Liquid oxygen at –297 F can cause freeze burns to the eyes and skin if it comes in contact with them.
  - Keep materials such as oil, grease, wood, kerosene, cloth, tar, and coal dust away from contact with oxygen.
  - Do not place liquid oxygen equipment on asphalt or surfaces with grease or oil deposits.
  - Remove all clothing, which has been saturated with oxygen gas. Such clothing is highly flammable, and should not be worn for at least 30 minutes.

Fuel Gas

- Many different fuel gases are available for oxyfuel cutting. They include acetylene, propane, methylacetylen-propadiene (MAPP), natural gas, propylene, hydrogen, and several propane or propylene base mixtures. Each of these fuel gases will produce different flame characteristics.

- Acetylene cylinders contain porous filler that is used to absorb acetone. The acetylene in these cylinders is then dissolved into the acetone. This is done to prevent acetylene from being drawn faster than the acetone will release it. The maximum safe rate for being withdrawn from the cylinder is $1/7^{th}$ of the cylinder's capacity per hour. If this rate is exceeded acetone will be drawn from the cylinder resulting a flame with a purple color.

MODULE 1d. TOOL LAB

- Acetylene Safety Precautions

  - Acetylene is not to be used at pressures above 15 psig in free form.
  - Concentrations of acetylene between 2.5 and 81% by volume in air are easily ignited, and may result in an explosion.
  - Keep cylinders away from overhead welding or cutting. Hot slag may fall on a cylinder and melt the fusible plug.
  - Fusible plugs on acetylene cylinders will melt at 212 F.
  - Acetylene forms readily explosive compounds with copper, silver, and mercury.
  - Acetylene must be kept away from these metals, their salts, compounds, and high concentration alloys.
  - Adequate ventilation is required. Acetylene gas produces a strong garlic odor. Acetylene may displace air in a poorly ventilated area, atmosphere which does not contain at least 18% oxygen may cause dizziness, unconsciousness, or even death.
  - Leave the handwheel, wrench, or key on the cylinder for emergency shutoff.
  - Always store acetylene cylinders in an upright position. If the cylinder had been laid down on its side, put in the upright position for at least 3 hours before using.

Pressure Regulators

- Regulators are pressure-controlling devices that reduce high pressures to a desired working pressure. A pressure adjusting screw adjusts these regulators. Regulators may be single or two stage.

- Regulator Safety Precautions
  - Keep contaminates such as oil, grease, dust, and dirt away from all inlet and outlet connections on regulators.
  - Never use oil on any threads or fittings on any regulator.
  - Before attaching an oxygen regulator to a valve, check to make sure that the regulator meets the pressure requirements of the supply.
  - All regulators should have the pressure adjusting screw backed out before opening the cylinder or station valve.
  - Never use acetylene above 15 psig.
  - Never stand in front of a regulator when the cylinder valve is being turned on.

MODULE 1d. TOOL LAB

Hoses and Fittings

- Oxygen hoses in the United States are always color coded green. The fittings have right handed threads and a smooth outside surface.

- The fuel gas hoses are always color coded red. The fittings have left hand threads and a notch on the outside.

- These fittings are designed to form a gas-tight seal with the application of very little mechanical pressure.

- The use of undersized or excessively long hoses can result I pressure drops that can result in a low flow rate. Insufficient flow rates can result in overheating of torches and backfires.

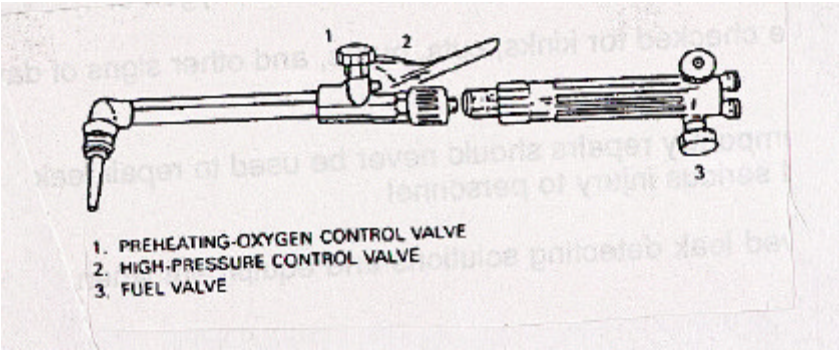
- Hose and fittings safety precautions

    - A fuel gas hose should never be used to transfer oxygen or vice versa.
    - Hoses should be checked for kinks, cuts, burns, and other signs of damage before use.
    - Tape or other temporary repairs should never be used to repair leaks, this could lead to fires and serious injury to personnel.
    - Use only approved leak detecting solutions and equipment when checking connections.

MODULE 1d. TOOL LAB

Torches

- There are basically three different types of cutting torches. However these torches come in many different styles and shapes.
  - Hand torch: A torch equipped with a one piece body with valves to control the flow of preheated oxygen and fuel gas, a spring loaded valve for the cutting oxygen, tubes carrying the gases to the head which accepts the cutting tip.
  - Combination Hand Torch: A welding torch equipped with valves to control the flow of oxygen and fuel gas which cutting, welding, or heating attachments may be attached.



  - Machine torches: A torch equipped with valves controlling oxygen, fuel gas, and cutting oxygen with tubes encased in a body with a head to accept the cutting tip.

- Torches are classified as being either a positive pressure or injector type(low pressure). In the positive pressure torch both the oxygen and the fuel gas are supplied at pressures high enough to sustain sufficient flow of both gases. In the injector type torch the fuel gas is supplied at a low pressure, relying on the high pressure of the oxygen to pull the fuel gas to obtain the correct flow of gasses.

MODULE 1d. TOOL LAB

- Torch safety precautions

  - A fire extinguisher should always be at hand when flame cutting for use if an emergency arises.
  - Always extinguish a torch whenever it is not in your hand.
  - If a torch backfires, shut it down, find the trouble, and remedy it before continuing to use the torch.
  - Be careful that a torch is not being directed at another person when lighting.
  - Be sure that the area where the cutting/welding is to be performed is clear of any hazardous or flammable materials.

Cutting Tips

- All oxygen-cutting tips have preheat flame ports(orifices) which are commonly arranged in a circle around the cutting oxygen port. The size of these ports will determine the thickness of the materials to be cut as well as the amount of gas supplied.

- Tips for use with acetylene are usually one piece in design and being flat on the flame end. Tips for use with MAPP and propane gas are usually two piece in design with milled spines.

- Of all the items needed to perform the oxyfuel cutting process, besides oxygen itself, the cutting tip has the greatest effect on the quality of the cut.

- During cutting procedures slag will form around the preheat and oxygen cutting ports. This will disrupt the preheat flame as well as the oxygen cuting jet, resulting in poor performance and quality cut. When this happens the tip should be removed and cleaned.

MODULE 1d. TOOL LAB

Tip Cleaners

- Cleaning is done by means of tools called tip cleaners. There are different types of tip cleaners available to clean the surfaces of oxyfuel cutting tips.

    - Tip drills, wire broaches(normally called tip cleaners), these are designed to clean the ports of the cutting tip.
    - Refacing tools are designed to keep the face of the tip flat, providing preheat flames of the same length.

Strikers

- When lighting your cutting torch it is important to use an approved spark lighting device. The use of lighters, matches can lead to personnel injury as well as injury to others around you.

Protective Equipment

- Appropriate protective clothing and equipment is required at all times when using oxyfuel cutting equipment. As cutting operations vary so will the required protective clothing and equipment, size and the location of cutting will determine this. Some or all of the following may be required:
    - No. 4 or 5 lens tinted goggles or face shields
    - Welding cap or hardhat
    - Safety glasses
    - Leather gloves suited for oxyfuel cutting
    - Flame resistant clothing
    - Respirators use appropriate respirator for type of fumes that will be produced.

Start Up and Shut Down Procedures

- Secure the cylinders to cart or a substantial support.

- Attach regulators to the valves, ensure valves are free from oil, dust and obstructions. Tighten inlet connection nuts firmly with a close fitting wrench.

- Inspect the hoses for cuts, burns, and kinks. Have them repaired or replaced, if damaged.

MODULE 1d. TOOL LAB

Start Up and Shut down Procedures cont.

- Connect hoses to proper regulators (green oxygen, red fuel gas).
- Attach hoses to the correct torch inlet.
- Before opening either of the cylinder valves, check to make sure that the regulator adjusting screw is backed out, so that no pressure is being exerted on the adjusting screw. This is done to protect the regulator parts from damage due to high-pressure surges.
- Open the oxygen cylinder valve very slowly to allow pressure to increase slowly into the regulator. Warning, do not stand in front of or behind the regulator when opening the valve. After the pressure in the regulator has equalized, open the oxygen cylinder valve completely so the valve will seal. Oxygen cylinder valves are designed to seal when fully opened and fully closed.
- Fuels cylinders equipped with a hand wheel should be opened no more than 1 ½ turns. Acetylene cylinders equipped with a valve that requires a key or wrench should be opened no more than ¾ turn. Fuel gas valves on cylinders should never be opened completely. This is done to allow the valves to be turned off quickly in case of an emergency.
- With the torch and tip directed in a safe direction, open the oxygen valve located on the torch body. Turn the adjusting screw on the oxygen regulator and adjust to he recommended pressure for the tip being used. Allow the oxygen to flow for at least five seconds for every 50 ft of hose. Close the inlet oxygen valve on torch body.
- Next open the fuel gas valve on the torch body. Turn the adjusting screw on the fuel gas regulator and adjust to recommended pressure is obtained. Allow the fuel gas to flow for at least five seconds for every 50 ft. of hose. Close the fuel gas inlet valve on the torch body.

MODULE 1d. TOOL LAB

Start Up and Shut down Procedures cont.

- The recommended procedure for lighting acetylene is to open the fuel gas valve on the torch body slightly (usually 1/8 to ¼ turn) light with a striker. Adjust the fuel gas valve until the acetylene produces a semi-smokeless flame. Open the oxygen valve slightly to produce a neutral flame.

- To extinguish the flame, turn off the fuel gas valve first then the oxygen valve. This is done to prevent the flame from burning back into the torch body and producing a flashback.

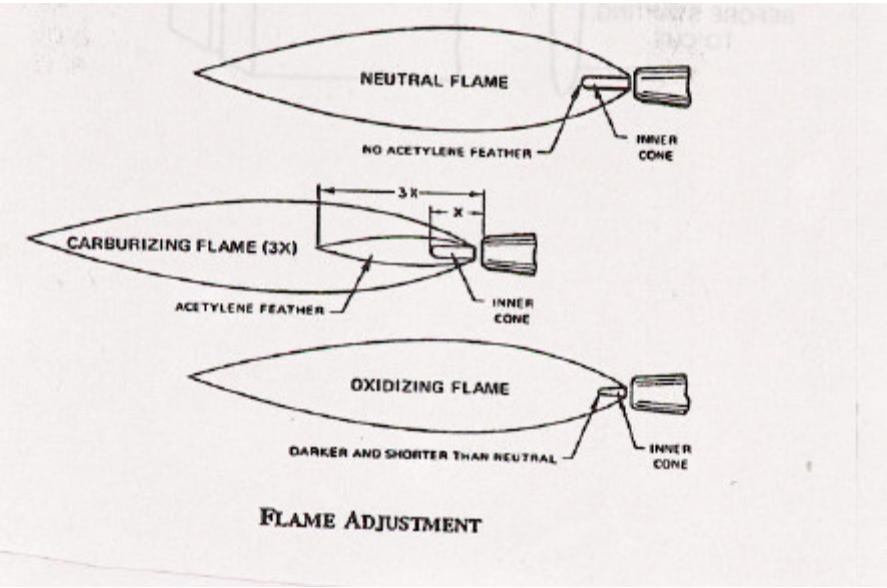
- After the flame has been extinguished, close both the fuel gas and oxygen valves on the cylinders.

- Open the torch fuel gas valve and bleed off the fuel gas from the regulator, hose, and torch. Back out the regulator adjusting screw and close the torch fuel gas valve.

- Open the torch oxygen valve and bleed off the oxygen from the regulator, hose, and torch. Back off the regulator adjusting screw and close the torch oxygen valve.

Flame Adjustment

- The flame adjustment is a critical factor in attaining satisfactory torch operation. The amount of heat produced by the flame depends on the type of fuel gas, intensity of flame, and the type of flame used.



FLAME ADJUSTMENT