EMERGENCY PARKING PROCEDURES

Position of an emergency vehicle on and emergency incident is crucial. The more likely a hazard it represents, the more critical the need for rapid, effective placement of stationary warning devices. The most effective is the placement of reflective triangles or flares to warn drivers of the upcoming situation. Remember that is there is a potential for flammables spilled, the reflective triangles are the better choice. It is a goal to protect the scene and the personnel operating on the scene. The goal of "protecting the scene" is to provide visible, early warning to surrounding traffic and thus avoid a collision (or avoid causing a collision).

Some simple tips to use for identifying and protecting the apparatus and personnel. During daylight hours and the vehicle is off the road the use of hazard lights (four way flashers) should be sufficient. IF the apparatus is still on the road then the use of emergency lights, hazard lights, and some other form of warning devices should be used (e.g. traffic cones, triangles, or flares). During darkness, use of as many lights as possible is the best safety. The lights generally cause traffic to slow to a safe speed around the apparatus.

If the need for additional traffic warning devices is warranted, then ensure that plenty of warning is given to oncoming traffic. Terrain and visibility may require that the additional warning devices be placed well behind the apparatus and in some cases around a curve or over a hill. Actual distances are based on the topography, buildings, and visibility conditions.

Safety Reminder – If you position yourself behind any parked emergency vehicle for the purpose of spotting and/or warning approaching traffic, you run the risk of being struck. Be vigilant, people are struck because they are not looking. **Never** turn your back on approaching traffic.

COMPETENCY COURSE PROCEDURES

PURPOSE OF COURSE

The competency course is designed to measure the proficiency of emergency vehicle drivers. The course is designed to measure a driver's skill, knowledge, and judgment. It can also identify to the candidate the limitations of the vehicle while completing eight specific exercises. The competency course is designed to fulfill one of several purposes:

- Assist in the training of a candidate emergency vehicle driver.
- Verify the competency of an existing vehicle driver.
- Examine the proficiency of an existing emergency vehicle driver.

Driving the course requires completing each station under ideal conditions in a controlled environment. Actual driving conditions represent less than ideal conditions because of constantly changing situations. There are specific performance criteria that are crucial to achieving proficiency while completing the competency course. They are as follows:

- Comfortable seating position.
- Ease and convenience for reaching all controls of the vehicle.
- Proper hand position on the steering wheel.
- Careful vehicle control.
- Precise steering adjustments.
- Consistent vehicle speed.
- Proper adjustment and effective use of vehicle mirrors.

To successfully be evaluated as an emergency vehicle driver requires more than the completion of the competency course. It must be supplemented by other exercises including street and highway driving in order to fully comply with NFPA 1002. The candidate should be taken through a predetermined route on a public way. Some of the actual activities that must be completed as a part of the over-the-road driving portion include but are not limited to:

- Make four left and 4 right turns.
- Travel either a straight section of urban business street that is several blocks long or a minimum of one mile or a 2 lane rural road.
- Travel across at least one through intersection and a minimum of two intersections where stopping is required.
- Travel over at least one railroad crossing.
- Travel on a road with at least one curve to the left and one to the right.
- Enter and exit a limited access highway. Use a conventional ramp entrance. Travel the highway a sufficient distance so as to safely execute two lane changes, on to the right and one to the left. Exit off a conventional ramp.
- Proceed down a grade. It shall be steep enough and long enough to require braking or shifting.
- Proceed up a grade. It shall be steep enough and long enough to require shifting to maintain a constant speed.
- Travel under, over, or across an underpass or bridge. It shall present either a vertical or horizontal restriction.
- Travel along or over any unusual or unique roadways or features that present a special consideration in the operation of the vehicle.

RULES AND PROCEDURES

In order to maintain safety during the competency test it is important that certain rules be followed. Many of these rules flow into normal operation of an emergency vehicle. The following should be deemed as the course rules:

1. Vehicle performing maneuvers on the course will have their headlights on.
2. No unauthorized vehicles or drivers allowed on the course during any exercise.
3. All vehicle occupants must wear occupant restraint devices.
4. Persons assigned to reset cones will wear bright clothing, safety vests, and stand clear of the traveled area.
5. Maximum speed on the course should not exceed 20-30 mph.
6. The distances between cones in any exercise may be adjusted to accommodate different lengths or widths of vehicles.
7. Course exercises will not be held outside if the course is icy or snow covered.
8. All vehicles will have a pre-trip inspection performed on them prior to using them for the competency course or over-the-road evaluation.

COMPENTENCY COURSE DESCRIPTION

STRAIGHT LINE EXERCISE: The purpose of the straight line exercise is to familiarize the driver with operating the vehicle within close quarters both in forward and reverse; and, to enable the driver to adjust the mirrors fro proper viewing, make minor steering adjustments, and gain confidence in transversing a restricted area.

This exercise is typically the first station in the competency course. The area is 6' 8" wide and is measured from inside edge of cone to inside edge of cone. It is 200' in length and has cones spaced along the sides of the course at intervals of 20 to 25 feet.

The exercise begins upon entering the straight line at the entrance. The driver travels through the exercise by "hugging" to the left side; stopping at the end of the station; and backing out of the course without brushing or knocking over any cones.

CONFINED SPACE TURNAROUND EXERCISE – The purpose of the turnaround exercise is to allow the driver to become familiar with the turning radius of the vehicle; and, to permit the driver to interpret depth perception

involving the placement of the rear of the vehicle as seen through the vehicle's mirrors.

This station is in an area 50' wide by 100' long. Cones are placed intermediately along the length of the area at 20 to 25 foot intervals. The entrance is at the center of the 50' side of the station.

The driver begins the station by entering and proceeding diagonally toward on corner of the confined space. The vehicle is then maneuvered back and forth without projecting outside of the areas boundaries until it can be driven out of the confined space. This exercise is **NOT** a three-point turn. In may take upto to 6, 7, or 8 turns for larger vehicles to accomplish the 180-degree turn.

ALLEY DOCK EXERCISE – The purpose of the alley dock exercise is to familiarize the driver with positioning of the vehicle to back into a confined space; and, to judge depth perception and distance using the vehicle's mirrors to position the rear of the vehicle at or close to a fixed point.

This section is exactly 10 feet wide, measured from inside of one cone to the inside of a cone and 30 feet long. The 30 feet can be used for all vehicles no matter the length of the vehicle since the vehicle does not have to be all the way in the dock area.

This exercise begins when the vehicle proceeds past the alley dock so as to position it for backing into the alley. The intent of the exercise is for the vehicle to be backed into the alley and stop within 6 inches of the back of the alley.

SERPENTINE EXERCISE - The purpose of the serpentine exercise is to familiarize the driver with the location of the corners of the vehicle for maneuverability purposes and the turning radius while moving forward and backward; creating a confidence in using the mirrors for this exercise.

The serpentine is an area 50 feet wide by 200 feet long. There are 4 cones set in the center of the 50-foot width and the cones are set at 40 feet apart, measured center to center. For vehicles with a wheelbase of less than 170 inches, the distance between the centers of the cones is reduced to 34 feet.

Upon entering the exercise, the vehicle should be driven along the right side of the center cones. After passing the 3rd cone the vehicle should be cocked at a slight angle so as to position the rear of the vehicle between the 3rd and 4th cones. The driver then backs the vehicle between them, passing to the left of the 3rd cone and to the right of the 2nd cone. Then the driver should pass to the left of the first cone and back through the entrance. After backing through and stopping at the entrance, the driver travels through the serpentine in a forward position. The vehicle should pass to the right of the first cone, the left of the second cone, right of the third cone and out the exit of the exercise.

OFF-SET ALLEY EXERCISE - The purpose of the off-set alley is to allow the driver to become aware of the front and rear tracking of the vehicle; familiarizing the driver with depth perception through the vehicles mirrors, especially recognizing the location of the right rear wheel.

The distance between the two alleys is 48 feet. It must be carefully measured from edge of cone to edge of cone. An extended front bumper or other projections of the vehicle must not extend outside the alleys. In other words, treat the alley edges as if they are building walls or parked vehicles.

When transversing the exercise the driver should proceed forward through the first alley and exit it. The driver should change the track of the vehicle and enter the second alley without rubbing or knocking down any of the cones. Typical problems involve changing the track of the vehicle too quickly or not straightening the vehicles track sufficiently before entering the second alley.

PARALLEL PARK EXERCISE - The purpose of this exercise is to allow the driver to understand the importance of vehicle positioning prior to starting a movement that requires exact right side placement; to familiarize the driver with the turning radius of the vehicle as it impacts restricted space placement; to enable the driver to locate the position of the right front extremity of the vehicle while completing a maneuver; and, to enable the driver to place the right side of the vehicle at a specific point utilizing the vehicles mirrors.

The parking space that the vehicle is to be placed in is **the length of the vehicle plus eight feet.** The depth of the parking space is eight feet and a marking of 12 inches should be marked away from the curb.

The driver shall pull the vehicle past the parking space and proceed to parallel park the vehicle in the designated space. The right side of the vehicle must be placed within 12 inches of the curb. Crossing over the curb, parking to far away from the curb, or knocking down cones that mark the parking place will result in penalty points added to the drivers score.

DIMINISHING CLEARANCE EXERCISE - The purpose of the diminishing clearance exercise is to familiarize the driver with the importance of properly aligning a vehicle when entering a very confined asymmetrical area; and, to familiarize the driver with traveling through a continually more confining restricted area.

This portion of the course uses an area approximately 100 feet in length and the entrance to the station is nine feet six inches wide, inside cone to inside cone. The end of the exercise measures eight feet two inches wide, inside cone to inside cone edge.

The vehicle is to pass through the length of cones without touching or knocking and cones over. Two of the most common errors involve speed fluctuations through the exercise and misalignment of the vehicle's track upon entering the station.

STOPPING EXERCISE - The purpose of the stopping exercise is to familiarize the driver with the position of the front of the vehicle and to require the driver to brake smoothly and precisely while bringing the vehicle to a stop at a specific point.

At approximately 40 to 60 feet beyond the end of the diminishing clearance station, two cones will be set parallel to each other and in the line of travel of the vehicle. Marks at 6 inches, 12 inches, and 18 inches from the cones will be made on the ground.

The vehicle will exit the diminishing clearance and proceed straight towards the two cones. The vehicle will then slow and come to a complete stop no more than 6 inches from the cones. The farther away from the cones will result inn more points being added to the drivers overall score.

TROUBLE

SHOOTING

GUIDE

Problem	Symptoms	Causes	Solution
Pump will not go into gear	No indication that pump is in gear (There are 3 signs a pump is in gear)	Parking brake is not applied Road/pump switch is not in correct position Gear shifter is not in correct gear	Start from beginning. Apply parking brake Place Road/pump switch in pump position ensure green indicator light is illuminated Place gear shifter in proper gear Watch for 3 signs that pump is in gear 1. reading on speedometer 2. sound of pump engaging 3. indicator light in cab and at pump panel is illuminated green
Pump will not go in gear after 1st attempt	No indication that pump is in gear (There are 3 signs a pump is in gear)	Road/pump switch malfunctioned	Follow manufacturer's instruction for placing pump in gear manually
Pump will not go in gear after 2nd attempt	No indication that pump is in gear (There are 3 signs a pump is in gear)	Road pump switch malfunctioned or Mechanical failure	Allow Supply Engine to flow water through your pump. Open appropriate intakes and discharges.
No pressure reading on master pressure gauge	All 3 signs that pump is in gear are present	Tank to pump or intake is closed (No water in pump) Master gauge is defective	Ensure proper valves are open Operate primer pump Check individual line gauge for that discharge
Pump will not supply its rated capacity <u>2 stage pump</u>	RPM's do match pressure on UL plate	Transfer valve in wrong position	Place transfer valve in volume/parallel position to supply max capacity

Problem	Symptoms	Causes	Solutions
Pump will not supply its rated capacity 2 stage pump (continued from last page)	RPM's do match pressure on UL plate. Max capacity not achieved. Intake may have no reading or high vacuum	Swing check valve may be blocked by debris. Blockage in pump piping or impeller	Remove blind cap or intake valve from main intake on pump. Push on swing check valve with a long object to remove debris Place additional supply line in service, reduce disch pressure, or back flush pump
Pressure drops while drafting	Low vacuum reading on intake gauge Increased vacuum reading	Air leak from valves, packing, or other pump devices Blocked intake or strainer	Ensure all valves not used are closed and blind caps are tight Ensure enough water is covering strainer Remove blockage and continue to flow water
Pump is overheating while pump is in gear	Overheat light and indicator is on & pump is very hot to touch	Possibly lack of flow through pump	Open discharge Open circulating valve Open tank fill, unless tank fill only runs off 1st stage of pump
Relief valve does not work or is slow reacting	When lines are opened & closed relief valve does not control pressure increases	Blocked strainer in pilot valve to discharge relief valve Relief valve is broken	Remove strainer and wash out sediment. Turn relief valve off & on under pressure of 150psi for 1 minute. Turn off relief valve and monitor pump gauges
Primer pump will not evacuate air and water adequately	Primer pump is running when primer is engaged	Engine RPM too low No oil in reservoir Vent hole in oil reservoir cap is clogged preventing the siphon effect	Increase RPM's Add oil Loosen cap or unclog cap to ensure the siphon effect

Problem	Symptoms	Causes	Solutions
Pump will not operate in series/pressure position	Pressures can not be achieved	Swing check valve is blocked	Remove blind cap or intake valve from main intake on pump. Push on swing check valve with a long object to remove debris Back flush pump
Engine temperature gauge is indicating overheating of engine compartment	Temperature reading is above normal range	Engine is overheating, not enough air flow to cool engine	Open auxiliary cooler Operate fan clutch Check grill in front of radiator for debris Use radiator fill valve
Supply line collapses while beginning to flow water or placing additional lines in service	Intake gauge is low or reads zero "0"	Kinks in supply line	Remove kinks in supply line
		Supply line not supplying the same amount of water being discharged	Throttle down until you get an increased intake reading. Reduce flow in other line or shut down Ask Supply Engine for more water Place 2nd supply line in service
	Water coming out of ground around barrel of hydrant	Hydrant not opened all the way	Open hydrant completely

Problem	Symptoms	Causes	Solutions
Pump will not supply sufficient pressures above >200psi	RPM's are normal compared to UL plate	Transfer valve in wrong position Swing check valve blocked	Place in series/pressure for pressures above >200psi Place pump in volume/parallel And back to series/pressure again. Listen for swing check valve to slam close. If not, remove remove blind cap or intake valve from main intake on pump. Push on swing check valve with a long object to remove debris Back flush pump
Pump will not prime	Water will not fill hard sleeve. No vacuum reading Possibly leaking water prior to attempting prime	Drain or bleeder valve left open Intake valve open Open discharge or circulating line/ booster line intake relief valve leaking hard sleeves are not air tight pump packing is leaking air	Ensure master drain, bleeders, drains, & auxiliary cooler are closed Close intake valves completely and tighten cap Ensure tank to pump is closed if no water is in tank Close discharges, booster line cooling valves, and circulating lines. Blind cap and tighten Tighten hard sleeve couplings Re adjust packing, take out of service

Problem	Symptoms	Causes	Solutions
		not operating primer long enough	Prime should be achieved in 15-20 seconds, operate primer until water is on ground and discharge is flowing water at 50-100psi. Do not operate longer than >30seconds
		Malfunctioning primer pump	See solutions in previous problems in "Primer pump will not evacuate air and water adequately" on page 3 of this guide
Intake pressure in relay increases above 100psi	Intake >100psi	Hose lines being shut down or intake pressure has increased	Open dump line discharge to maintain residual intake pressure of 50psi Changes in pressure above 10psi to below 100psi should not be adjusted nor should dump lines be utilized. Expect some fluctuation in relay.

ATMOSPHERIC MONITORS

INTRODUCTION

Emergency incidents pose potential hazards to the health, welfare, and safety of firefighters and other rescue workers alike. Hazards may be identified while approaching the scene, or after the completion of a thorough scene size up. Conversely, the presence of toxic or flammable atmospheres may complicate or hinder the recognition of hazardous environments. Though warning signs or clues may point to the existence of these dangers, the only practical means for detecting and measuring the presence of these hazardous conditions is through the use of atmospheric monitoring, or metering devices.

Atmospheric monitoring provides a means of early warning and detection for those personnel entering an existing, or potentially hazardous environment. These devices aid not only in the detection of noxious or deadly gases, but also assist in measuring (e.g., as a percentage or in parts per million) various gas concentrations in ambient air. Once an atmospheric environment is deemed unsafe, various interventions may be initiated (e.g., ventilation or securing utilities) to mitigate the problem(s).

HOW ATMOSPHERIC DEVICES WORK

Monitors (or meters) are designed to provide a responder with early warning and detection of potential atmospheric dangers. Today's meters are portable, easy to operate, and safe for use in numerous types of atmospheres. Furthermore, they are designed to measure in concentrations as low as parts per million (ppm); these concentrations represent very small amounts of a given contaminate or gas.

In order to operate an atmospheric monitoring device properly, personnel must be capable of interpreting various meter readings, as well as understanding why and how a given device responds in a given atmosphere. Without this knowledge, responders may walk into toxic or oxygen deficient atmospheres without warning.

Each sensor housed within a given atmospheric monitoring device is calibrated to alarm at a specific point or concentration. Single-gas meters, or "Gas-Tracs," are designed to alarm when detecting specific gases or toxins for which they are calibrated. With multi-gas meters, one, or all of the sensors could alarm at the same time. The most popular sensors in use today are those which detect combustible gases, oxygen, and various toxic gases (e.g., Carbon Monoxide and Hydrogen Sulfide).

Combustible Gas Sensors(CGI) measure the amount of flammable vapor in ambient air. Most meters are set up to measure flammable vapor concentrations as a percentage (0%-100%). An alarm will activate at a level well below the Lower Explosive Limit (LEL) of the vapor being measured. LEL refers to the lowest concentration of a flammable gas, when mixed with ambient air, forms an ignitable mixture. Hopefully, you

will never encounter atmosphere that is at 100% of LEL. At 100%, an explosion is imminent and you are in serious danger!!

Oxygen Sensors measure the amount of oxygen present in ambient air. These sensors are set to alarm in an oxygen deficient atmosphere (19.5% or less) or in oxygen enriched atmosphere (23.5% or more). You may recall that ambient air normally has an oxygen concentration of 20.9% to 21.0%.

Oxygen sensors are important for various reasons. First and foremost, oxygen deficient atmospheres pose a life safety hazard and the potential for asphyxiation. Secondly, and equally important, is the pertinence of oxygen concentrations as it relates to flammability issues. In the presence of fire, lower oxygen concentrations may result in slower fire growth or eventual extinguishment. On the other hand, low oxygen concentrations in a confined space subject to fire poses a potential for backdraft. Similarly, oxygen enriched air poses the potential for rapid or explosive fire spread. Thirdly, oxygen needs to be present to acquire a proper "LEL" reading. In an oxygen deficient atmosphere, you will observe a reading that is actually below the correct "LEL" percentage. As a rule of thumb, correct "LEL" readings require a minimum of 10% oxygen to be reliable without the use of some type of dilution appliance.

Toxic Sensors are more commonly designed to aid in the detection and measurement of Carbon Monoxide (CO) and Hydrogen Sulfide (H2S). CO is a by-product of the combustion process and is usually associated with malfunctioning furnaces or appliances. H2S is a common toxic often found in manholes, sewers, or other confined spaces. It is also found in atmospheres where materials are rotting or decaying. Only 10 ppm is needed to affect the well being of responders. The unit of measurement utilized by toxic sensors is parts per million (ppm). As discussed earlier, ppm represents a small fraction of the overall concentration of a given gas or toxin.

Put in perspective, consider the fact that Hydrogen Sulfide possesses a danger level of a mere 5 ppm. For every million parts (or units) of this gas, only five parts (or units) is required to produce an inhalation hazard to humans. This is an extremely low level concentration and poses potential health hazards for responders. Self-Contained Breathing Apparatus (SCBA) is required when mitigating incidents involving this product.

TYPES OF METERS

There are two basic types of meters in use by the fire service: direct reading and visual and audio alarms. Direct reading meters display digital readings on the meter screen at the time of sampling. Direct meter reading meters may display a myriad of readings depending on the types of sensors installed in the device. Nevertheless, personnel must be capable of identifying and interpreting the values displayed. For example, most combustible gas or oxygen sensors display concentration values in terms of percentages. Toxic sensors, on the other hand, display concentrations in ppm.

In general, direct reading meters will flash an LED light and or possess an alarm which activates when a sensor detects an unsafe atmospheric level.

Visual and audio type meters include "Gas-Tracs" and other single-gas sensing meters. "Gas-Tracs" are calibrated to alarm at 50% of the LEL of a flammable gas. When this type of meter alarms, a series of lights (green, yellow or red) activate; each light represents a different level of concentration. As a secondary means for warning its user, an audible alarm is also activated at higher atmospheric concentrations.

It is imperative that users of any atmospheric monitoring device familiarize themselves with the individual capabilities of each device in their workplace. Instruction manuals are the best source for acquiring this information.

An important issue all personnel must consider about these metering devices is a phenomenon referred to as "relative response." Atmospheric metering devices are designed to detect the presence of one or more specific gases. If a meter detects a specific gas, it will show a "direct" reading for that gas. If, however, one utilizes a meter calibrated for Methane to detect gasoline vapors, the meter will provide a "relative response" reading. Another words, the meter is registering the presence of a gas to which it is not calibrated and is thus providing a relative reading of its concentration.

Should one utilize a meter to detect and determine atmospheric concentrations outside that which the meter is actually calibrated, a relative response rating should be obtained. The simplest way to accomplish this means is to multiply an acquired reading by a factor of two (2). This represents a "street wise" method for determining the concentration of flammable vapor in air.

HOW SENSORS WORK

The mechanics behind how sensors work is complicated. Despite this fact, the evolution of meter technology has produced improved reliability and ease of operation.

In practice, sensors operate on a simple process. Essentially, air passes over a sensor(s). The sensor absorbs the sample, converts it to an electrical signal, and transmits a reading to the display screen. In some instances, the electrical signal activates an alarm.

Combustible Gas Indicators (CGI) utilize a system of Catalytic Beads connected by a balanced resistor which measures the electrical resistance between the "Sensing Bead" (actually burns the flammable gas) and the "Reference Bead" (stays at a neutral temperature). This electrical resistance between the tow beads is converted into an electrical signal sent to the display screen to be read as a percentage of the "LEL". Even though there is actual burning going on inside the sensor, a Flame Arrestor is employed to make the meter intrinsically safe.

CGI sensors are also susceptible to being "Poisoned" or "Inhibited". Poisons are substances that will adhere to the Catalytic Bead and cause permanent damage to a portion and/or the entire Sensing Bead. A sensor that has been exposed to a poison becomes desensitized and cannot recover. Such poisons include TRV Silicone, Armor-All, and Tetraethyl Lead (found as a gasoline additive). Inhibitors are also substances that adhere to the Catalytic Bead and decrease the "life of a sensor. These substances include Sulfur Compounds, and Halogenated Compounds.

If you think your meter has been exposed to a poison or an inhibitor, calibration is the only way to identify if there has been any loss of sensitivity to that sensor or if the sensor needs to be replaced.

Toxic and Oxygen sensors utilize and Electrochemical Sensor which consists of two electrodes (the Working electrode and the Counter electrode) suspended in a liquid electrolyte. When the toxic gas or oxygen reaches the Working Electrode, an electrochemical reaction occurs. The electrical resistance between the Working Electrode and the Counter Electrode is measured and converted into an electrical signal that is sent to the display screen as a parts per million (ppm) or percentage (%)reading depending on what you are measuring. Remember that since there is always Oxygen present, the Oxygen Sensor is always sensing oxygen whether the meter is turned on or not. This will decrease an oxygen sensors' life from the normal 24-36 months in a toxic sensor to 12-18 months in an oxygen sensor.

Any sensor is susceptible to adverse conditions. Humidity, extreme high or low temperatures and corrosive atmospheres can have an adverse effect on a sensor. These effects can be seen by a "stray" in a sensors reading. You may see a 1 or a 2 reading when first turning on a meter or you may see a -1 or -2 reading. This does not mean that your meter is not working properly. To acclimate your meter to its surroundings, do a "Zeroing" function to the meter. If the problem persists, have the meter calibrated.

There are chemicals that may have a "cross-sensitivity" with a specific sensor. You may see a reading on the display screen that is not the gas the sensor normally looks for. An example of this is Hydrogen. Hydrogen is a byproduct of a charging battery. As the battery charges, Hydrogen gas is produced and off-gased. If entering an area with a meter containing a CO sensor, the CO sensor will react to the Hydrogen present in the room. It will appear that you have a reading for CO, but you may actually be detecting the cross-sensitivity to Hydrogen. Along with Hydrogen, the CO sensor will also show a cross-sensitivity to any chemical in the "ENE" family such as Acetylene and Ethylene. This does not mean that the CO sensor can be used as a substitute metering device for these materials, but it may explain why you see a CO reading when CO is not present.

RANGES OF DANGEROUS ATMOSPHERES

The Environmental Protection Agency and OSHA has established "action levels" designed for use by hazardous waste sites. These levels are designed to ensure safe operating environments for affected employees. Since fire/rescue personnel are often faced with incidents requiring interior operations or confined spaces, it is important to consider all environmental and physical characteristics of an incident. Serious consideration must be granted to the existence of, or potential for, leaks (gas or liquid) within, or outside, the confines of a given structure. Meter readings are certain to be different on the interior, versus the exterior of a structure.

When working in the presence of combustible gases, one must consider the following operating guidelines:

- Atmosphere less than 10% of the LEL – continue work with caution;
- Atmosphere is 10% - 25% of the LEL – continue work with extreme caution; and
- Atmosphere is greater than 25% of the LEL – withdraw immediately!

Personnel should remember that most multi-gas meters will alarm at 10% of the LEL. This low alarm parameter is likely to keep personnel out of harm's way while compensating for relative responses.

When working in the presence of potentially hazardous oxygen-rich or oxygen-deficient atmospheres, one must consider the following operating guidelines:

- Atmosphere is in range of 21% - normal range – safe to operate;
- Atmosphere is below 19.5% - utilize SCBA - combustible gas values will be skewed;
- Atmosphere is between 19.5%-23.57%; continue work and monitor with caution; and
- Atmosphere is greater than 23.57% - explosion hazard! - withdraw immediately!

When working in the presence of Carbon Monoxide (CO), one must consider the following:

- Atmosphere is greater than 35 ppm – utilize SCBA; and
- Atmosphere is greater than 2,000 ppm – atmosphere is extremely combustible!

When working in the presence of Hydrogen Sulfide (H2S), one must consider the following:

- Atmosphere is greater than 5 ppm – utilize SCBA.....consider withdrawing due to inadequate Personal Protective Envelope (PPE).

Conversion Formula of Percentage to parts per million (ppm): 1% = 10,000 ppm

CALIBRATION, ZEROING and BUMP TESTING

Calibrating a metering device ensures it will respond appropriately in a given atmosphere for which it is designed to operate. Calibration is accomplished by exposing the sensor(s) to a known concentration of gas. These known concentrations are then set so when the sensor is exposed to that gas in the future, it can determine how much of the gas is present. Since improper calibration techniques may lead to equipment failure, only trained personnel should perform this function. Furthermore, trained personnel should follow all manufacturer guidelines and recommendations. Lastly, to ensure equipment readiness, calibrations should be performed on a MONTHLY basis.

Bump Testing is a field operation that should be done to all meters at the beginning of every shift or prior to placing any air monitoring meter into service. A bump test is a functionality test to ensure that all sensors in the meter are working. This is done by exposing all the sensors to the gases that they are designed to meter. You should see a rise in the readings on the display screen. Continue to let them rise until they reach their alarm settings (or in the case of oxygen, to its lower alarm setting). This will ensure that the meter is detecting and that the alarms activate when they reach their alarm settings. At the completion of the bump test, you will have a functioning meter.

Zeroing a meter ensures that all of its sensors are aligned in accordance with normal atmospheric measurement parameters. Most multi-gas meters display a menu-driven guide on their displays explaining the process to the user. Zeroing should always be performed outside a potentially hazardous environment. In other words, this process should be performed in a "clean" air environment – not in a potentially contaminated area such as next to the tailpipe of the apparatus. If performed properly, the user should observe the following results:

- Combustible Gas Sensors = 0% LEL
- Oxygen Sensors = 20.9% to 21.0%
- Toxic Gas Sensors = 0 ppm

Once the meter has been zeroed out, it should be ready for use. If the meter's sensors do not respond appropriately (i.e., to the proper values), the meter may require a complete calibration or manufacturer servicing.

CARE AND MAINTENANCE

Without a doubt, the most important factors impacting the readiness and serviceability of any piece of machinery is proper maintenance and upkeep. As such, always follow manufacturer guidelines regarding the use and care of their products. Battery life is dependent on regular charging and maintenance. Meters stored in chargers on fire/rescuer apparatus may require the availability of trickle chargers and

shore lines. Battery packs may require replacement on a daily, or fairly regular, basis. Some meters even possess a low battery alarm.

Meter sensors require the same, if not more thorough, care and maintenance as batteries. In general, meters are delicate instruments and are highly susceptible to damage. Sensors can be easily replaced or interchanged. Nevertheless, sensors must be treated delicately. Various chemicals may damage sensors. In some instances, a meter may then produce unreliable readings or lose its sensitivity. A malfunctioning meter could lead its users to disaster!! Finally, sensor life will largely depend on the relative use or disuse of the meter. Remember, for example, that oxygen sensors are always functioning, even if the meter is turned off. Sensors also have a specific shelf life. Outdated sensors will tend to drift during use, offering its user wide variances in actual measurements.

PRACTICAL USE

Most incidents will present the responder with various clues as to the potential hazards posed. Occupancy types, tank or container shapes, placarding, and color markings are several indicators for fire/rescue personnel to utilize when evaluating the presence of potentially hazardous atmospheres. Toxic and flammable atmospheres, on the other hand, are not as easily detected.

To reduce the likelihood of disaster, ensure all meters are properly calibrated and zeroed, prior to use. Utilize two meters at each incident and compare each meter's results. Consistent readings amongst the two are indicative the sampling results are accurate. Results which differ may require further investigation, perhaps with the assistance of another meter. When approaching a building in which a leak is suspected, hold the meter in front of you. As you approach, the meter will hopefully provide a warning if appropriate. If the meter alarms, walk towards the side of the structure and note any subsequent alarming of the atmospheric device. In this manner, a perimeter (i.e., hot zone) may be established. Prior to entering a structure, place the meter in the crack of the door. Perhaps, the meter may alarm, thus providing an early warning prior to entry. As a matter of practice, ensure all sensor readings are considered and evaluated. If, for example, the oxygen sensor is reading low oxygen levels, it is obvious an atmospheric contaminant is displacing the "good" air. If necessary, utilize SCBA and withdraw!

Atmospheric monitoring is a critical element in evaluating site or scene safety, establishing safety zones, and determining the need for proper protective clothing. Always utilize a meter's readings to formulate strategic planning and carry out sound tactical decisions. It could mean your life or the lives of your co-workers!

Engine Company Positioning
At Emergency Incidents

Auto Fires: Montgomery County PSTA Practical Skills Manual

Ideally position Engine uphill and upwind. Park Engine blocking necessary lanes of traffic in roadway or parking lot to protect crews and pump operator. Park Engine at least 100ft from any Auto fire.

Personal Injury Collisions: FRC Policy 24-04 Vehicle Accident Response

Position Engine behind the collision scene blocking necessary lanes of traffic in roadway or parking lot to protect crews and pump operator if the vehicle should catch fire. EMS transport units and Rescue Squad should be in front of the Engine. Do not count on police to block the collision scene. Many may block the scene and later move their cars for other reasons. They may not understand what safety needs the fire department has on the scene of collisions. If you require assistance, be specific and communicate with the police.

Trench Collapse: FRC Policy 65-89 First Responder for Trench Collapse Incidents

Park the Engine 250 feet from the scene. Turn off apparatus if possible. Establish an off-site staging area for other apparatus arriving at the scene. Eliminate all sources of vibration up to 500 feet.

Natural Gas Emergencies: FRC Policy 25-07 Natural Gas Incident Response

Outside natural gas leak,

First due units should park uphill and upwind from incident at a safe distance for all natural gas emergencies if possible. All other units Level I stage such as on major gas leaks.

Natural gas leak inside a structure,

First due units should park uphill and upwind from incident at a safe distance for all natural gas emergencies if possible. Do not park directly in front of a building reported to have a natural gas leak inside the structure. All other units Level I stage 500yds or greater from the scene.

Structure Fires: FRC Policy 24-07 Sop for Safe Firefighting Operations

All Engines take assigned position on appropriate side of the structure. Park Engine out of the way and do not block other apparatus trying to gain access to the structure. Ensure that room is left for aerial apparatus. Do not park where you may block ground ladders from being taken off aerial apparatus.

Hazardous Materials Incidents/Un-known Material: 2004 DOT Guide Book

Guide 111, Isolate in all directions 100 meters. For tanker truck fires isolate 800 meters in all directions. Consider your apparatus may be placed back at this distance initially until required action and material identification has been determined by the unit or command officer. If apparatus approaches a tanker truck fire for the purpose of cooling it down to prevent BLEVE, do not approach from the ends. This is the danger area if the tank should explode.

Staging: FRC Policy 20-02 Incident Command System

Level I staging is not past the last hydrant or 500yds from the incident.

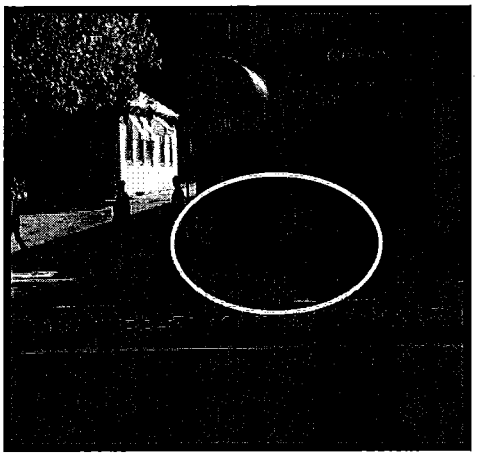
For Level II Staging, stage at a pre determined location. Apparatus should be in close proximity to each other. When possible, park where your apparatus can be moved into place when needed at the fire ground or exposures. Do not block other apparatus at the staging location. Your apparatus or others may be required to clear the incident and go back in service at different times. When parking apparatus on narrow roads, all apparatus should be parked on the same side of the road.

Engine Company Water Supply Positioning

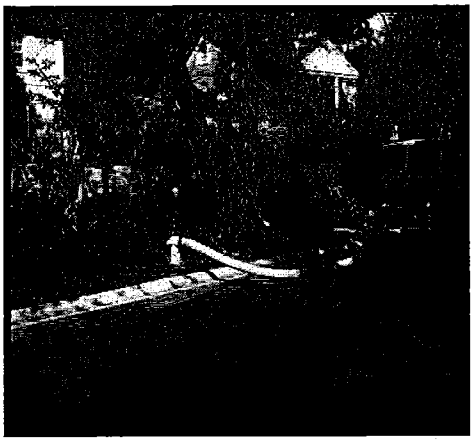
How will your position affect other incoming units?

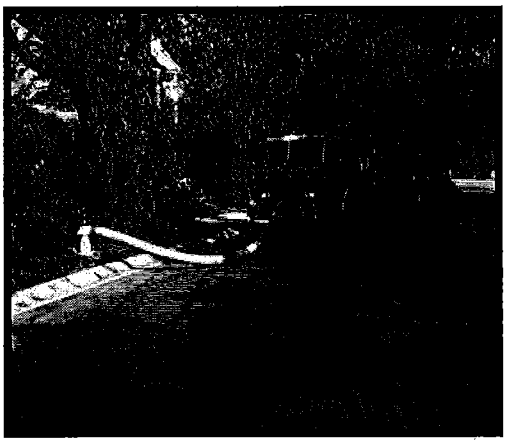
Other Considerations;

- ✓ Deployment of attack lines
- ✓ Access to structure
- ✓ SOP's
- ✓ Water supply issues
- ✓ Collapse zone
- ✓ Room for Truck Company
- ✓ PIC/EMS Incidents – Protection of personnel

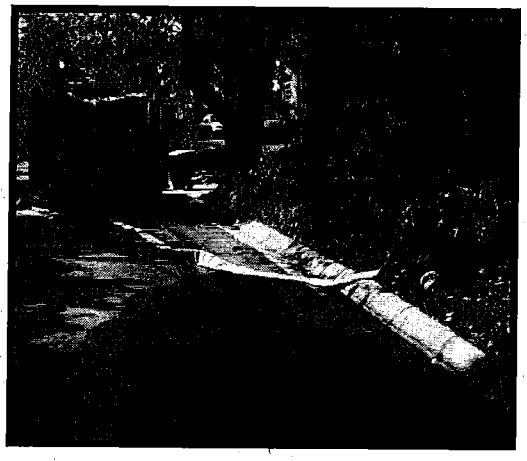


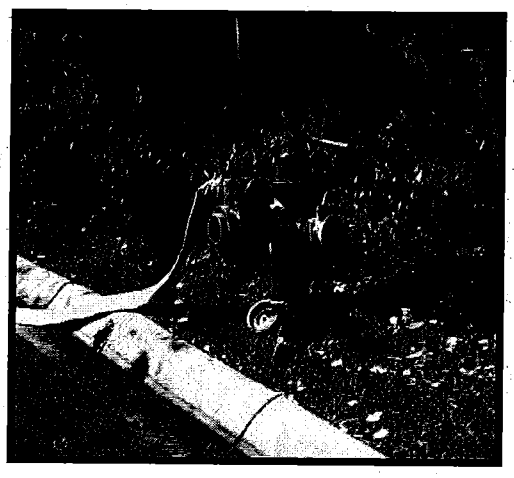
The 1st due engine selecting a hydrant directly in front of the address may block access for other units.



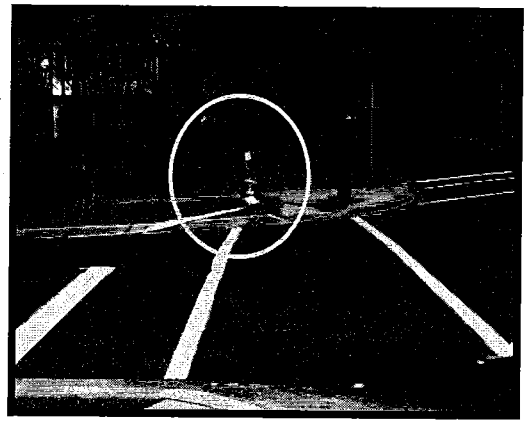


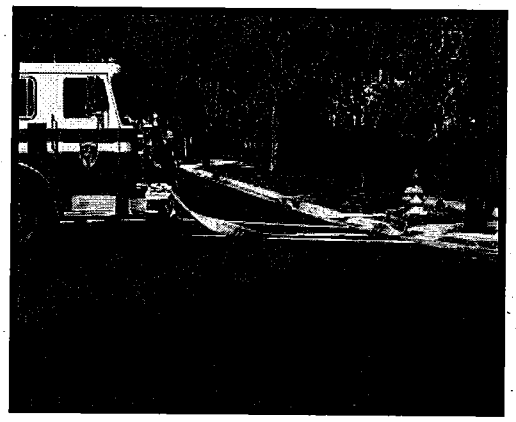
Road is now blocked by 1st due engine company



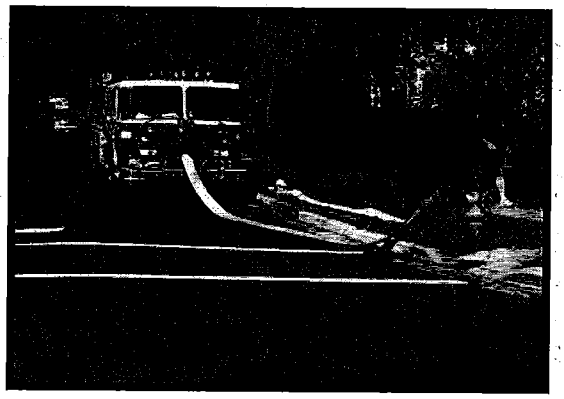


The 1st due engine has pulled passed the hydrant to allow access for special service and has implemented the heavy water hook-up for maximum use of hydrant.



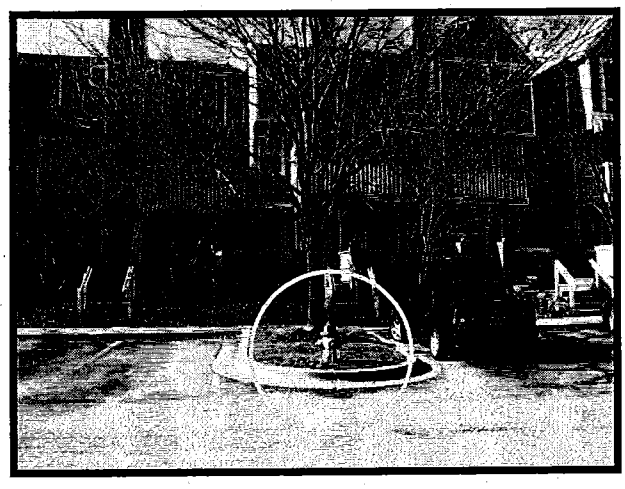


In this example the water supply engine has blocked the access for other units. Consider parking out of the way and connecting the humat valve and charge the hydrant. Position Engine for water supply after the other units have made their access.



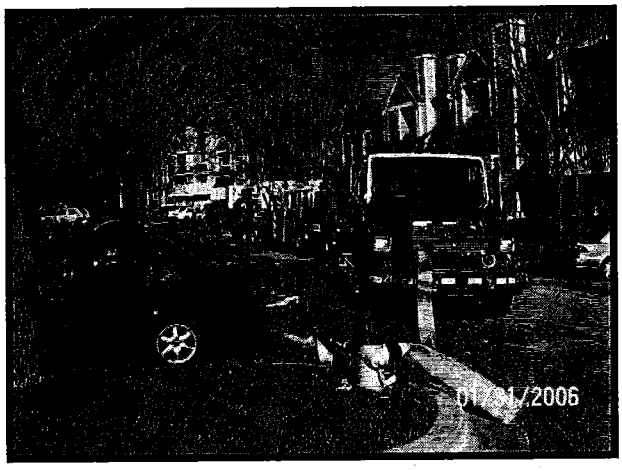
Water supply engine has positioned so not to block access to road.

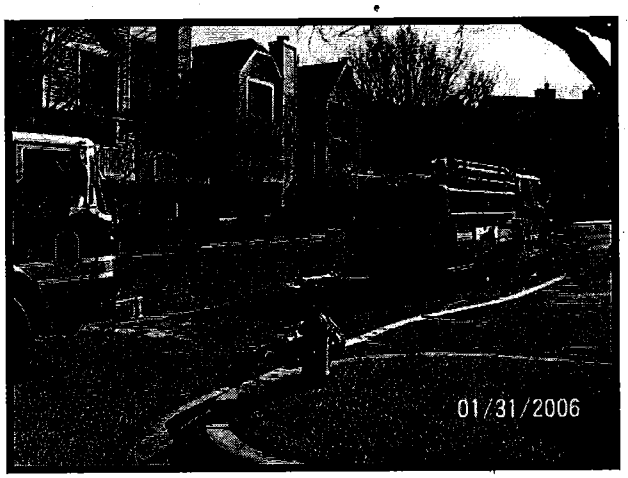
Multi-Family Structures

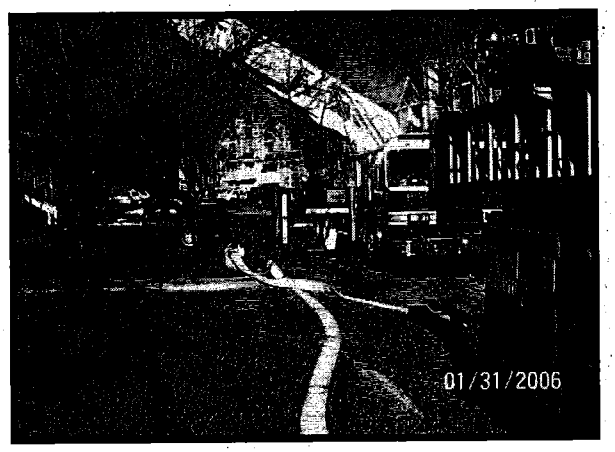


The hydrant in this photo sits directly in front of the structure of origin.

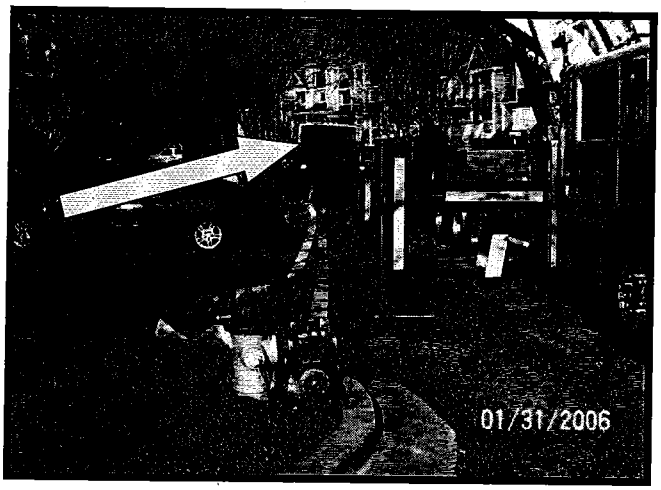
If the engine elects this hydrant as their water supply, then the aerial may have restricted access.



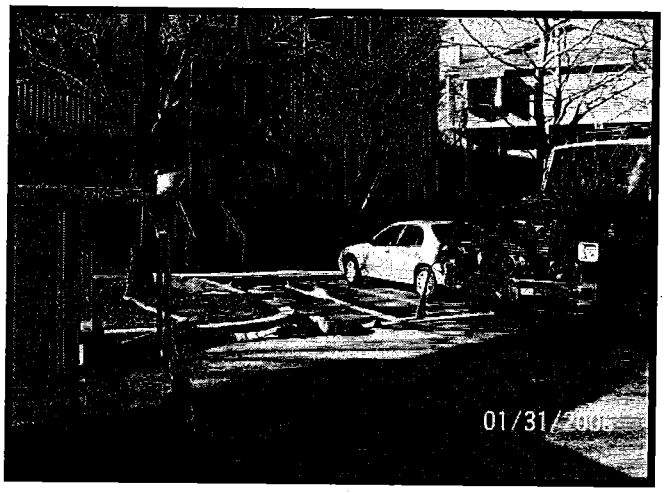




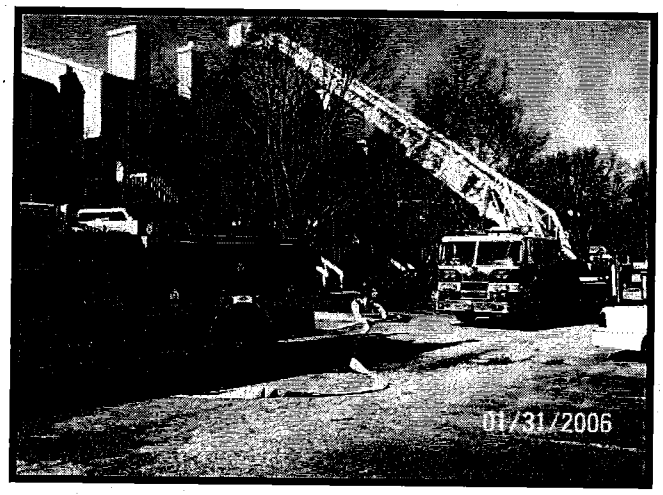
Consider driving past the hydrant to facilitate aerial access to the structure. Use short lengths of hose to make your hydrant connections (consider using a "heavy water" hook-up) Drivers should be well versed in the use of various adapters.



Another option would be to allow the aerial to respond ahead of the engine thus allowing for optimum positioning. The engine can still make their connections from the rear of the aerial and have access to deploy attack lines.



Leave a space cushion behind the aerial to facilitate the removal of ground ladders.



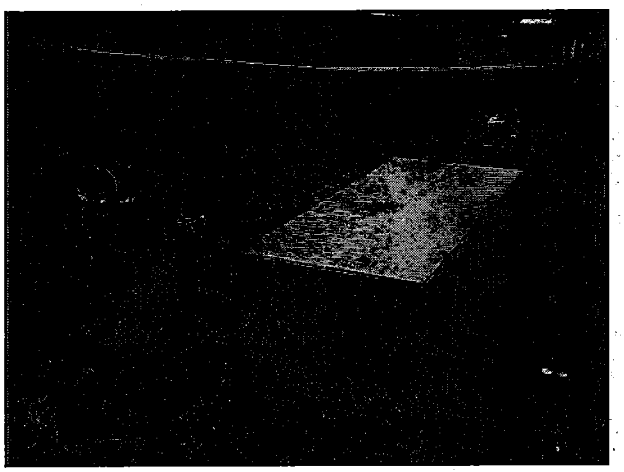
Engine placement has a major impact upon aerial placement and the optimum scrub area provided.

Remember, your apparatus position will have an impact on other units.

METRO Standpipe Fire Department Connection (FDC)

Purpose: To establish a standard procedure for METRO standpipe water supply operations.

Tactical Objective: To develop an uninterrupted water supply for the utilization of METRO standpipe systems.



Metro emergency escape hatch and standpipe FDC

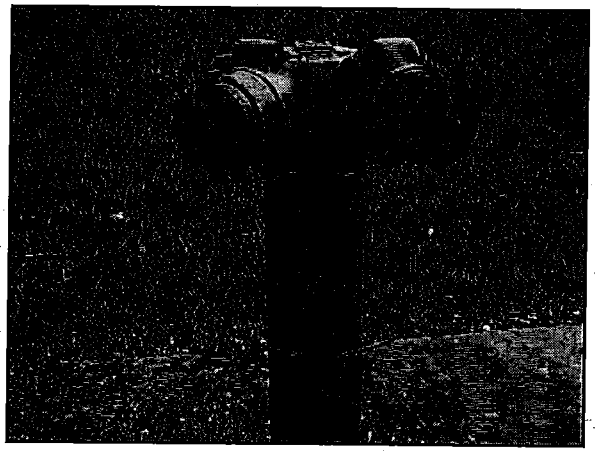
Background: Various configurations, combined with significant lengths and depths of METRO standpipe systems pose unique operational challenges to MCFRS personnel in their efforts to provide adequate fire fighting water. Incidents within the METRO system may certainly be within the scope of flow requirements in the range of over 500gpm for a sustained time frame (>30 minutes)

Procedure

- ❑ Identify the appropriate hydrant location.
- ❑ Establish water supply with dual 3 inch lines, one 4 inch line, or reverse lay from connection to the hydrant. Supply the connection from the Engine with two 3" supply lines.
- ❑ Connect to hydrant using soft suction hose and dress 2 ½" butt with quarter turn gate valve.
- ❑ Take assigned fire ground position and prepare to receive hydrant water.
- ❑ Place transfer valve in the "Volume" position.

- When hydrant water arrives, fill system at **hydrant pressure** until full. Notify Incident Command if system does not fill within ten (10) minutes.

- Operate Engine at appropriate engine pressure considering flow requirements and additions/subtractions for head pressure.



FIRE DEPARTMENT DRY STANDPIPE	
SHAFT IDENTIFICATION NO	EB-1
VERTICAL DROP	75 FEET
MAX HORIZONTAL FEET	1175 FEET

- Plan for water supply expansion if the incident escalates.

Key Operational Considerations

- Immediately begin water supply evolution upon arrival if dispatched in this position. Do not wait for instruction from command to initiate.

- A single, 3-inch line supply line will support 500gpm no farther than 600-feet without excessive friction loss and pump discharge pressures.

- A single, 4-inch supply line will support 800gpm no farther than 1000-feet without excessive friction loss and pump discharge pressures.

- Each connection has an identification plate to indicate the rise, run, and system location. Cross reference with METRO map book to assure appropriate location.

- Station siamese connections near entrances are connected to the standpipes along the platform and in each fire equipment cabinet at platform ends and within stations.

- When supplying connections at fan, vent, or emergency shafts remember that these shaft gates may be opened for evacuation but **not** entered by personnel until approved by the incident commander.

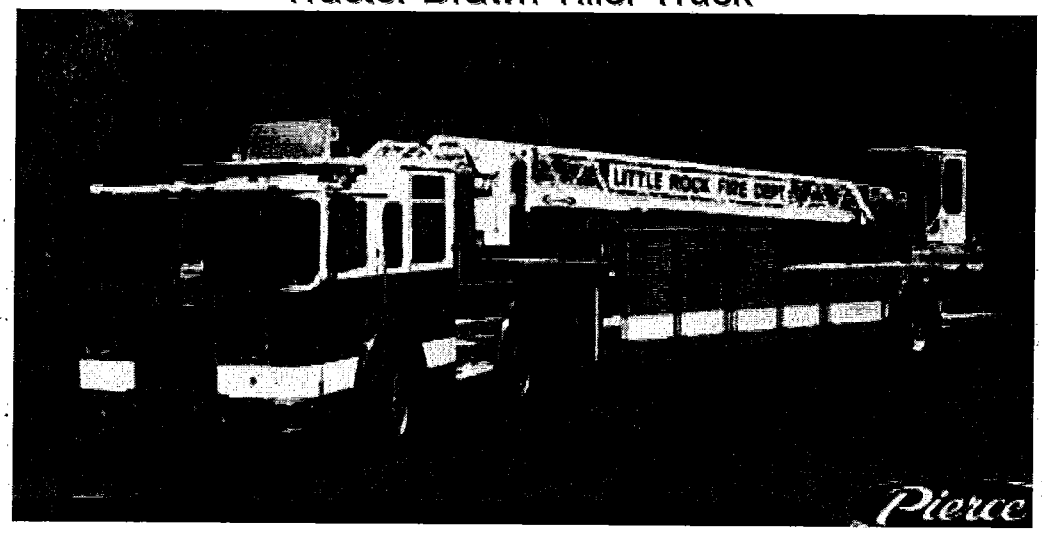
- When filling systems do so at **hydrant pressure** until full, as indicated by the sound of the exhauster clappers shutting and indications of pressure on the pump panel gauges.

- Listen for sounds of possible pipe fractures and loss of pressures while flowing the system.

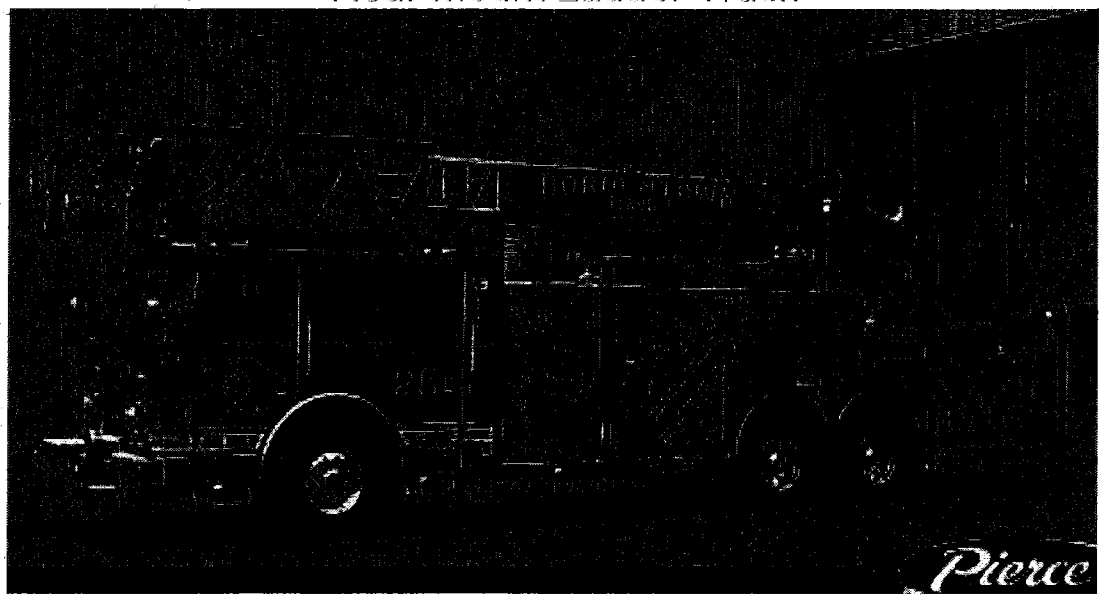
Aerial Apparatus Positioning

Midship Aerial Tower

Tractor Drawn Tiller Truck



Rear-mount Ladder Truck



Rear-mount Aerial Tower

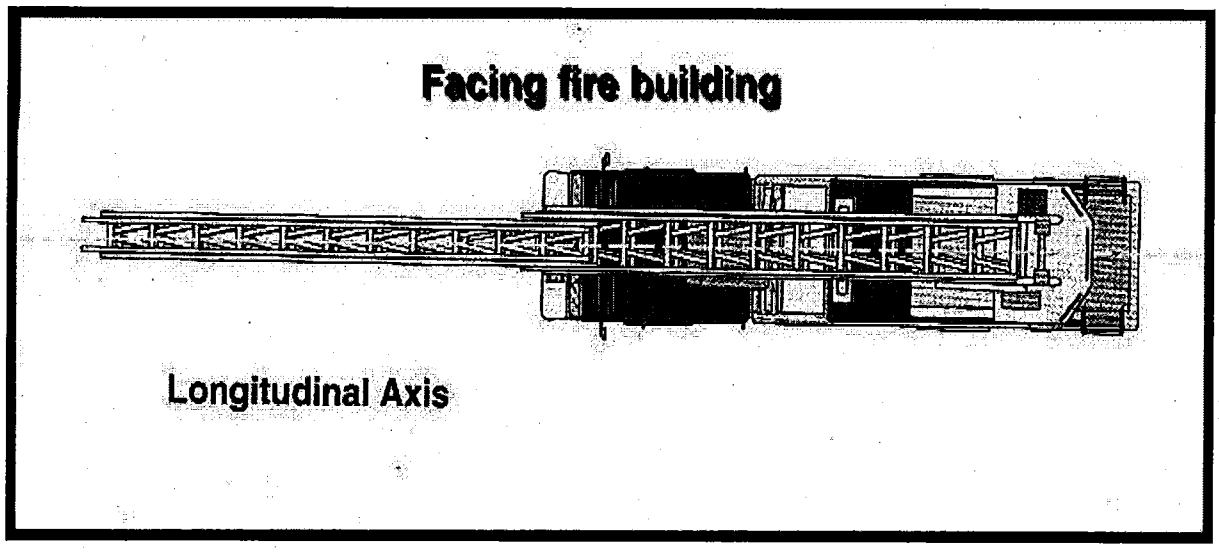
Considerations for positioning Rearmount & Midship Tower Ladders & Ladder Trucks

- Rescue is the 1st priority on the fireground. You must determine what your unit will be used for based on the dispatch information and the conditions observed upon arrival.
- An aerial unit must be positioned very close to a structure if the aerial device is to be deployed.
- Since the aerial device has a fixed length, it is imperative to get within reach of the target. That means, taking a few moments to get around obstacles or getting them moved will go a long way.
- Most electrical cord reels on trucks are between 200-300 feet. So the unit must be positioned within this range or portable generators will have to be used.

Pulling into a structure vs. backing-in or paralleling

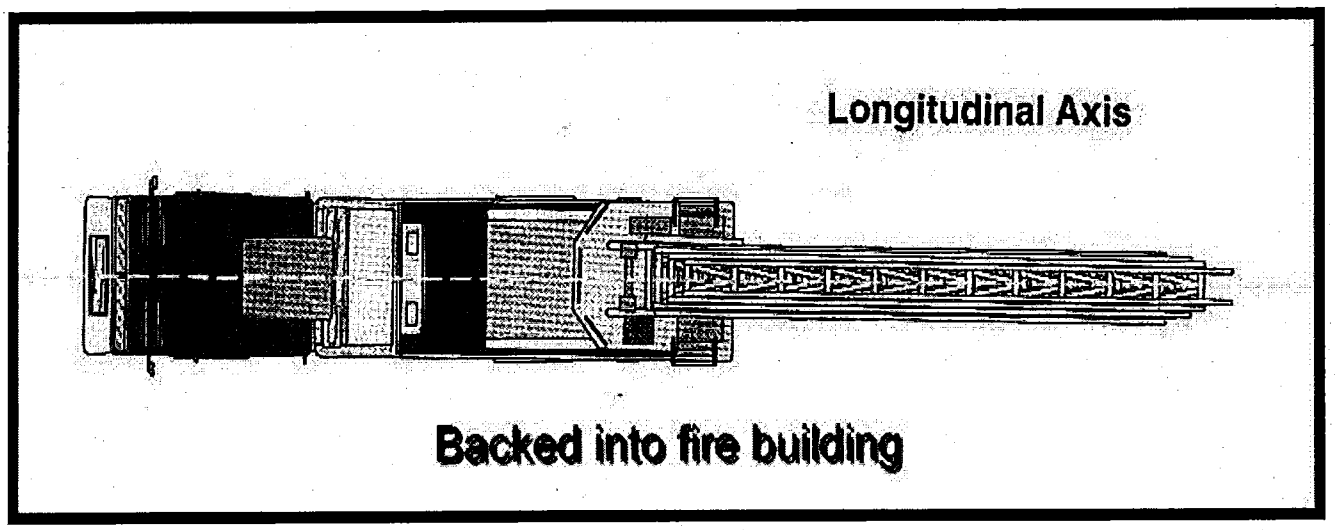
Drivers must know the pros and cons of pulling into, backing, or paralleling a structure.

Pulling/Nosing- Is when the front of the unit faces the structure as it is parked or positioned. At this position, the aerial will be in use over the cab and unit. Aerial reach may be lost due to the aerial device extending over the vehicle before it reaches a target. This is the most stable aerial position.

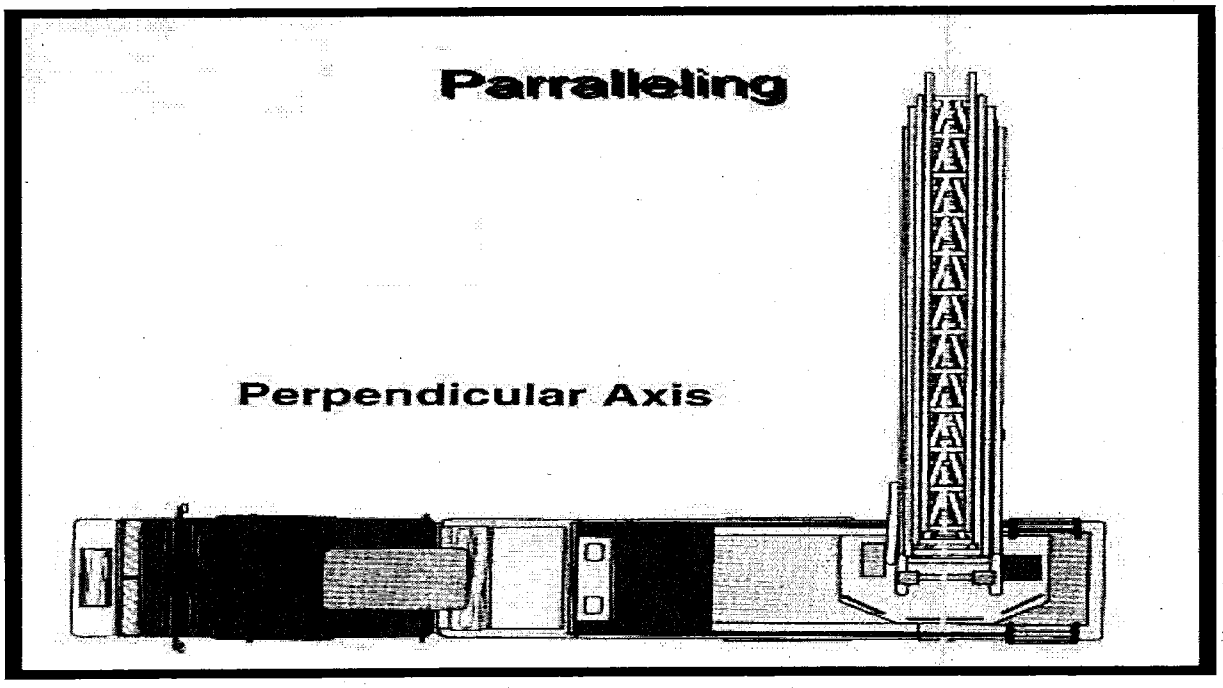


Backing- Is when the rear of the vehicle is closest to the building. On rear

mount aerials, the turntable is closer to the structure than the cab and provides for maximum aerial reach and very good stability.



Paralleling- Is when the side of a vehicle is parallel to a side of a building. This is the most common of positioning choices. Midship towers must position in this fashion if master streams are to be used at grade (ground level) or below grade.



- Rear mount trucks and towers should be backed into buildings when the height of the building is more than 3 stories, or the choice of positioning is keeps the turntable more than 35 feet away.

- Operating the aerial device off the side of the vehicle is a good option when pulling in or backing in are not valid options.
- Positioning the aerial device parallel with a building still affords the operator the opportunity to get the turn table close enough to the building for the maximum reach.
- Operators of midship towers should position these units parallel to buildings 3 stories or less in case the master stream device is needed at or slightly above street level.

"Scrub Area"

A Scrub area is an area of a building or object in which the tip of the aerial ladder or platform will reach.

- Drivers and unit officers must maximize the Scrub Area whenever the aerial device is being considered.
- A Scrub Area for a tower ladder or platform should be considered from the ground floor on up.
- A Scrub area for ladder trucks should be considered from the second or third floor on up.

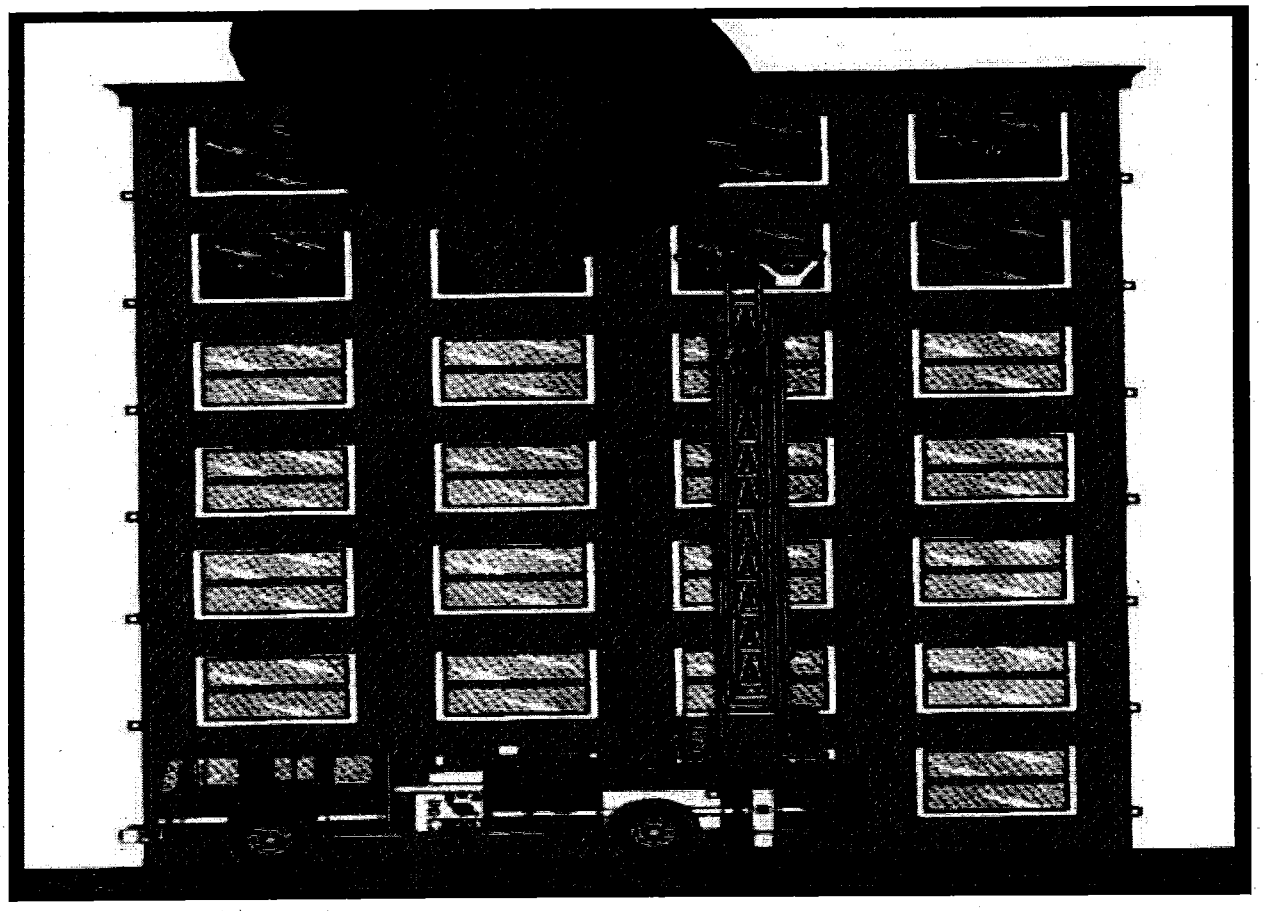
Using an aerial ladder or platform for Rescue

In situations that require using aerial apparatus for rescue, the main objective is to reach as many victims as possible with the minimum number of aerial movements. Remove victims in the following order of priority:

Rescue priority considerations

- Most severely threatened by current fire conditions
- Largest number or groups of people
- Remainder of people in the fire area
- People in exposed areas

Rescue Priorities



- Rescues should be attempted (if possible) on the upwind side (windward) of a window or door to maximize visibility in heavy smoke conditions and to minimize possible heat exposure.
- If the possibility of rescue lies in buildings with windows on multiple sides, corner positioning may be the best position.

Raising the Aerial Device to a Victim

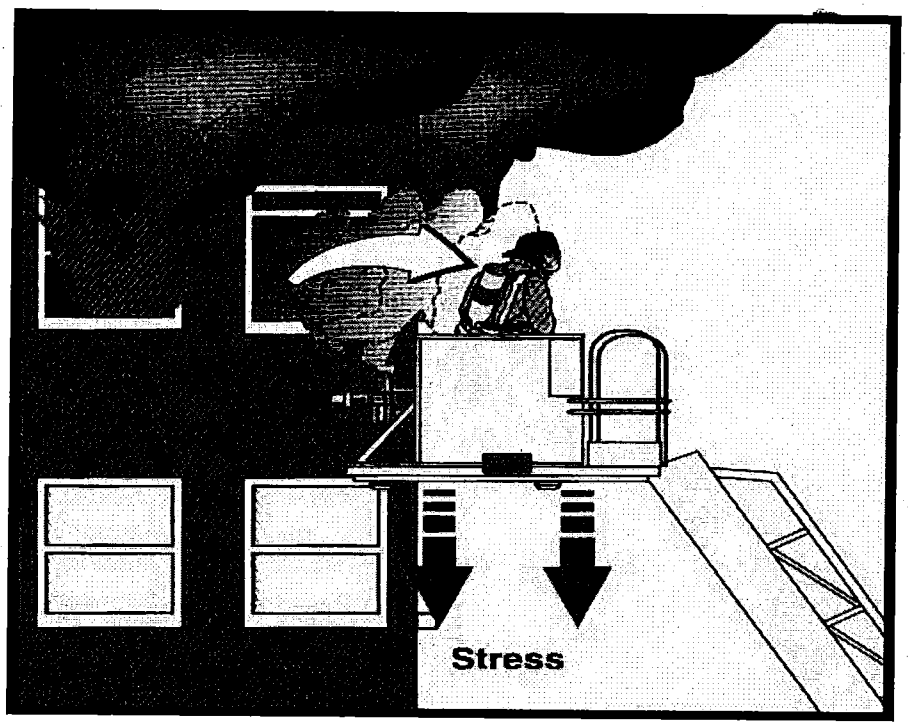
When the aerial device is deployed out of the cradle of the apparatus, it must be used in the following order or sequence while being moved to a target:

- Raise (out of cradle)
- Rotate
- Extend
- Lower (into object or target)

It is very important <u>not</u> to extend the aerial ladder or platform up to a victim

requiring rescue from below. This action may cause the victim to jump onto the aerial device.

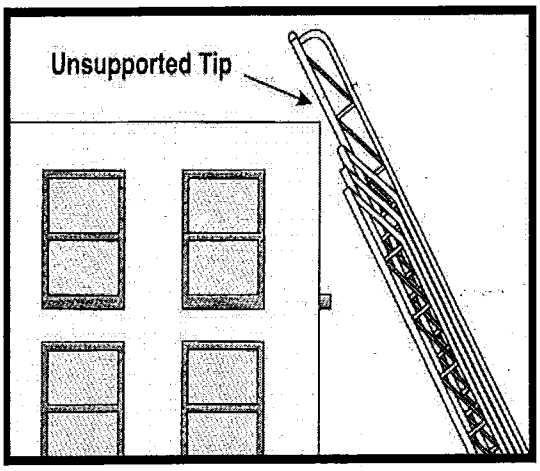
Fire fighters or victims jumping down onto a platform or aerial ladder could cause tremendous stress resulting in damage and/or failure!

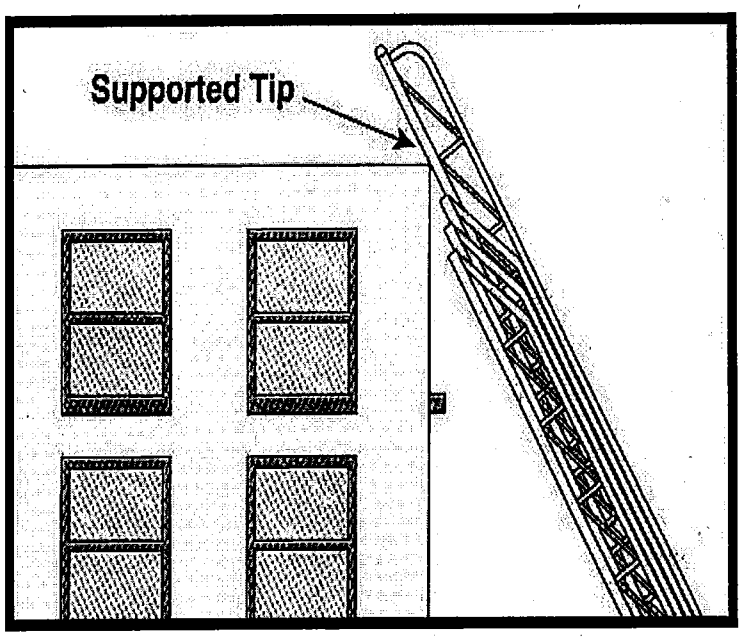


In all situations, the best position is one in which the aerial device is perpendicular to an object or target (window sill, door opening, roof line, balcony, etc.). This is when both beams are spaced evenly above the target line. Placing only one beam in contact with a target could cause the ladder to twist when load is applied, damaging it!

If an aerial ladder or platform is designed to be used in the unsupported position, place the tip 4 to 6 inches above the target. This allows the ladder or platform to contact the building as people climb or descend without placing unusual stress on the device.

Supported and unsupported aerial ladder tip positioned on a roof top





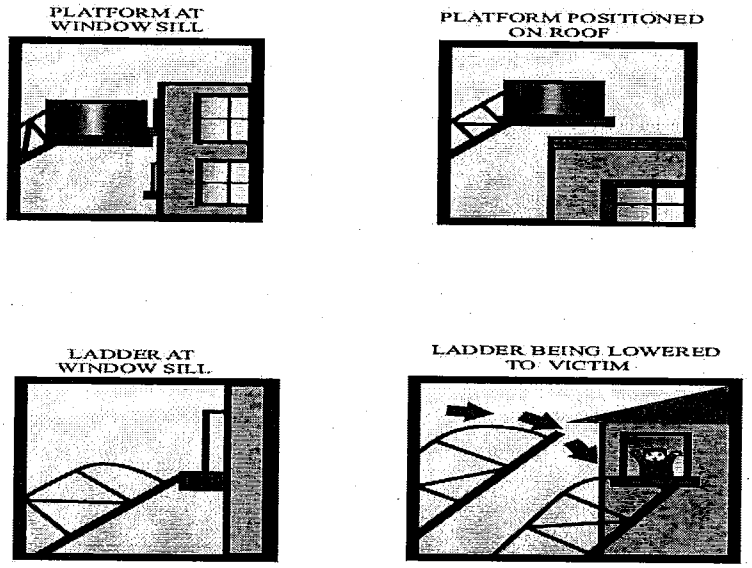
Remember, a ladder placed at a window for rescue should be positioned at or below the sill. If an opening is large enough or there is enough room for a victim or firefighter to climb over or around the ladder rails, the ladder could be placed inside a window or over a railing system.

It is also important to remember, if an aerial ladder is equipped with manual ladder locks not to get the ladder wedged under a sill when trying to extend the ladder while disengaging the ladder locks. The ladder must be extended first before the locks can be disengaged.

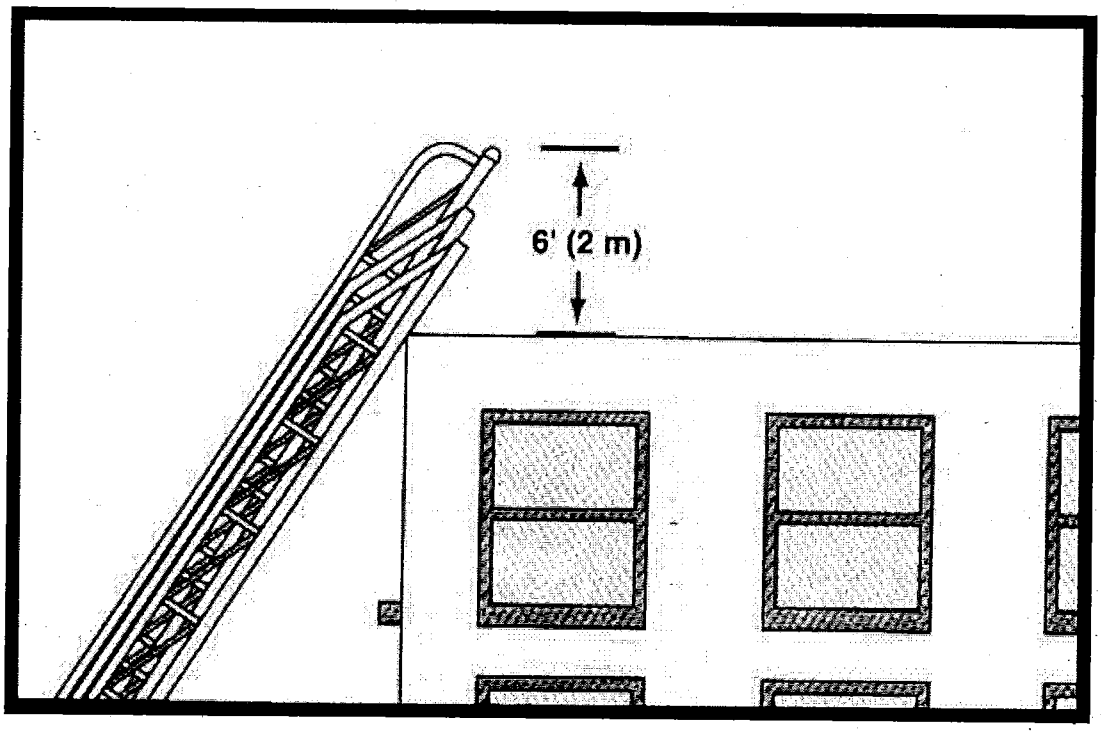
When positioning an aerial ladder on a roof for rescue, the tip of the ladder should be extended 6 feet above the roof line, if possible.

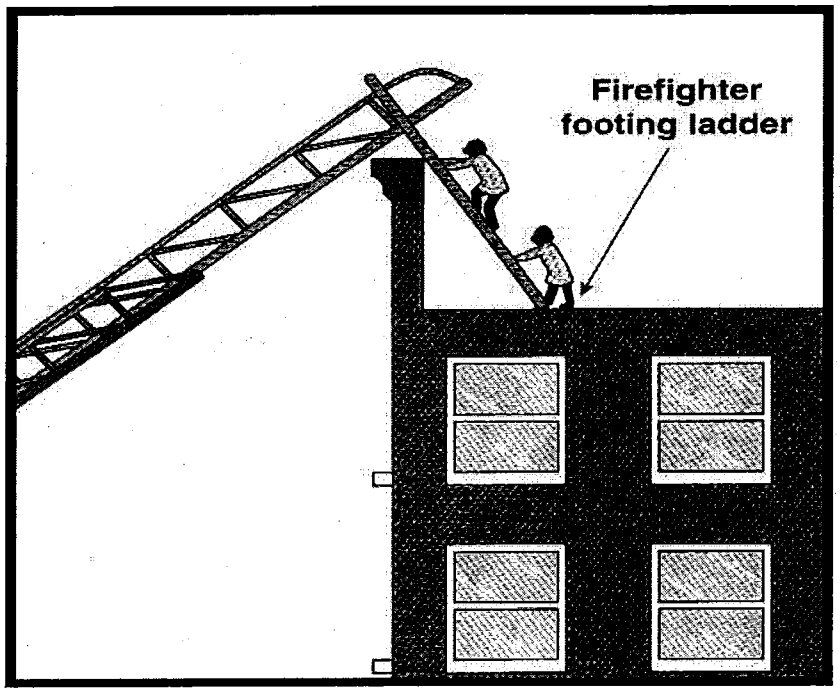
When positioning a platform or bucket on a roofline for rescue, the floor of it should be placed over the roof line overlapping it, or even with the roofline.

Platform and ladder positioning at windows or roof:



Extend the ladder tip 6 feet above the roof edge. This provides a handhold for firefighters and victims.





Placing the top railing of a platform at a window sill, door, or balcony railing is also an option when affecting a rescue. This allows the victim to be lowered into the platform. Use caution while performing this technique, shock loading the aerial device could result if the victim jumps down into the platform or is lowered to quickly.

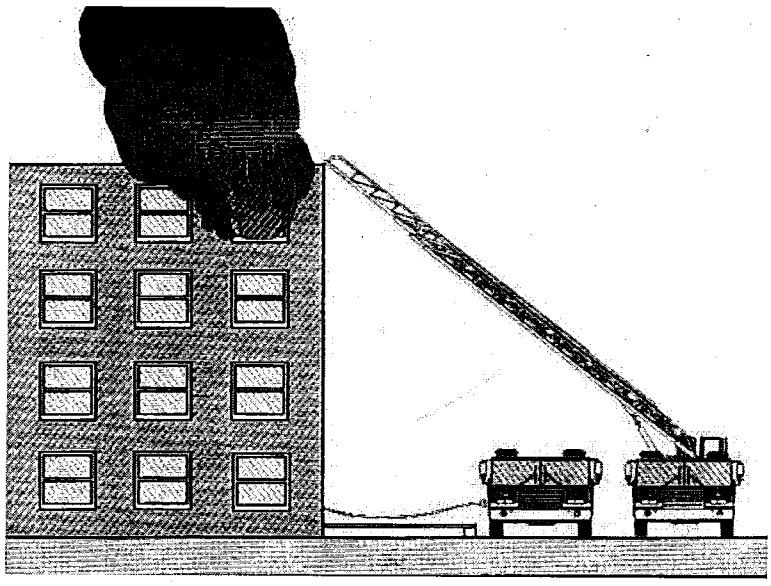
Positioning for use on upper floors

Aerial apparatus should take preference over other apparatus on building fires. Engine driver/operators have been taught to leave room for the trucks and towers mainly by pulling past or just short of fire buildings. This option may not always be available to incoming or first arriving engine companies. Because of sidewalks, parked cars, tight parking areas, and other roadside obstacles, other positioning alternatives must be considered.

Tactical considerations affecting aerial apparatus positioning.

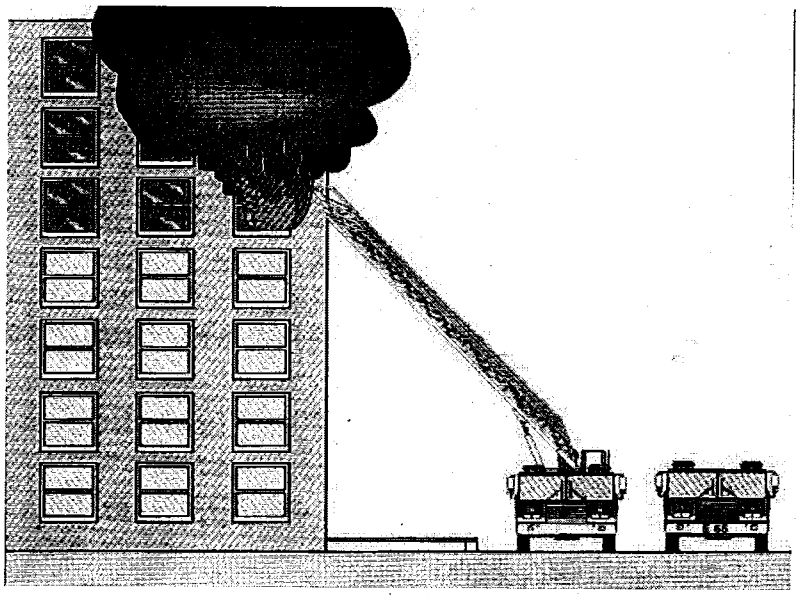
The following are considerations only and not department policy.

- If the fire is located on upper floors of a building that is <u>less than five stories</u>, the aerial apparatus may be positioned outside of the engine company.
- If the building is <u>greater than five stories</u>, the aerial apparatus should be positioned inside the engine company.



*If fire is located on the lower levels of this building, this tactic is not recommended for Aerial Towers. The engine company might prevent the tower from sweeping low while the master stream is in use.

If the building is greater than five stories, the aerial apparatus should be positioned inside the engine company.



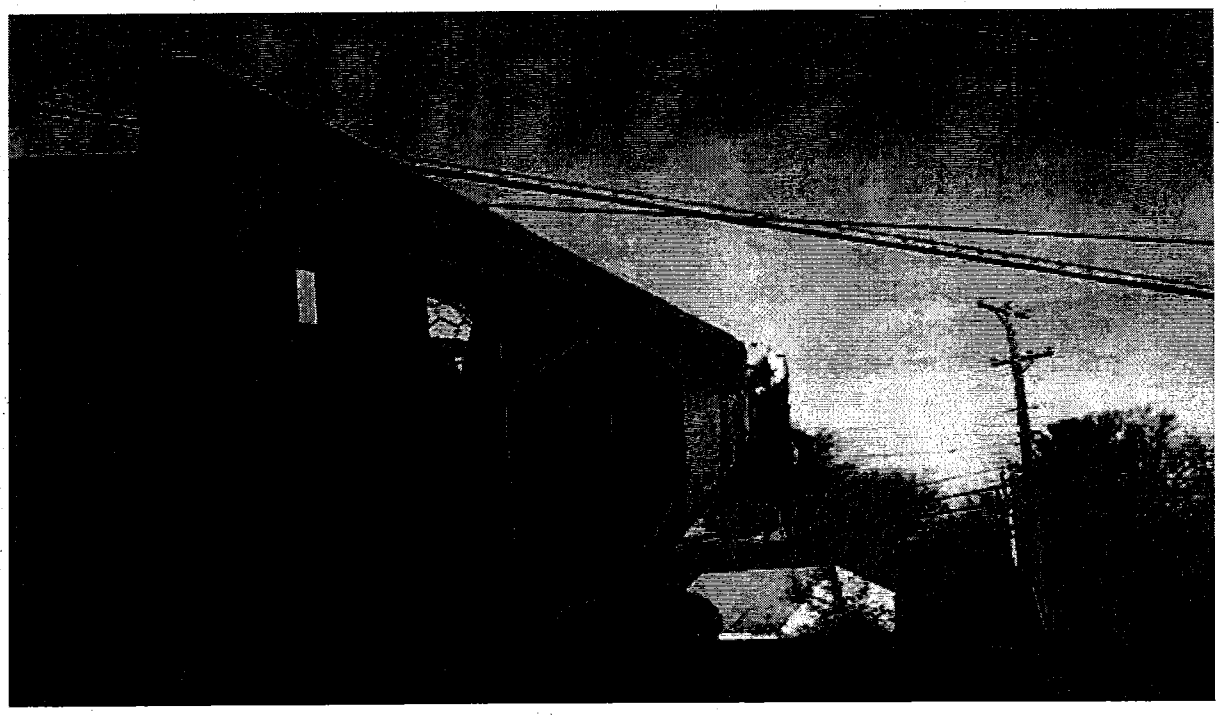
Operating near overhead obstructions and electrical wires

Aerial driver/operators must always be aware of overhead power lines and obstructions.

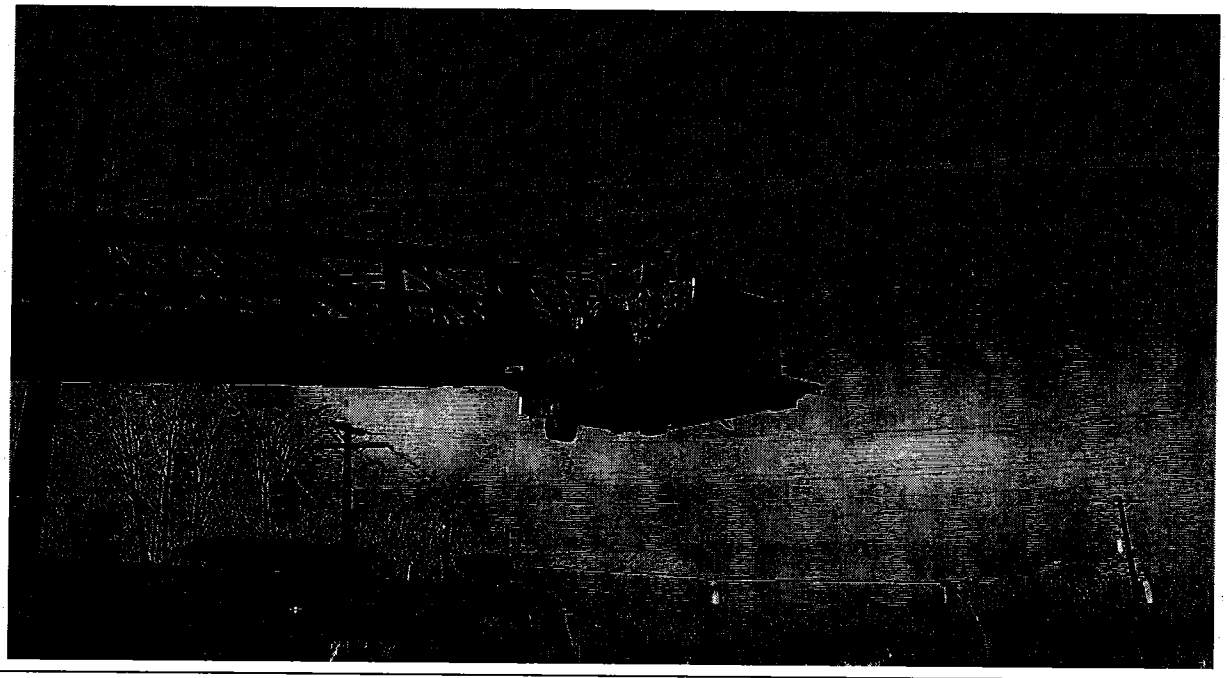
If possible, avoid spotting the apparatus in positions that require a lot of maneuvering around obstructions. This cannot always be avoided, so use extreme caution.

- The goal is always to maintain a distance of at least 10 feet between the aerial device and overhead electrical lines.
- Caution must be exercised around other types of overhead lines such as telephone and cable TV lines.
- Other obstructions such as trees, poles, vehicles, overhangs, and other building parts should also be avoided.

Maintain a <u>ten feet</u> distance between the aerial device and electrical lines:



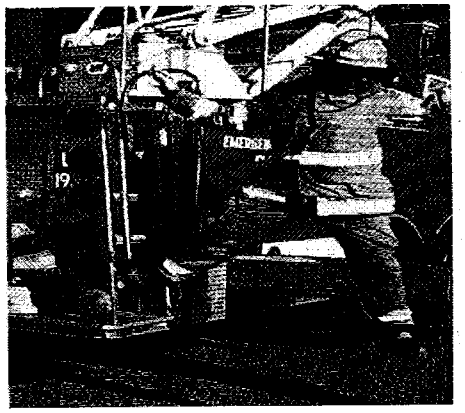
Caution must be exercised when operating around other types of overhead obstructions such as telephone and cable lines:



Warning!

If it becomes necessary to exit an apparatus in contact with electrical lines, personnel need to jump clear of the energized apparatus to reduce the risk of being electrocuted. At no time should they be in contact with the truck and the ground at the same time.

If it becomes necessary to exit a potentially energized aerial device, the firefighters should jump clear of the apparatus.



Warning!
Before you decide to jump clear of an energized apparatus, make sure that you will not be jumping into standing water or high moisture areas which may be in contact with the downed power lines or apparatus and could be energized!

Off-road positioning "Lawning"

Positioning aerial apparatus off-road is necessary at times but extreme caution must be exercised if it has to be considered. Positioning off road does not necessarily mean that the apparatus will have to be positioned on a soft surface but in many cases it does.

If aerial apparatus needs to be positioned off-road or on a soft surface, the following should be considered:

- The manufacturer's recommendations (does the manufacturer endorse setting up on these surfaces?)
- The type of surface; glass lawns (rain saturated or hard due to freezing), hot pavement (thin, basketball or tennis courts, or parking areas, etc.), muddy fields
- Is the surface hard enough to support the weight of the apparatus?
- Has there been any precipitation lately?
- Is the grade or topography too steep to stabilize the apparatus according to the manufacturer's recommendations?

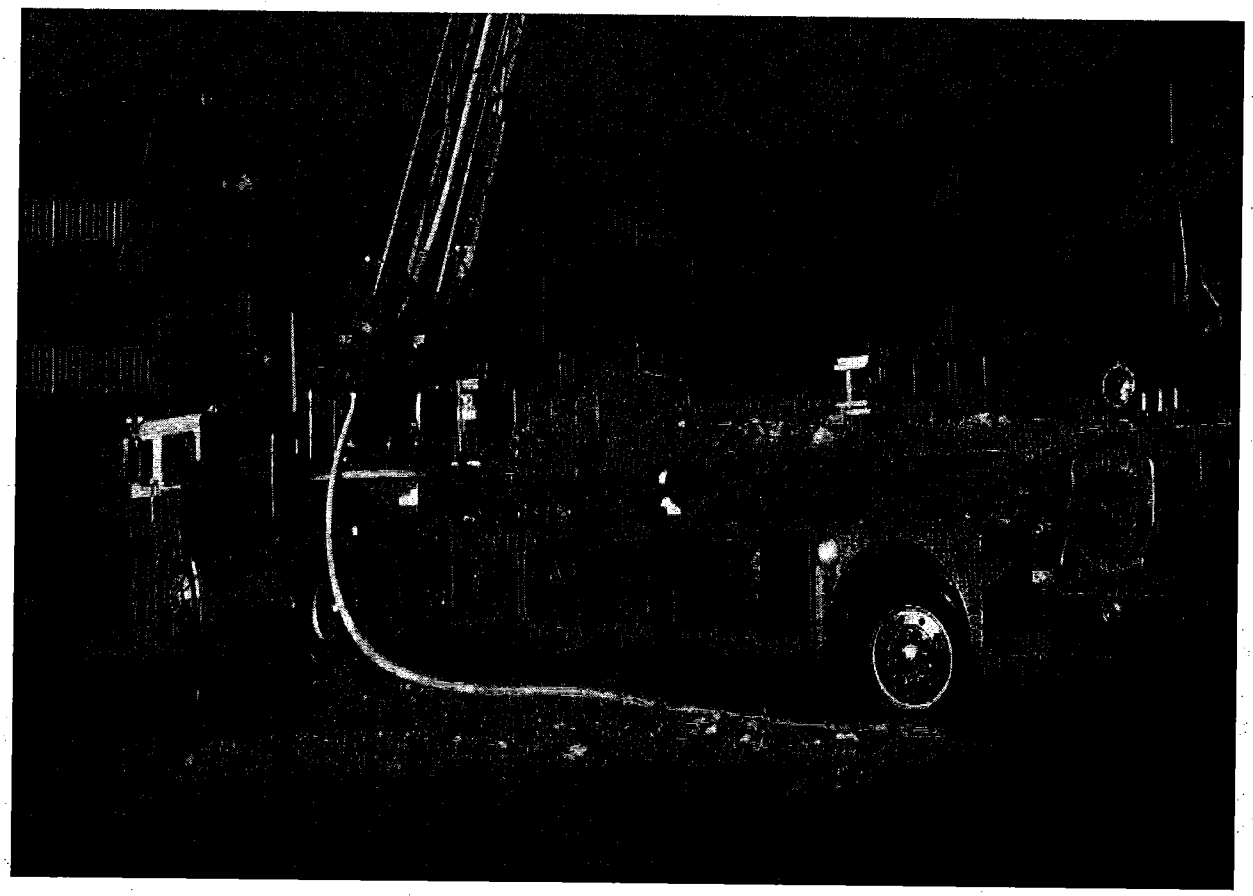
Warning!
If the aerial unit has to be "Lawned" or stabilized on a soft surface, it should remain supported on its stabilizers until it is ready to be relocated back onto a hard surface. This action will prevent (in most cases) the unit from sinking into the ground up to the axles causing it to get stuck!

Wind and weather considerations

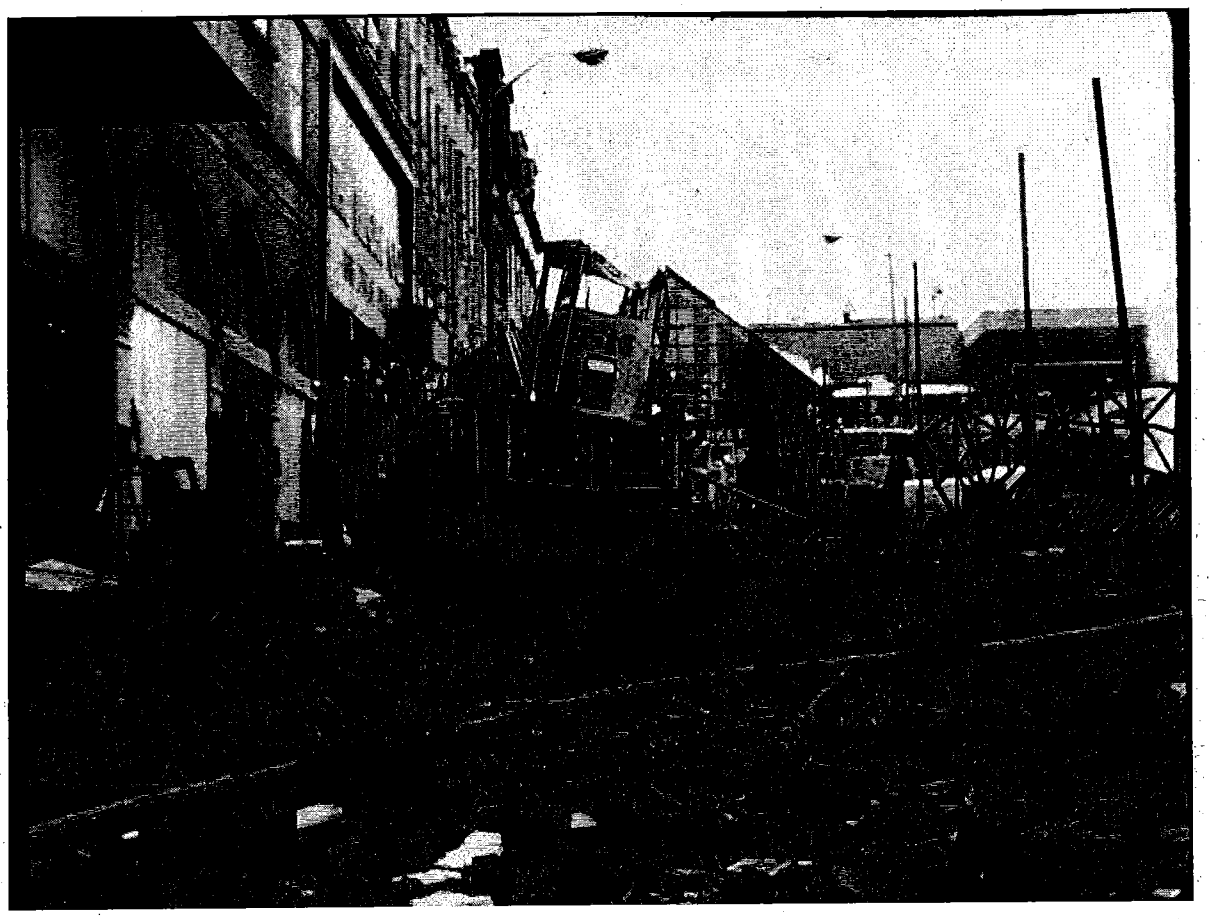
Windy conditions can have adverse affects on aerial apparatus. You must be aware of the manufacturer's recommendations regarding when to use an aerial device in these conditions. Many manufacturers recommend not using the aerial when the wind speed exceeds 35 mph. You must know what the limitations are of your apparatus!

Operating in icy conditions can also have adverse affects on the apparatus and operators. Stabilizing aerial apparatus on compacted snow or even ice can be very dangerous, as the snow or ice can melt away after stabilization has been completed causing the apparatus to settle and potentially become unstable. This is not always avoidable but must be continually monitored by the operator and crew.

- Ice accumulations on an aerial device can add weight to it reducing the rated capacity. So be aware!
- Refer to the user's manual regarding deicing procedures for your apparatus.
- Most often keeping the aerial ladder greased according to the manufacturer's specs is the best remedy.



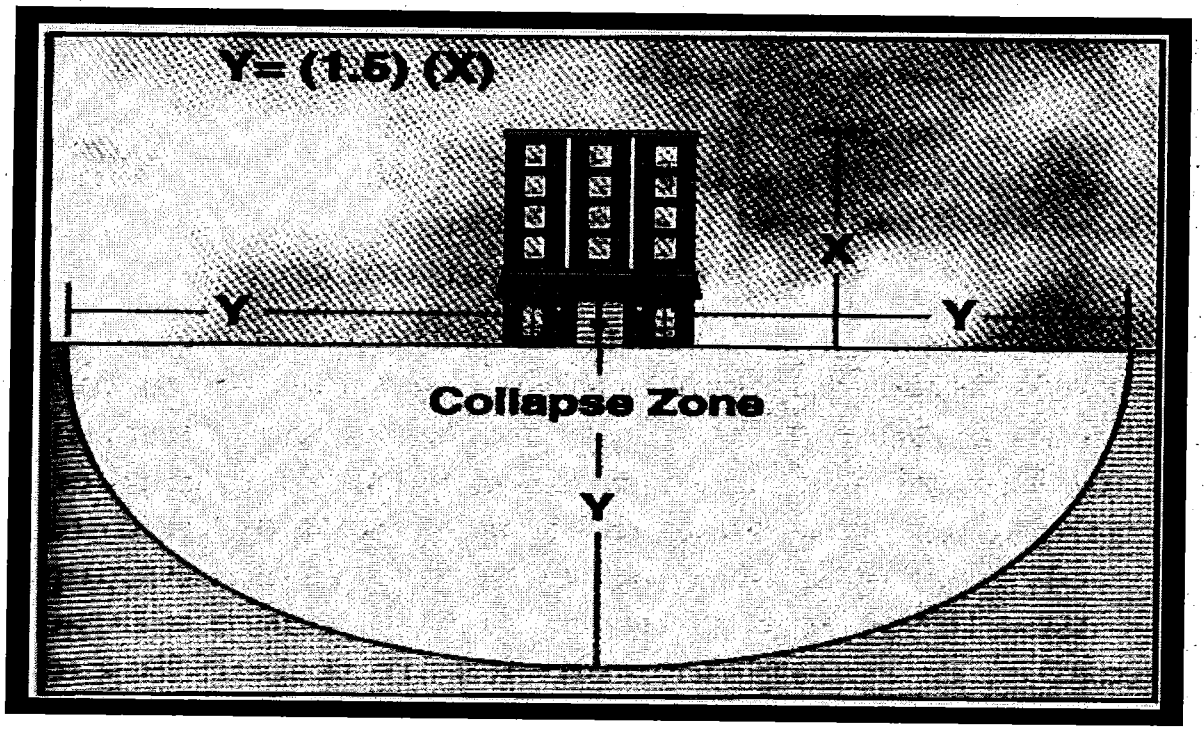
Collapse Zone



Collapse Zone

The condition of the fire building, as well as other building-related concerns, must be considered when positioning the apparatus. Buildings that have been subjected to extensive fire damage or buildings in poor condition before the incidence of fire may be subject to sudden collapse.

Apparatus should be parked far enough away from these types of fire buildings so they will not be in the collapse zone should a collapse occur! The collapse zone should be at least equal to <u>one and one-half times</u> the height of the building.



Operating near Railroad Tracks

****NEVER OPERATE APPARATUS ON TRACKS****

- TRY TO PARK APPARATUS ON THE SAME SIDE OF THE TRACKS AS THE INCIDENT
- KEEP APPARATUS AT LEAST 25 FEET AWAY FROM TRACKS
- KEEP AERIAL DEVICES AT LEAST 25 FEET ABOVE THE LEVEL OF THE RAILS

Aerial Positioning

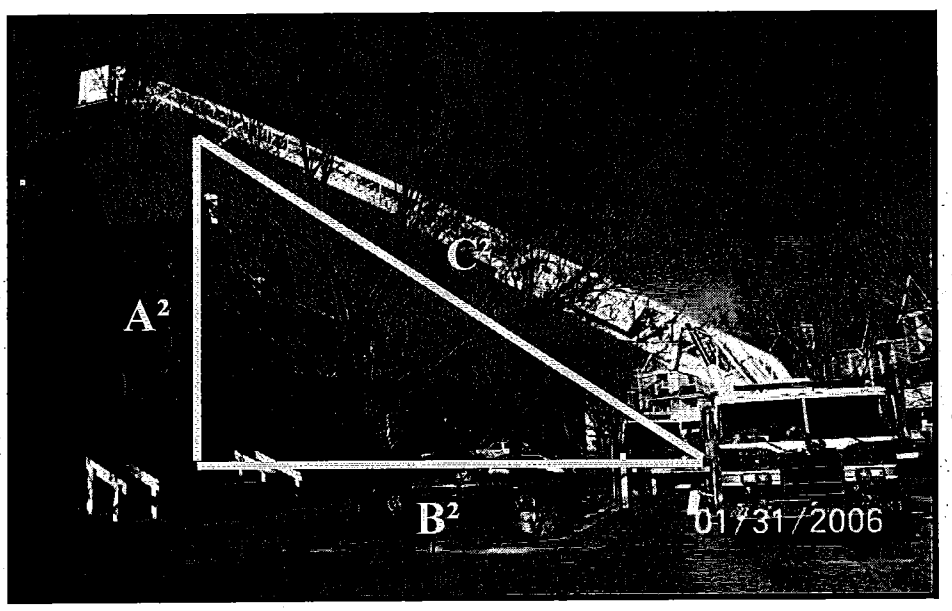
Aerial positioning is dependent on many factors such as access, type of structure, primary objectives, hazards, obstructions and most importantly the reach of the aerial ladder. The effective reach of an aerial ladder or tower will depend on the configuration of the apparatus i.e., is the vehicle a rear mount, mid-ship or tractor drawn aerial or tower.

Regardless of the type of aerial apparatus you are operating, the key consideration when using an aerial ladder or tower is the position of the turn table in relation to objectives. To further illustrate this point we must understand how the turntable position affects the usable reach of an aerial device. The greater the distance the turntable is away from the target area, the less height and reach will be available.

The Pythagorean Theorem

"To understand the importance of reach and height of a ladder, consider a right triangle. The length of the hypotenuse (longest side of a triangle) equals the square root of the sum of the other two sides. When an aerial ladder is elevated, the ladder is the hypotenuse of a triangle of which the ground and the vertical wall of the building at the point to be reached represent the other two sides. Thus, the distance a given length of ladder will reach depends upon the other two sides of the triangle". (Fire Officers Guide to Operating Aerial Apparatus, 1974)

The square of the length of the hypotenuse of a right triangle equals the sum of the squares of the lengths of the other two sides. $A^2 + B^2 = C^2$



In this illustration, "A" equals the height of the building (use 12 feet per floor for commercial and multi-family structures), "B' equals the distance from the building to the turntable and "C" is the required distance to reach the building.

Example 1:

A^2 (36x36) + B^2 (50x50) = C^2
1296 + 2500 =3796
(Calculate the square root of C^2)
The square root of 3796 is 62.
In this example the required reach is 62 feet.

Example 2:

A^2 (75x75) + B^2 (25x25) = C^2
5625 + 625 = 6250
(Calculate the square root of C^2)
The square root of 6250 is 79.
In this example the required reach is 79feet.

The significance of this is for the aerial operator to recognize the importance of turntable positioning in relation to the targeted objectives.

POWER TOOLS AND EQUIPMENT

Portable Fans

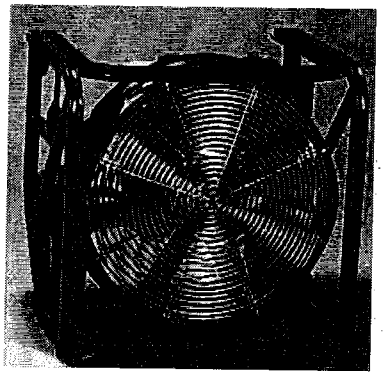
Portable fans provide the fire service a vehicle for achieving one of several critical elements of any firefighting effort: timely and effective ventilation of an affected structure. Whether carried out as part of a well-coordinated fire attack, or during overhaul operations, the ability to rapidly remove 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)

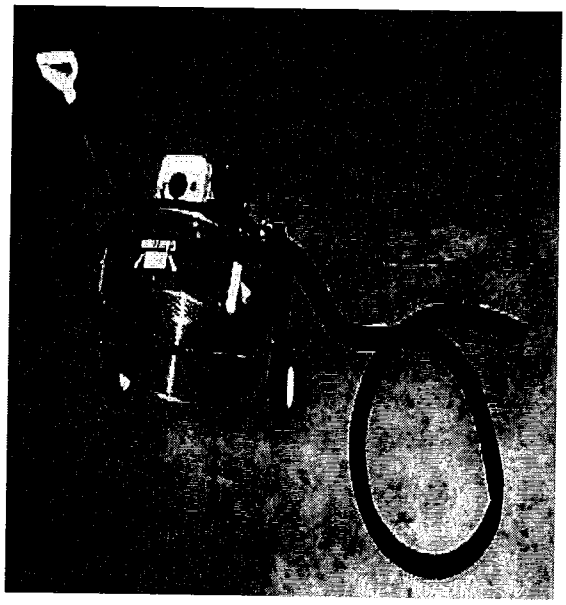
The type of fan employed on the fireground is largely driven by the nature and availability of specific power sources. Until the early 1990's, the fire service utilized electric "smoke ejectors" for all ventilation applications. This resulted from the fact gasoline-powered fans had yet to be introduced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

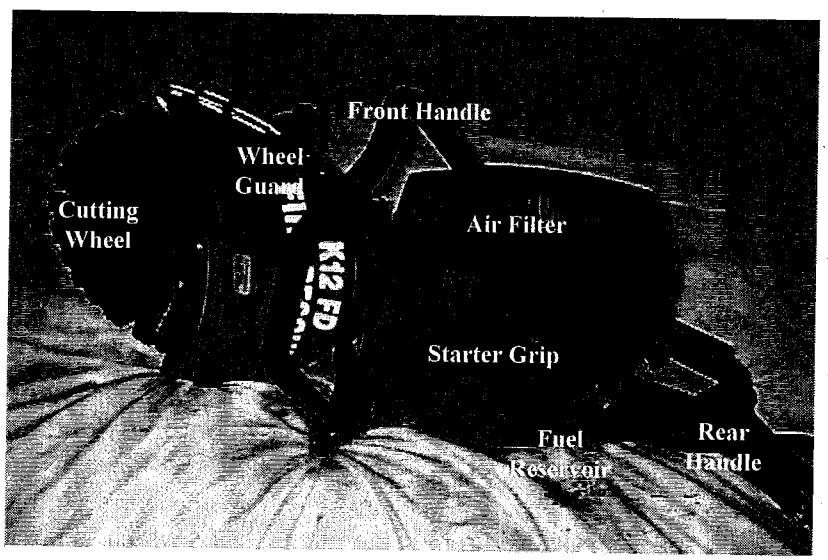
When operating these saws, a firefighter must wear proper personal protective equipment (PPE). Proper PPE must include adequate hearing protection, approved eye protection, turnout gear (when appropriate), and leather work/firefighting gloves.

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.

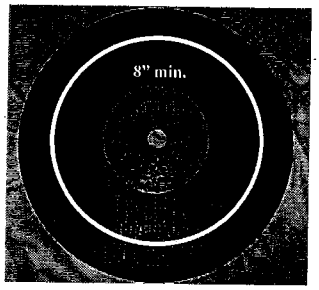
Composition	Material	Material To Cut
Composite /Abrasive	*Aluminum Oxide*	*Metal*
This blade type can be used to cut all ferrous metals. Ferrous metals include mild steel, stainless steel, rebar, and metal pipes.		
Composite /Abrasive	*Silicon Carbide*	*Stone Cutting*
This blade type can be used to cut 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:

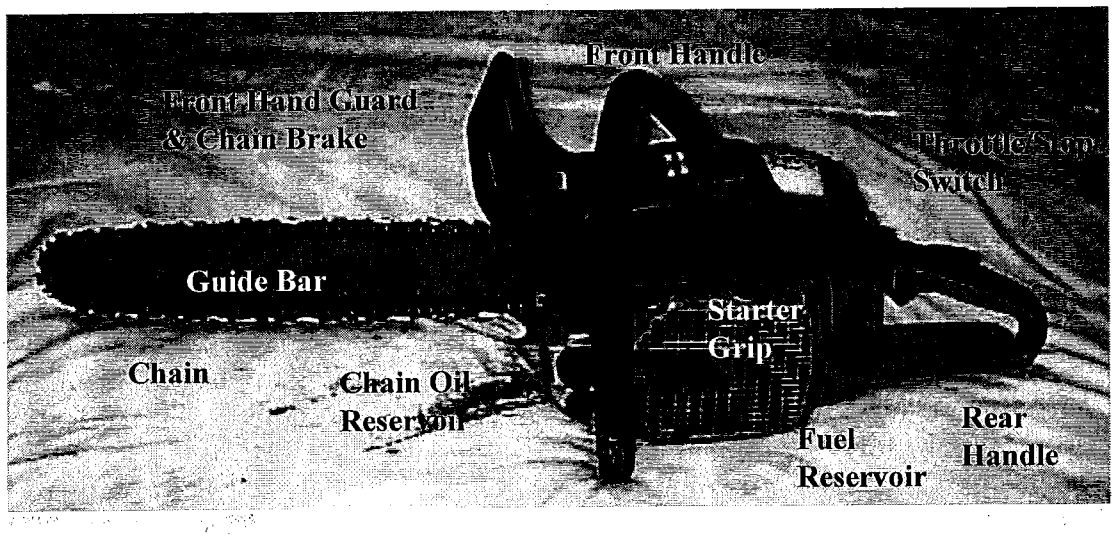
- the fuel reservoir is full and the fuel cap is secure;
- the blade guard is in place and positioned properly;
- the drive belt is secure, undamaged, and belt tension is appropriate*;
- the starter rope and housing are in place, and the rope is not frayed; and
- the cutting wheel is securely mounted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

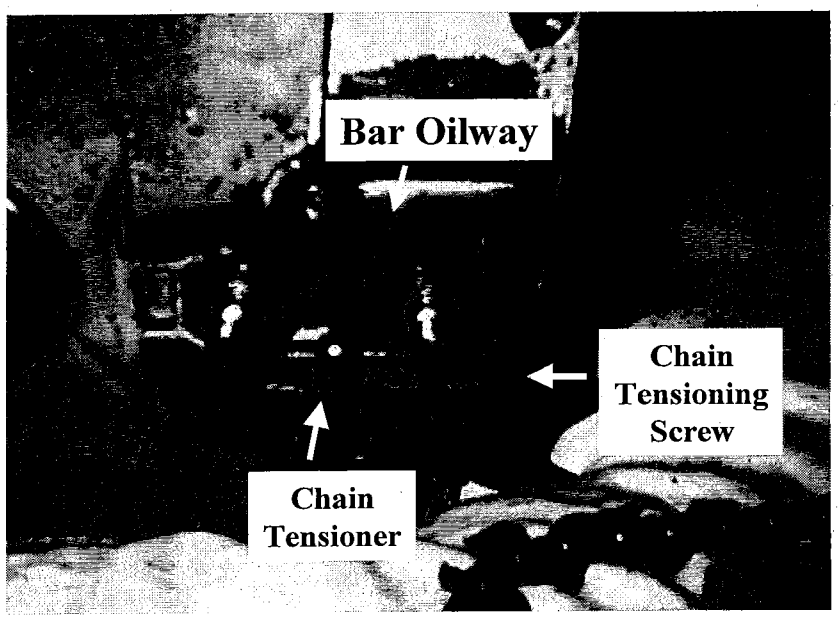
A critical component of safe and effective chain saw operation is that which relates to chain lubrication. The saw's chain and guide bar must be continuously lubricated during operation to protect them from abnormal wear. On most saws, the capacities of the oil and fuel tanks are balanced in such a manner 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.

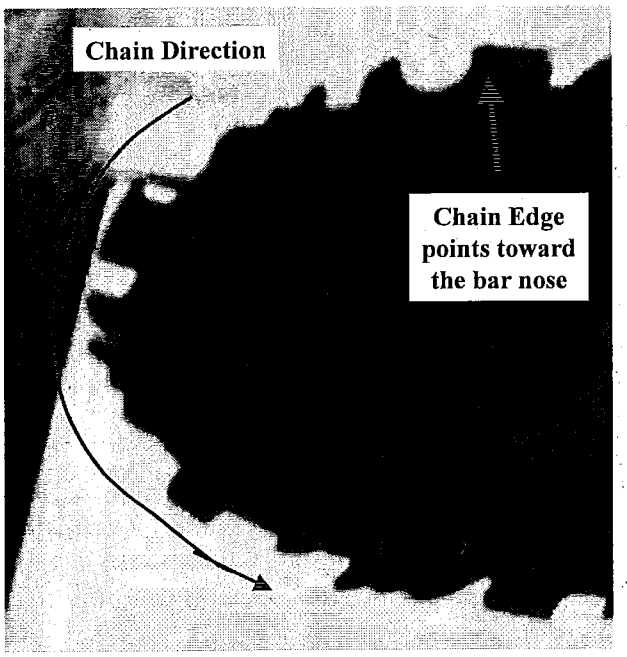
Chain Tension:

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

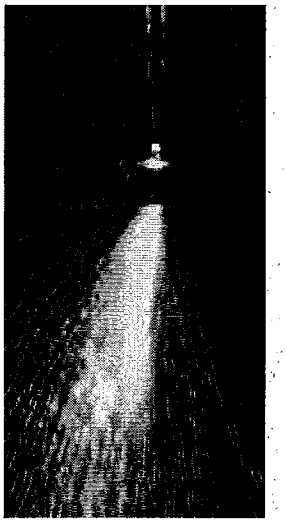
Within the fire service a great separation exists as to the proper procedure to perform operational checks on small motor driven equipment. Some will say that the tool needs to be started every day to ensure that it will operate when needed on the next emergency incident. While others say that starting 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.

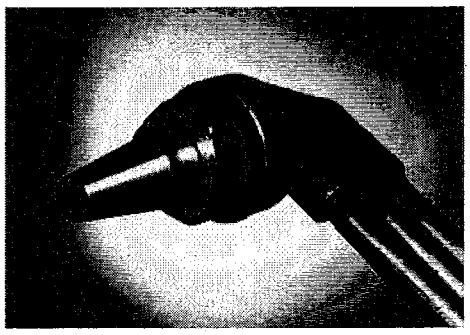
Other gases used in torch operations are propane, methylacetylene-propadiene (MPS), natural gas, and propylene. A variation of MPS is MAPP. MAPP is actually a mixture of MPS that is sold by Airco Inc.

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.

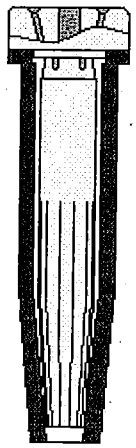
Torch Tips



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

Elevators

Introduction

The intent of this manual is to provide information needed to safely and efficiently deal with elevator emergencies. This section includes but is not limited to elevator knowledge and inspection, general operation and safety features. The mission of elevator rescue is to safely remove occupants from an elevator that has malfunctioned and stopped in the hoistway while maintaining the safety and welfare of the occupants and fire/rescue personnel.

Terminology

Machine Room: Normally found on roof of structure above the hoistway if a Traction elevator. The main disconnect for the system is found in the Machine Room. If the elevator is Hydraulic, the Machine Room will be found on the lower level near the elevator.

Hoistway: May also be known as the Shaft. The vertical opening that encloses the elevator.

Car: The passenger enclosure.

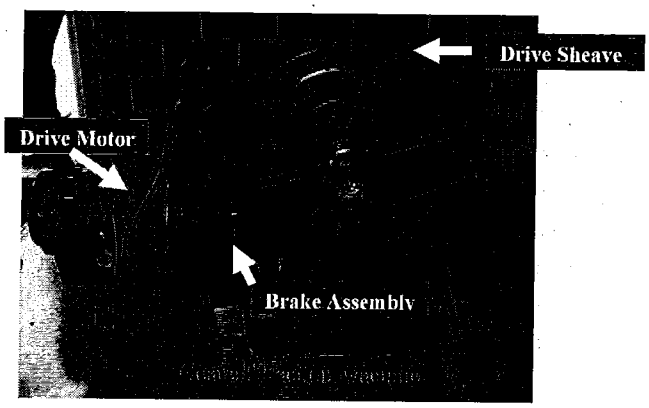
Landing Entrance: The elevator doors located on each floor of the structure. This provides the access for use of the keys or pole.

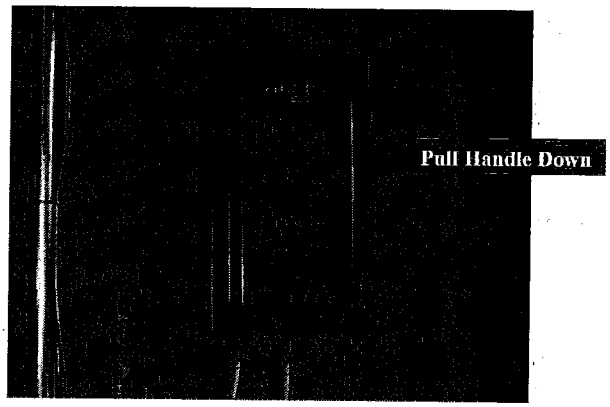
Pit: The bottom portion of the hoistway. Contains numerous moving parts.

Elevator Types

There are two types of elevators, hydraulic and traction. Hydraulic elevators have a motor-driven pump, a hydraulic cylinder and a fluid reservoir. Pressure is put on the cylinder and the car is raised. Gravity lowers the car back to the lowest floor. Traction elevators have a hoisting machine, ropes/cables and a counterweight. Traction is achieved by friction on the driving sheave, which in turn raises and lowers the car.

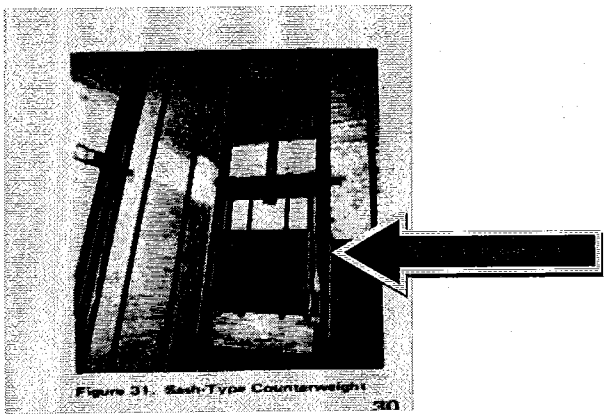
The traction elevator can either use a geared or gearless traction machine. Regardless of the type it will have a governor, controller and machine disconnect switch.


Drive Sheave
Drive Motor
Brake Assembly


Pull Handle Down

Hoisting ropes are wire cables designed specifically for elevator use. The ropes are designed to carry not only the weight of the car but the live load within the car. Multiple ropes may be used to increase traction. Redundant ropes provide a safety factor for the car. The ropes are all oily and can have burrs on them. Gloves must be used when functioning with the ropes.

Counterweights are specifically designed weights on the opposite ends of the hoisting rope from the car. The counterweight equals the cars' total dead weight plus 40% of the cars' designed live load



Lock-out/tag-out is the process of locking/removing power from the machine and declaring a safe work area.

Elevator Car Rescue

If a patient needs to be rescued from a car that is not in working order, access to the car will need to be made. This access can be made in one of three ways. First, using the elevator keys, disengage the door interlock mechanism. Second, use an elevator pole to disengage the door locking mechanism. If neither of the first two options work, use standard forcible entry tools to break and remove the doors.

When beginning any elevator rescue, locate the car and contact the occupants. Check the fireman's' service first to see if the car will move. Attempt to use the keys and pole prior to using forcible entry. Finally, remember to ALWAYS protect the hoistway.

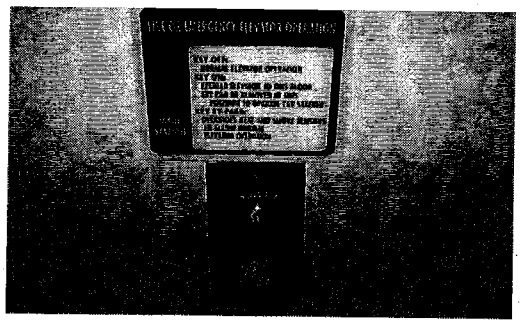
Only remove patients from a non-working elevator if it is safe to do so. Remember to follow all standard safety policies. Perform Lock-out/Tag-Out. Remember to stay within the hoistway of the rescue operation. Prior to performing the rescue, determine which exit will be safest for both the occupants and the rescuers: car top, side exit, through the doors. Do not have any more than two rescuers on top of the elevator car.

Important: Always follow Lock-Out/Tag-Out procedures for the main power disconnect prior to entering an elevator hoistway for rescue.

Comment [CU1]: What about power control?

Fireman's Service

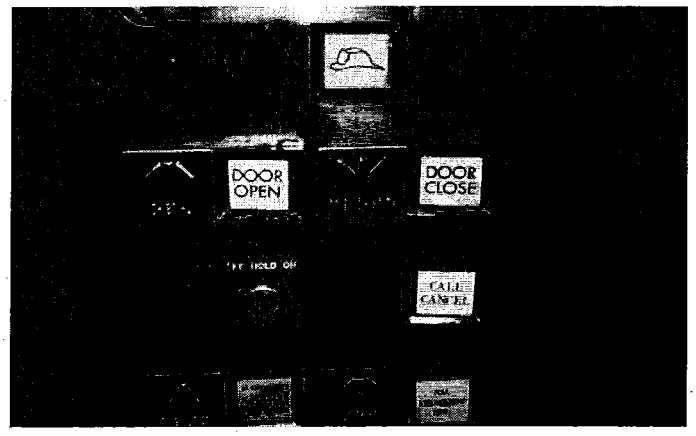
The Fireman's Service button is activated by utilizing the key switch in the lobby of the building. Once the key has been turned to the On position, the elevators will all come to the lobby and park with the doors open. This function will only work if the elevator is activated. Phase 1 of this function is completed when the elevator is in the lobby or at the desired floor. This will prohibit residents from utilizing the elevator during an emergency. Below is a picture of the fireman's service button found in the lobby of a building.



Once inside the elevator, observe the fireman's service button. If lit, the elevator is in fireman's control. By accessing the key switch inside the elevator, Phase 2 of the elevator control begins and the fire department will have control of the elevator. Test the door open/close buttons to make sure that they still work. This will prevent the elevator from stopping at the wrong floor. Remember to stop the elevator several floors below the reported fire.

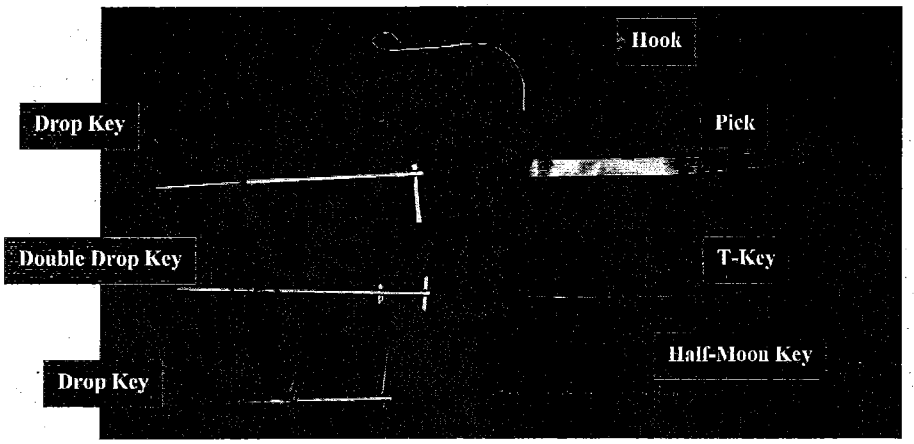
Comment [CU2]: Explain how firemen's service functions

Comment [CU3]: Explain Phase 1 & 2

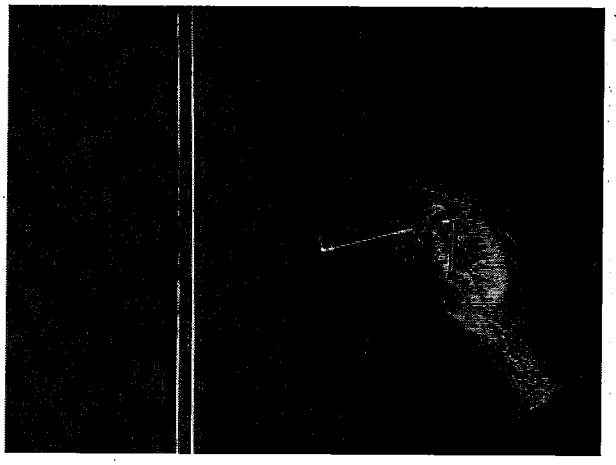


Elevator Keys

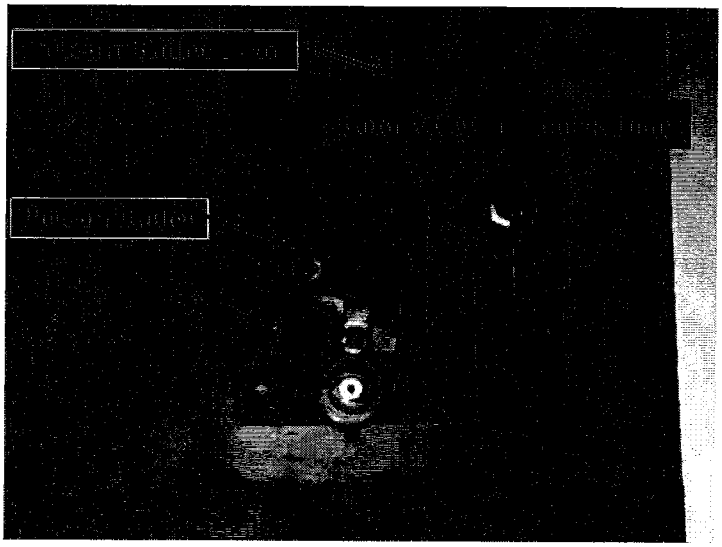
Below are examples of various elevator keys used to access the hoistway doors.



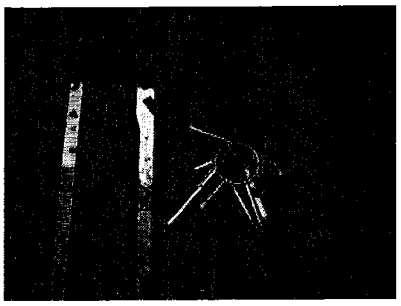
Insert the appropriate key through the hole on the front of the car door until the tip drops.

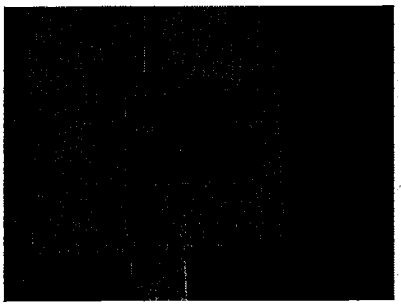


Once the key drops through the backside of the car door, turn the key until it catches on the pick-up roller arm. Continue to turn key until car door opens.

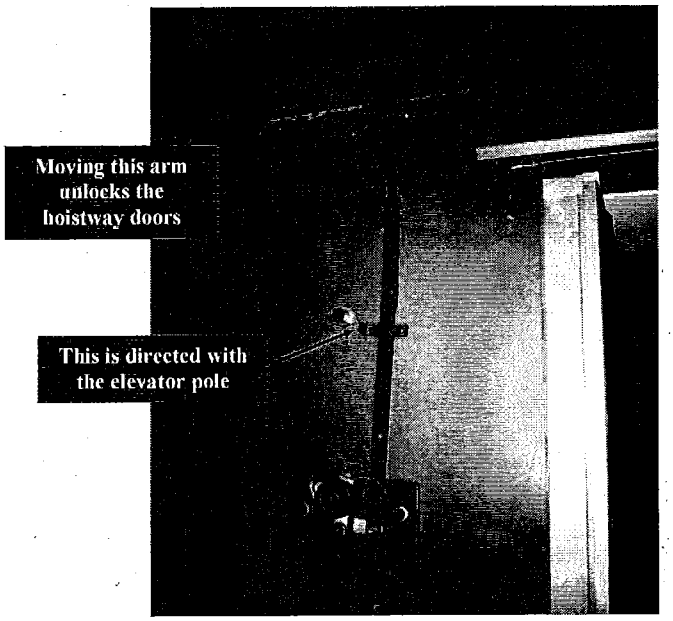


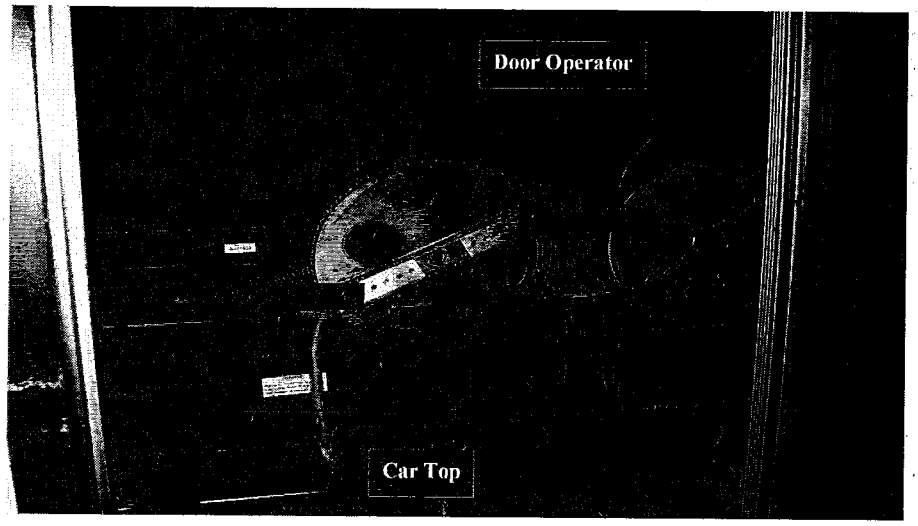
Poling the Elevator





If poling the elevator is necessary, use the hook and access from the closest door using the appropriate elevator key. Using the pole, unlock the hoistway door above. Additional personnel stationed at the elevator above will open up those doors, pull up the pole and utilize that pole to open the door above.



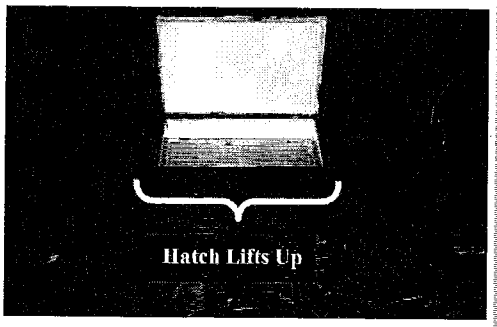


Hoistway doors provide protection for the hoistway opening. They may be single speed or two speed horizontal, bi-parting vertical, or swinging. Swinging doors are normally found on residential elevators. The doors operator will open the car doors which will then allow access to the passengers. The car doors are the only doors that are powered.

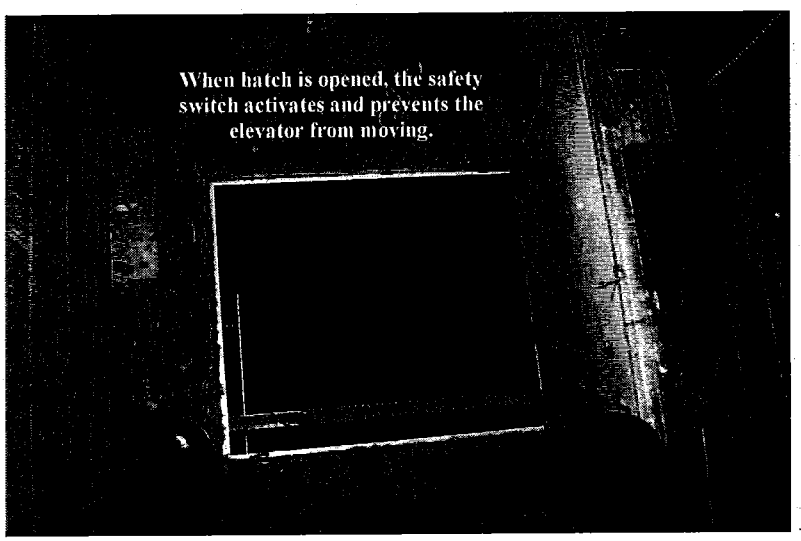
Comment [CU4]: Insert car top control procedures.

Emergency Hatch Access

If access through the door of the non-working car is not available, use the cartop of the adjacent car for your inspection. To move the working car in-line with the stuck car, have a rescuer enter the working car. The rescuer then takes the working car down below the stalled car. Open the hoistway door of the working car and locate the car top inspection station. On the inspection station, move the stop switch to Off and the Inspection/Automatic switch to Inspection.



Have the rescuer exit the working and then close the doors using the wheel on the door operator. Close the hoistway doors and while standing in the middle of the car top, push the direction button to move the elevator into position next to the stalled car. Open the emergency hatch of the stalled car, and, using a folding ladder, rescue any trapped individuals.



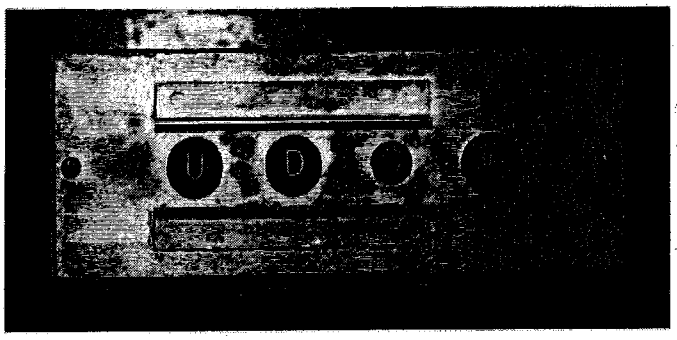
Comment [CU5]: Insert step by step recluse sequence.

Comment [CU6]: Insert recommended forcible entry techniques

Comment [CU7]: Insert pictures an info on all interlocks.

CAR TOP INSPECTION STATION

Car Top Inspection Station: A control panel on top of an elevator car which, when activated, removes the car from normal service and allows the car to run at inspection speed from the car top station only.



22

Steps for Elevator Rescue

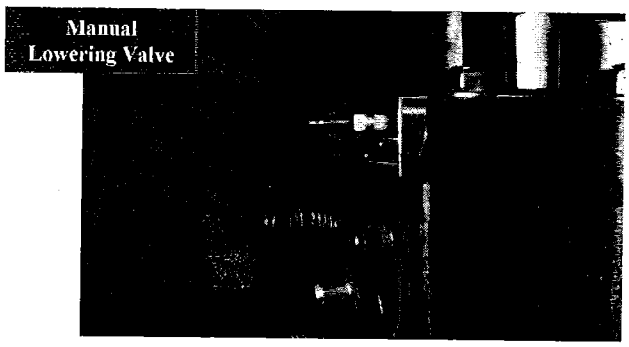
1. Locate the elevator in the hoistway. Check the position indicators and relay to officer.
2. Determine if any medical emergencies exist inside the stalled elevator.
3. Lockout/Tagout main line disconnect in machine room.
4. Determine what is best access for rescue.
5. Open hoistway doors using elevator keys or by poling the elevator. Open the car doors – use the door operator if necessary.
6. If no access to the doors is available, use the adjacent elevator to access the car top.
7. Do not place too many people on top of the working elevator when performing a rescue. Move them to the nearest hoistway door for exit.

Forcible Entry

If forcible entry through a hoistway door is necessary,

Hydraulic Elevator Emergency Access

If a hydraulic elevator is stuck between the floors, you may have to manually lower the elevator in order to perform a rescue.



First, using lock-out/tag-out, ensure that the power has been shut off and place a firefighter at the lower hoistway opening with the doors open. Open the valve at the top of the car until the elevator moves. When the car reaches the same level as that of the firefighter at the lower hoistway, close the valve. This will stop the elevator and allow access for the rescue.

Elevator Fires

If an elevator has had significant fire damage, do not get on or into the elevator. Extinguish the fire using long hooks to remove any debris. If the cables have been exposed to high heat, they may fail causing the elevator to drop into the pit.

Pneumatic Tools

Introduction

Pneumatics refers to technology dealing with the application of pressurized gas (potential energy) to produce mechanical motion (kinetic energy). Pneumatic systems used in the fire/rescue service primarily use compressed gas as the source of power.

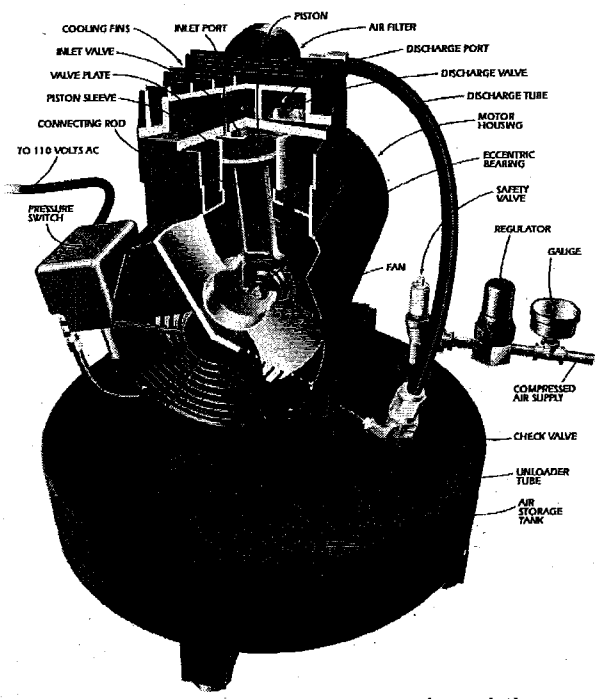
There are a variety of pneumatic tools used in the fire/rescue service, each with a specific function. While some of these tools were developed specifically for rescue, many are simply borrowed from other industries, such as the automotive repair industry.

All of the components of a pneumatic tool setup will be discussed in this module, starting with the air source and working downstream to the actual tool.

Air Sources

The key component to any pneumatic tool or airbag operation is compressed air. Compressed air can be obtained from a variety of sources on a rescue incident:

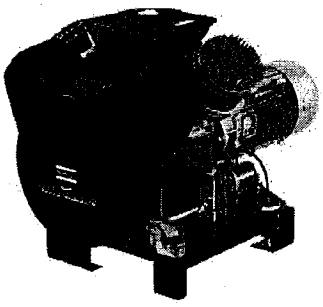
Air Compressors



Air compressors provide an unlimited supply of air. The most common type is the positive-displacement compressor that uses a reciprocating piston. (Other types that utilize impellers or rotary screws do exist.) The piston air compressor has components similar to an internal combustion engine: a crankshaft, connecting rod and piston, cylinder and a valve head. Typical compressors come in 1- or 2-cylinder versions and can be single- or two-stage.

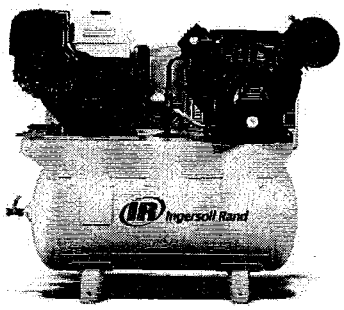
The compressor supplies a storage tank. When needed, air is drawn from the tank and the compressor replenishes it. Air compressors stop supplying the storage tank when pressure inside the tank reaches a specified limit. When air is consumed and the pressure in the storage tank drops below a certain level, the compressor starts up again.

Air Compressors (continued)



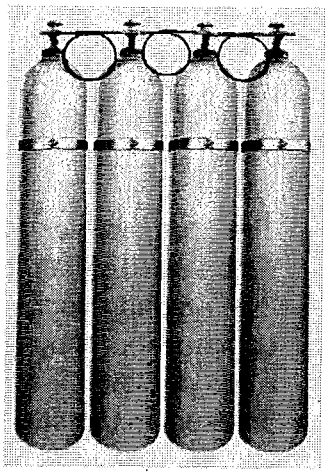
Air compressors can be permanently mounted in a structure or on apparatus or they can be portable. They can be driven by an electric motor or an internal combustion engine, either directly or via a PTO.

The source of the compressor's power isn't as important as the compressor's capacities for air production. Two important specs to know about a compressor are its ratings for volume and pressure output. Volume output for air compressors is expressed in cubic feet per minute (cfm). The cfm rating of the compressor will dictate the quantity and type of pneumatic tools it can adequately supply. The pressure rating of the compressor is also a factor to consider. A higher pressure in the storage tank means a larger quantity of air. Larger quantities of air can support tools with higher air consumption rates.



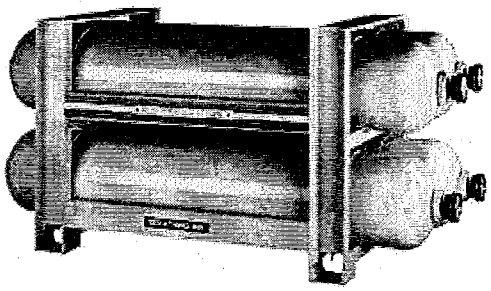
The quality of the air coming out of an air compressor is vital to tool and equipment performance and service life. Ambient air contains moisture. When air is compressed, its temperature increases as well as its ability to hold water vapor. When air travels away from the compressor to the storage tank, its temperature decreases. When the temperature decreases, the water vapor condenses and builds up in the storage tank, air lines, and tools. The water can corrode air tanks and damage internal components of air tools and equipment. Some air compressors use oil to cool and lubricate internal components. Some of this oil can leave the compressor with the air and make its way to tools and equipment. Incorporating air treatment devices like air dryers and filters are a necessity for prolonging the service life of a pneumatic system.

Cascade Systems



Another air source is a cascade system. A cascade system is a group of high-pressure cylinders (two or more) connected together and fed by an air compressor. The cascade systems on apparatus are usually filled from an external compressor at a fire station. Air in a cascade system moves from the point of higher air concentration to the point of lower concentration. The cylinder with the higher air pressure will force air into the cylinder with the lower pressure until the pressures in both cylinders equalize. Since all cylinders in a cascade system are interconnected, air can be drawn from only one cylinder or a combination of any or all cylinders. However, pulling from only one cylinder at a time will help maintain higher pressures in the remaining cylinders.

Cascade System (continued)



Cascade systems are most often used in the fire service to fill SCBA cylinders. These systems are filled with air compressors that meet OSHA and NFPA respiratory standards for breathing air. Therefore, air supplied with a SCBA cascade system will not contain the level of moisture and contaminants found in industrial air sources.

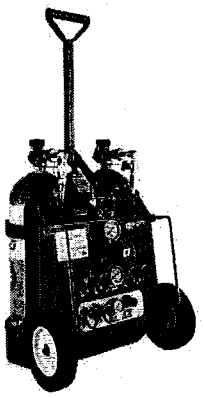
Self-Contained Breathing Apparatus (SCBA) Cylinders

Self-Contained Breathing Apparatus cylinders (SCBA) are a good portable air source when operating pneumatic tools and air bags. The caveat to their portability is the limitations on air volume. It is important to know cylinder capacities and quantities available during a rescue operation.

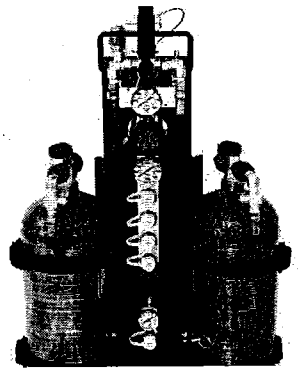
Scott 4500psi SCBA Cylinder Capacities	
30-Minute	45 standard cubic feet
45-Minute	65 standard cubic feet
60-Minute	87 standard cubic feet

**Scott Carbon-Wrapped, CGA Threaded Cylinders at 4500 psi – www.scottsafety.com

Mobile Air Carts



The air cart is a commercially made device that holds high-pressure cylinders. Two manufacturers of fire/rescue specific air carts are Scott Safety and Air Systems International. Both of these variations contain two SCBA cylinders. They are connected to a manifold and provide a number of air outlets. The air cart is designed to operate off of one cylinder at a time. It will provide an audible alarm when the pressure in the cylinder being used reaches a level of approximately 500 psi. At that point, the remaining cylinder can be opened, and the air cart will transition to the higher pressure. The cylinders are set up in an arrangement that allows for the replacement of one cylinder while using the other. This arrangement allows for an uninterrupted air supply. They also contain a high-pressure inlet that allows hookup to an external air source such as a Mobile Air Unit.



Air Brake Systems

The air brake system on commercial trucks can be used to supply air for pneumatic tools. The engine air compressor produces air for the air brakes and other components. These air systems generally operate around 120 psi.

Tractor trailers have an air connection between the tractor and the trailer in order to provide an air supply for the rear brakes. There will be two hoses, one red and the other blue. The hoses are connected via a glad hands coupling. The blue hose is used for normal braking operation and it is referred to as service airline. The red hose is the emergency airline. In the event that the red airline becomes disconnected (such as when the trailer disconnects from the tractor), the trailer brakes are automatically applied. On some trailers, the same type of connection can be found at the rear end of the trailer.

The service and emergency airlines are supplied by the engine air compressor on the tractor. An adapter can be used to make the connection to the glad hands coupling on the rear of the tractor, providing an air supply for pneumatic tools and equipment.

Fire Apparatus Auxiliary Air

Fire apparatus will typically have air connection(s) for auxiliary air hookup. These connections are supplied by the air reservoirs that are part of the vehicles air system. Just like the commercial air brake systems previously discussed, fire apparatus air systems can provide approximately 120 psi of useable air.

Tire Fill Adapter

With the correct type of adapters, air can be drawn from the tires of vehicles on the scene. Generally, fire apparatus tires have an inflation pressure ranging from 110 to 120 psi while passenger cars may only have 25 to 35 psi to offer. Consideration should be given to the volume of air necessary to accomplish a task when utilizing this air source.

Air Regulators

Air sources such as SCBA cylinders, air carts, cascade systems and some air compressors produce high pressure air (pressures in SCBA cylinders can be as high as 5500 psi). However, the majority of the pneumatic tools and airbags (even "high pressure" airbags) used in the fire/rescue service operate below 150 psi. Exceeding the normal operating pressures of pneumatic equipment can not only be a waste of valuable air supply, but also potentially damaging to the equipment. Therefore, a pressure-reducing device (pressure regulator) is needed to provide useable low pressure air.

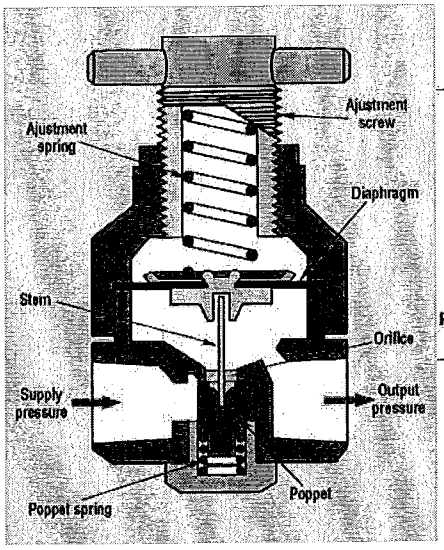
Components and Operation

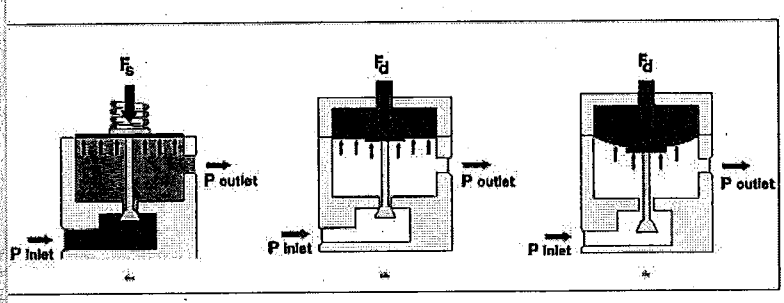
Pressure regulators are comprised of three functional elements:

- A pressure reducing or restrictive element (generally a poppet valve)
- A sensing element (generally a diaphragm or piston)
- A reference force element (generally a spring)

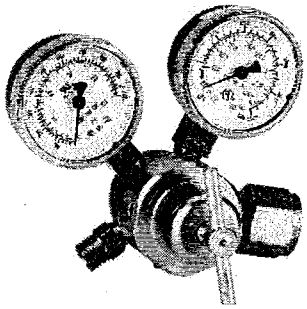
At a basic level, an air regulators work like this:

1. High pressure air flows into the high pressure chamber of the regulator
2. The adjustment screw is tightened, which compresses the spring
3. The spring compression produces force that pushes down on the diaphragm/piston
4. The force on diaphragm/piston pushes down on the valve stem, opening the poppet valve
5. Air is able to enter the low pressure chamber of the regulator
6. The regulated air creates a force that opposes the diaphragm/piston and closes the poppet valve.
7. Increasing the force in the spring will result in an increase in opposing force from the air in the low pressure chamber and thus an increase in outlet air pressure. Decreasing the force in the spring will have the opposite effect

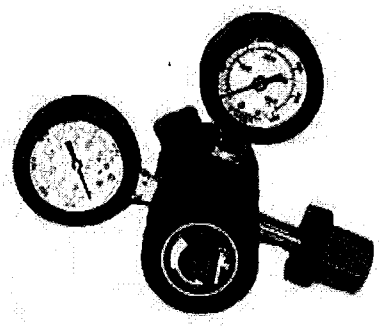




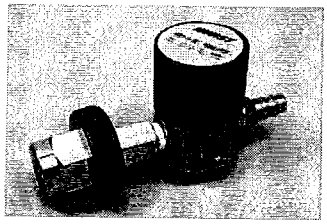
Diaphragm regulators are generally more sensitive to pressure changes and react more quickly. They are used for increased accuracy and low pressure applications. Piston regulators are more rugged and used when higher outlet pressures are required and are not held to as tight a tolerance. Both types are typically equipped with gauges to read both inlet and outlet pressures.



Diaphragm Regulator



Piston Regulator



Hurst PermaSet Regulator

A third type of regulator that is sometimes used in the fire/rescue service is the permanently-set or preset regulator. This regulator has a sensing element that is already set and is not adjusted during use. The outlet pressure on this style of regulator is set at the factory, generally at maximum of 175 psi. Hurst and Paratech utilize this style of regulator with some of their airbag controller setups.

Maintenance and Use

General operating practices are outlined in this section. Manufacturer's recommended operating procedures should always be followed when using a regulator.

Prior to connecting a regulator to an air source, perform the following:

- Check the regulator for any damage
- Ensure that inlet and outlet pressure gauges are reading "zero"; the regulator will still function with incorrect gauge readings, but a faulty outlet pressure gauge prevents accurate outlet pressure settings which could damage the equipment connected to the regulator
- Check the high pressure connection for the presence of an O-ring; replace if necessary
- If adjustable, ensure that the adjustment knob/handle is turned fully counterclockwise to lower outlet pressure and close the poppet valve, preventing the flow of air through the regulator. If the poppet valve is not closed when the high pressure source is opened, air can flow through the regulator, possibly at pressures too high for downstream equipment

Maintenance and Use (continued)

Once the regulator is connected to the air source, the operator should:

- Check for air leaks at the inlet (high pressure) coupling; if leaks exist, shut down the air source, check for O-ring issues and attempt to reconnect
- Connect the outlet (low pressure) coupling to an appropriate air hose
- If equipped, open the delivery shutoff valve on the regulator – this will allow air to flow through the regulator outlet downstream to the equipment
- Slowly turn the adjustment knob/handle clockwise to increase the outlet pressure to the correct setting; it may be necessary to fine tune the pressure adjustment once air tool operation begins and air is flowing through the regulator (Permanently set or preset regulators will automatically provide the set working pressure.)

Upon completion of the air tool/equipment operation, shut down the regulator as follows:

- Turn off the air supply
- Bleed the pressure from both the high pressure and low pressure sides of the regulator. Some regulators have an exhaust port that will slowly bleed pressure. Others require manual bleeding.
- Once both pressure gauges are at "zero", return the adjustment knob/handle back to the fully counterclockwise position.
- Disconnect the air hose from the outlet coupling and the air source from the regulator inlet.

Regulators should be stored in a clean, dry environment. Gauges are susceptible to damage so appropriate precautions should be taken to protect them. Any damage to the regulator or gauges and/or faulty operation should place the regulator out-of-service for repairs or replacement.

Air Hoses

Air hoses are a critical component of any pneumatic tool and airbag setup. They are the connecting medium between the equipment and can have a direct effect on air volume and pressure. Air hoses can be constructed of various types of rubber or plastic and may contain a form of fabric reinforcement. The hose should be marked with a service or working pressure; never exceed the manufacturer's recommended operating pressures.

Hose lengths can be short (around 16 feet for many airbag systems) or as long as 200 feet (common length for apparatus hose reels). Much like fire hose, air hose creates friction losses. The magnitude of these losses depends on hose diameter and length as well as air flow.

The Association for Rubber Products Manufacturers (ARPM) provides some tabulated data in their "Hose Handbook" referencing friction loss in air hose. Some of this data is shown in the tables below:

Friction Loss in Air Hose (psi) per 100-foot length

Hose I.D. (inch)	Gauge Pressure at Line (psi)	Cubic Feet Free Air Per Minute (SCFM)		
		3.0	5.0	10.0
1/4	100	3.73	10.36	-
	150	2.60	7.21	-
	200	1.99	5.53	22.14
3/8	100	0.44	1.23	4.92
	150	0.31	0.86	3.42
	200	0.24	0.66	2.63

From ARPM Hose Handbook, 8th Edition – Table 11-4A

Friction Loss for Pulsating Air through Hose (psi) per 100-foot length

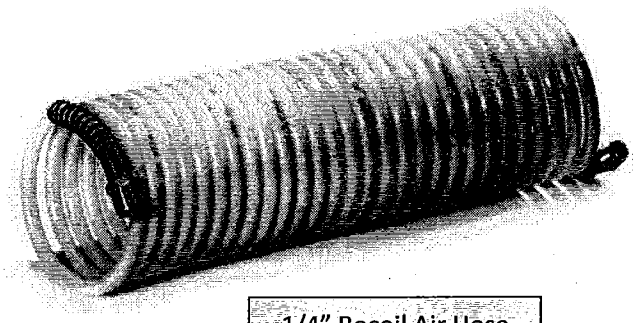
Hose I.D. (inch)	Gauge Pressure at Line (psi)	Flow of Free Air (SCFM)		
		30	40	50
1/2	50	10.0	20.2	36.2
	80	5.6	12.0	21.6
	100	4.6	9.6	16.8

From ARPM Hose Handbook, 8th Edition – Table 11-4B

**The above tables refer to "Free Air" at atmospheric pressure (14.7 psi) and 80°F
**The pressure drops listed assume hose with smooth I.D. tubing and full-flow couplings. Greater pressure drops will occur in hose with rough I.D. tubing or restrictions at couplings/fittings.

The majority of pneumatic tools and equipment used in the fire service will require a minimum air hose diameter of 3/8". Smaller ¼" air hoses (commonly found on small home air compressors) will not meet volume requirements and can result in inefficient tool operation or even damage.

3/8" Air Hose



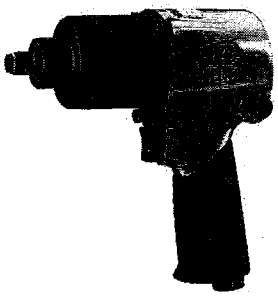
1/4" Recoil Air Hose

Pneumatic Tools

As mentioned at the beginning of the module, the majority of pneumatic tools used in rescue are actually designed for the automotive repair industry. However, there are some tools designed specifically for fire/rescue applications.

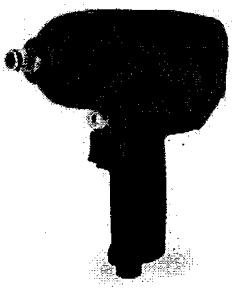
Types of Pneumatic Tools

Impact Wrench



Pneumatic impact wrenches provide high torque output. In addition to rotation, impact wrenches apply a hammering force. They are commonly used in automotive, construction, and assembly industries.

Impact wrenches come in drive sizes similar to ratchet sets. Common automotive drive sizes are ¼", 3/8", ½", ¾" and 1". For industrial applications, drive sizes can be as large as 1 1/2" and 2 1/2". Due to the high torque of an impact wrench, regular sockets should NOT be used. Standard chrome sockets are fairly brittle and can shatter from too much vibration. Impact sockets are made from chrome-molybdenum alloy steel, which is a softer more malleable material. These sockets are designed to absorb the high impact forces from an impact wrench and deform instead of shattering like standard sockets.

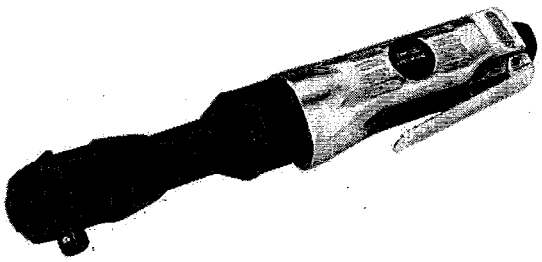


Torque ratings can range considerably depending on the size of the impact wrench and its application. Working torque ranges can be anywhere from 25 to 350 lb-ft. Maximum torques can exceed 1000 lb-ft.

Air consumption also varies with size and application. For automotive applications, average consumption rates can be 5-10 cfm. Under load, these torque wrenches may use in excess of 20 cfm. For industrial and manufacturing applications, air consumption rates can dramatically increase – some as high as 40 cfm.

Air Ratchet

Air ratchets apply far less torque and operate at lower RPMs than impact wrenches. They are designed to increase efficiency and save time in applications where standard ratchets would be used.



Air Ratchet (continued)

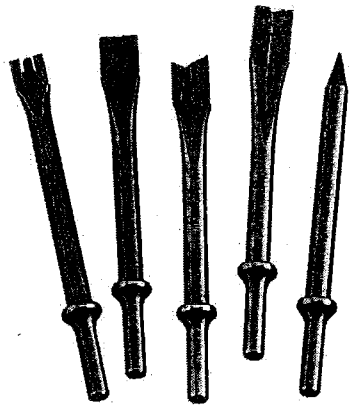
Standard drive sizes for air ratchets are ¼", 3/8" and ½". Due to the lower torque ratings, impact sockets are not required. Torque ratings can range from 5 to 75 lb-ft.

Average air consumption rates for air ratchets are around 4-5 cfm.

Air Hammers

The air hammer (or "air chisel" as it's sometimes called) is one of the more commonly used pneumatic tools in rescue. In fact, a larger version of an air hammer, which will be discussed later in this module, was developed specifically for fire/rescue applications. As the name suggests, air hammers create a hammering action through the use of a piston.

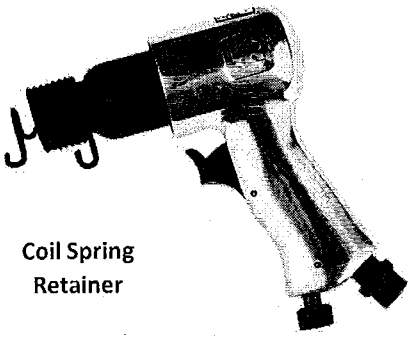
The working end of the air hammer is the chisel. Chisels are used to pierce and cut metal. There are numerous types of chisel designs, each with different specialties.



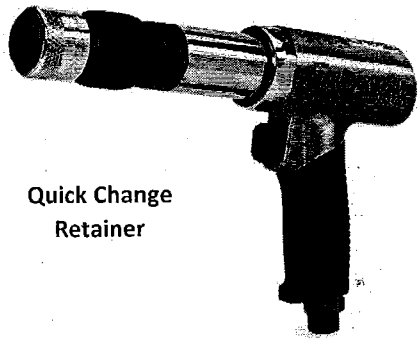
Some Common Types of Chisels
(from left to right)

- Tailpipe/muffler cutter
- Straight/flat chisel
- Cutting chisel
- Edging tool
- Tapered punch

Chisels are held in the air hammer with a retainer. There are two types of retainers: coil spring and quick change. Most air hammers can be fitted with either type, but the quick change retainer is preferred for fire/rescue work. Quick change retainers are faster and easier to use and also minimize the risk of a chisel dislodging from the hammer during use.



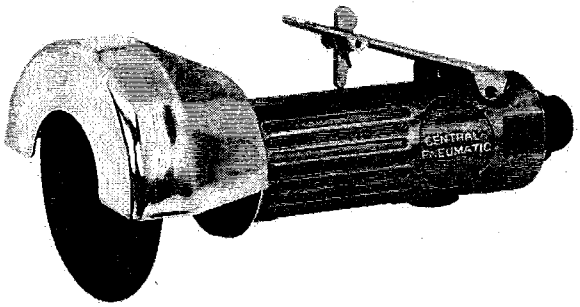
Coil Spring Retainer



Quick Change Retainer

Air consumption rates for air hammers are around 2-3 cfm, with some peaking between 10-15 cfm under load.

Cut-off Tool

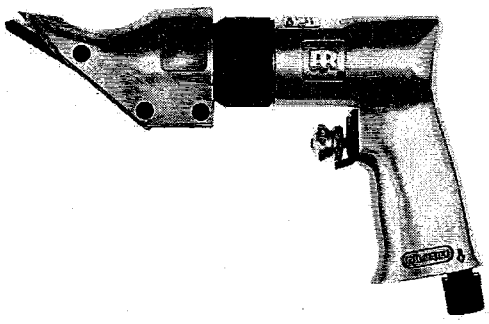


The pneumatic cut-off tool is simply a small version of the gasoline-powered Partner and Husqvarna rotary cut-off saws carried on almost all truck companies and rescue squads. An abrasive cutting disc is attached to an arbor rotating at high speed (20,000+ RPMs). Most pneumatic cut-off tools use a $2^{7}/_{8}$" cutting wheel.

It is important to only used appropriately-sized cutting wheels and ensure that they are securely fastened to the arbor. Blade guards are standard on cut-off tools and they should be used. If cutting wheels are damaged in any way or worn to the point where they will no longer effectively cut, they should be replaced.

Air consumption rates are around 5-10 cfm, depending on the specific cutter.

Air Shear



Air shears are another type a pneumatic cutting tool. They are capable of cutting plastics and all types of aluminum, tin and up to 18-20 gauge steel. Unlike the cut-off tool's consumable cutting wheels, the air shear's blades are part of the tool and should not need replaced under normal use.

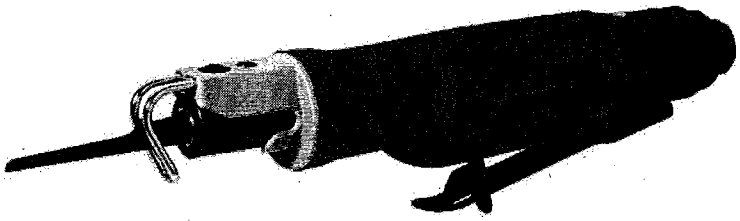
Air shears consume 4-5 cfm.

Air Reciprocating Saw

The air reciprocating saw is a smaller version of electric and battery-powered reciprocating saws found on almost all fire apparatus. The bi-metal blades can cut a variety of plastics and thin metals.

Standard ½" shank air reciprocating saw blades come in 14-tooth up to 32-tooth construction for coarse to fine cutting.

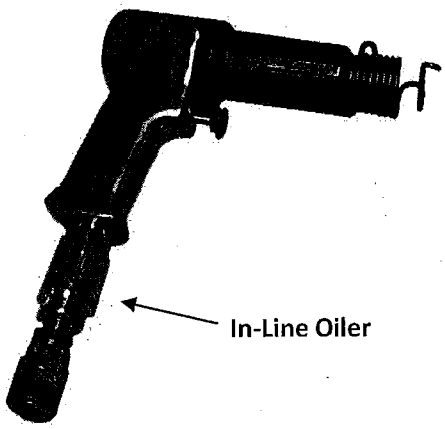
Common air consumption rates are 1-2 cfm during normal use.



Maintenance and Use

Air pressure is an important component of proper tool operation. The pneumatic tools mentioned in this module typically have manufacturer-recommended operating pressures of 90 psi. The tools will operate at pressures above 90 psi, which will increase torque and possibly improve performance. However, in the long run, this will reduce the life expectancy of the tool. Operating pressures less than 90 psi will result in tool inefficiency and decreased performance. One common mistake made by operators is to set the air regulator at the tool operating pressure and never give it a second thought. However, by the time the air reaches the actual tool, the pressure may be significantly reduced. Several factors (such as air leaks, hose configurations and lengths, the number and types of couplings, etc.) can reduce air pressure. So if the tool is not functioning as it should, this could be one possible cause.

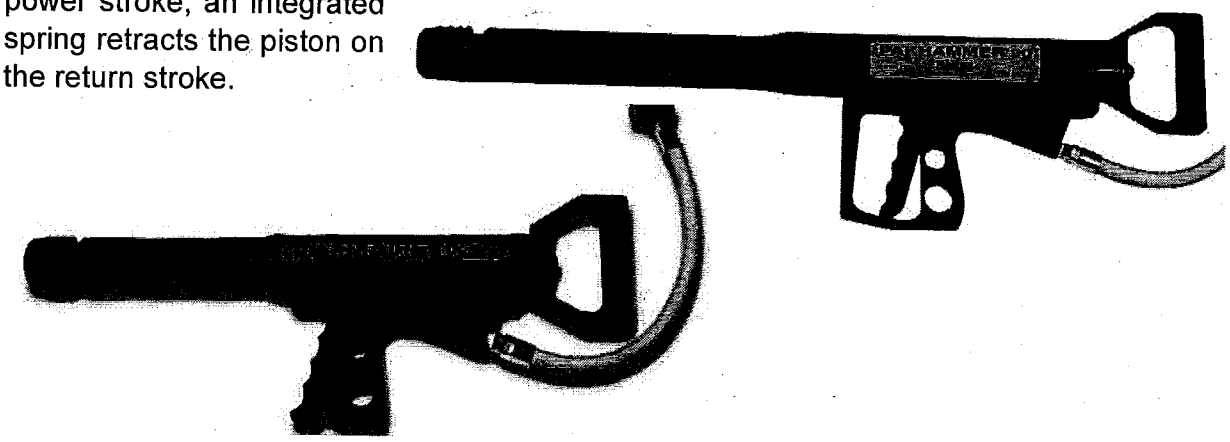
All of the pneumatic tools discussed in this module contain many internal moving parts. To maintain peak efficiency and improve tool life expectancy, these internal components must be clean and well lubricated. Air tool oil provides the necessary lubrication and rust prevention for the internal moving parts. Some pneumatic tools are equipped with in-line oilers that introduce oil into the tool air during normal use. Tools without oilers must be manually lubricated on a regular basis. In addition, many pneumatic tools have grease fittings that require periodic service. It is important to follow manufacturer's recommendations for the types of lubricants and their proper use.



Hoses and couplings can be a source of water, dirt, grit, and other contaminants that will cause damage and excessive wear to internal tool components. Be sure to inspect all couplings before connecting them. If necessary, clean and dry them before use. Store all pneumatic equipment in a clean, dry environment. Regular preventive maintenance will help ensure the tools perform as they should when needed.

Paratech Airgun and Pakhammer

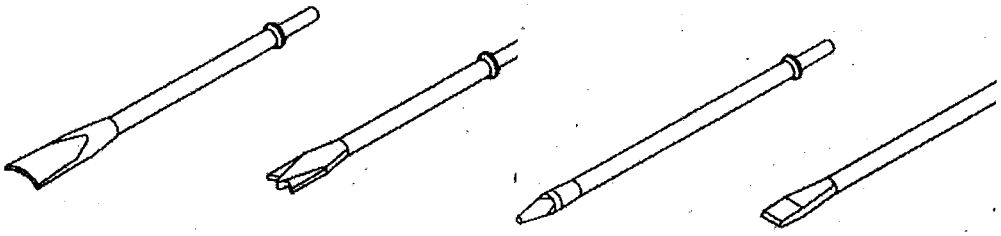
The Paratech Airgun and Pakhammer are two pneumatic impact tools designed specifically for fire/rescue applications. The two are used for forcible entry (piercing, cutting, and breaking) as well as medium duty breaching and breaking of masonry walls. They utilize a piston much like a traditional air hammer. However, Paratech designed the Airgun and Pakhammer with air conservation in mind. Both tools only use air on the power stroke; an integrated spring retracts the piston on the return stroke.



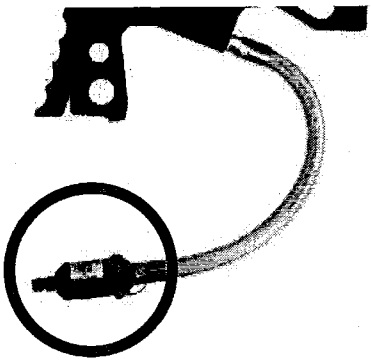
Airgun and Pakhammer operating pressures range from 40 up to 200 psi, depending on the application. However, increasing operating pressures will increase air consumption. For the Airgun, air consumption is rated at 5 SCFM @ 40 psi but 15 SCFM @ 200 psi. The larger Pakhammer consumes air at a rate of 8.5 SCMF @ 40 psi and 19 SCMF @ 200 psi.

One of the large benefits of the Airgun and Pakhammer over traditional air hammers is power output. Both tools are designed for rescue and therefore provide increased cutting/breaching/breaking force. The Airgun is rated for 71 ft-lbs. @ 50 psi up to 369 ft-lbs. at 200 psi. The Pakhammer is rated for 158 ft-lbs. @ 50 psi up to 876 ft-lbs. @ 200 psi.

The Airgun and Pakhammer can be used with a wide variety of bits on a broad range of materials. The user manuals for each tool list recommended tool bits and operating pressures for specific applications, whether it's cutting automobile posts, breaking concrete, or shattering castings.



Routine maintenance of the Airgun and Pakhammer will keep them operating at peak efficiency. The surface of the tools should be kept clean of dirt, grease, etc. If the tool has been operated in a dusty, abrasive environment or if the tool bit retainer assembly is subjected to a damp or wet material, Paratech recommends cleaning the retainer assembly with dry cleaning solvent and lubricating with air tool oil afterwards.



Both tools are fitted with an in-line oiler. As air passes through the oiler, a controlled volume of lubrication is picked up with the air to maintain continuous fog lubrication of the internal components. The oil level should be periodically checked. If empty, fill the oiler housing until half-full with Marvel® Air Tool Oil.

Pneumatic Lifting Devices – Air Bags

Introduction

There are several different tools carried on Truck companies and Rescue Squads used for lifting. One such piece of equipment is the air bag.

Air lifting bags are capable of lifting heavy loads with relative ease and efficiency. Some of the largest bags are capable of lifting over 90 U.S. tons. Proper training and education are paramount to a successful lifting bag operation. Operators must fully understand the principles behind bag design and operation as well as the necessary safety precautions.

Just a few of the applications that air lifting bags can used for include:

- Lifting and up-righting overturned vehicles
- Person(s) pinned under a heavy object (e.g. tractor trailer, train, vehicle, etc.)
- Rescue/recovery after collapses
- Forcing solid objects apart
- Providing a seal for leaking pipes drums or other cylindrical containers

Some of the advantages of air bags include:

- Long life
- Fairly lightweight
- Low insertion heights
- Quick and easy to set up
- Relatively low operating pressures
- Ability to lift on a slope
- Provide a smooth, quiet lift
- Provide an anti-slip surface
- Flexible
- Corrosion resistant
- Fairly simple to use

Air lifting bags are categorized into three different types based on their working pressures:

1. High Pressure
2. Medium Pressure
3. Low Pressure

Each type has unique features and capabilities. However, all three share a similar equipment cache for operating. Each type of bag and the associated equipment will be discussed in this module.

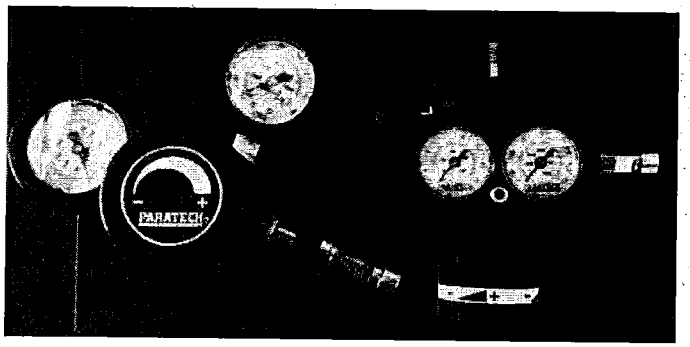
Equipment

Air Source and Pressure Regulator

Several different types of air sources were covered in the "Pneumatic Tools and Equipment" module. While most of those air sources are capable of providing air for an airbag operation, some are preferred over others.

Air from industrial and vehicle-mounted compressors often use oil to lubricate internal compressor components. In addition, these air sources contain moisture from ambient air. While filters and dryers are often incorporated into the compressor design, they do not guarantee the absence of contaminants. Some of the synthetic oils used in modern air compressors have been shown to damage and degrade interior components of air bag systems, specifically O-rings. Conversely, breathing air sources (e.g. SCBA cylinders) are filled with air that meets stringent OSHA and NFPA respiratory standards. The compressors that supply breathing air are equipped with advanced moisture separators and purification chambers that eliminate the contaminant and moisture issues of industrial compressors. For this reason, breathing air is the preferred source for air bag evolutions.

As with pneumatic tools, air must often be taken from a high pressure source like an SCBA cylinder and brought down to a proper operating pressure for air bags. The pressure regulators described in the "Pneumatic Tools and Equipment" module are used to perform this task.



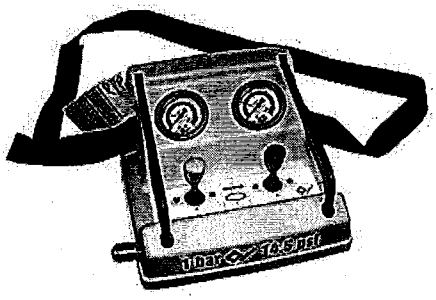
The working pressures for air bag lifting systems range from 7 psi up to 145 psi.

**Note: Another common unit of pressure used with airbags is "bar".

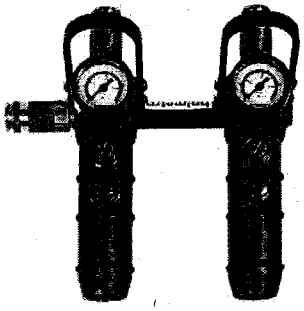
1 bar = 100 kPa = 14.5 psi.

Do not confuse the unit of bar with Standard Atmospheric Pressure (atm), which is 14.7 psi or 1.01325 bar.

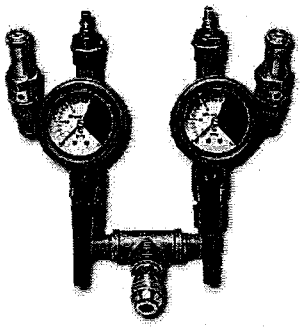
Controller

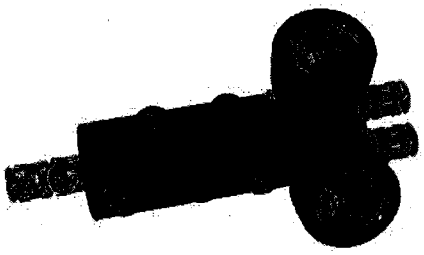


The controller is the device which allows air to flow in and out of the bag. It contains the gauges that allow the monitoring of the air pressure inside the bag. It also contains two internal relief valves to prevent over pressurization of the bags. Most high pressure air bag systems have a maximum working pressure of 8 bar/116 psi or 10 bar/145 psi. Whenever the pressure inside the bag exceeds this mark, it will be indicated on the gauges on the controller and the internal relief valve will vent (allow the extra pressure to escape). It will continue to vent until the correct pressure is reached. This is called relief valve reset and it should occur at the maximum working pressure as indicated on the controller by a red marking.



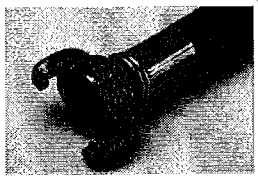
Controllers are outfitted with either "deadman" controls or quarter turn valves. Deadman controls return to a neutral position when they are released preventing accidental over pressurization. Quarter turn valves act like an on/off switch but they must be manually set to the desired position (much like a gated wye). Attention must be paid not to keep the quarter turn valve in the open position after the desired lift has been achieved.

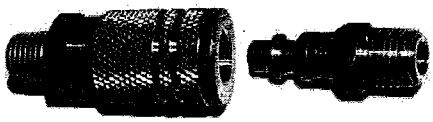




Connections

Controllers provide a coupling, typically with a female end, to connect to the air supply. At this point in the connection, the air pressure should have already been reduced by the air regulator to the working pressure of the lifting system. If this is not true and air is applied to the controller at high pressure from the air source, severe damage can occur to the controller. Some couplings may be quarter turn, which require that you turn and push the collar back before you can attach to the other part of the fitting. Others may be quick-connect which will always readily go together. The type of couplings will vary by manufacturer.

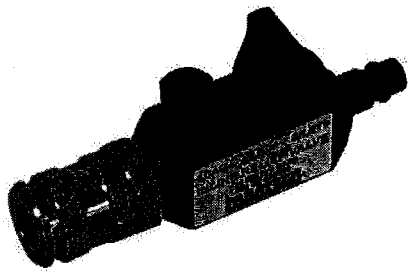




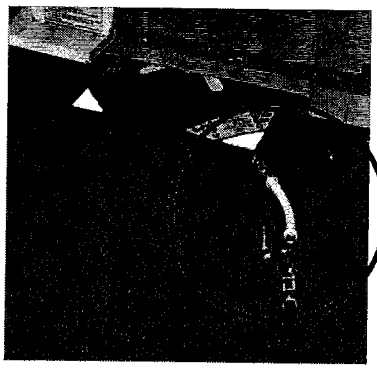
The set of couplings located on the front of the controller are most likely proprietary by manufacturer in order to avoid mixing components from one brand with another. These connections are used to connect the air hoses going from the controller to the air bags. Some manufacturers make these couplings in such a way that you cannot connect the hoses directly from the air supply to the bags without using a controller, thus interposing a relief valve which prevents over pressurization of the bags. These connections may also be used to add a second relief valve, usually with a shut-off, between the bag and the controller.

In-Line Relief Valves

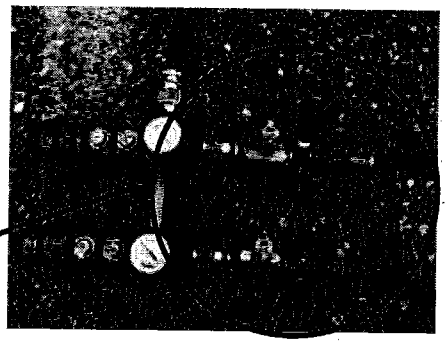
Placement



In-line relief valves work in the same fashion as the internal relief valves. They are considered in-line because they are located between the controller and the airbag rather than an internal component. In-line relief valves can be placed at the controller or at the airbag itself. Frequently these devices are placed at the controller to limit persons working near the load. Relief valves are usually only placed at the airbag when there is a limited number of air hoses and only one controller. By placing the relief valve at the bag, the hoses and controller can be removed and used at a different location on a different bag. Prior to disconnecting the hoses, the quarter turn valve is closed to prevent air from being lost from the bag. Some manufacturers incorporate the relief valve into the air hose so the placement of the relief valve is predetermined.



Relief valve placed at the airbag



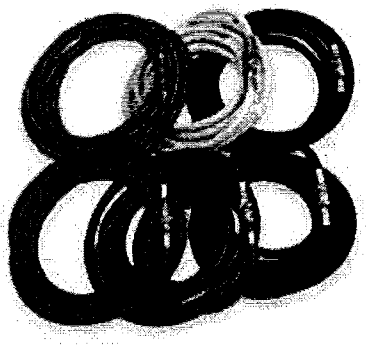
Relief valves placed at the controller

Operation

Relief valves are preset to a specific pressure, normally the maximum working pressure of the system. Whenever the pressure inside the system exceeds this benchmark, the relief valves vent allowing the excess pressure to escape through vent holes on the valve body preventing over pressurization of the bag. When the relief valve vents, a hissing noise will be heard until the proper pressure is reached.

Hoses

Lengths

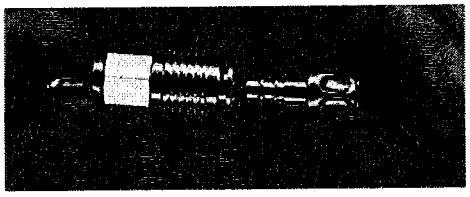


Hoses are usually around 16, 32, and 50 feet in length, ¼" to 1 ½" in diameter (depending on type/pressure of bag), and color coded for easier identification of the bags when using more than one bag.

Couplings

Couplings are different from one lifting system to the other. The couplings for the high pressure system are different from the couplings for the low and medium pressure systems. In addition, the hoses from the low and medium pressure systems are different from the hoses used by the high pressure system. The low and medium pressure systems use a higher air volume therefore, their diameter is greater.

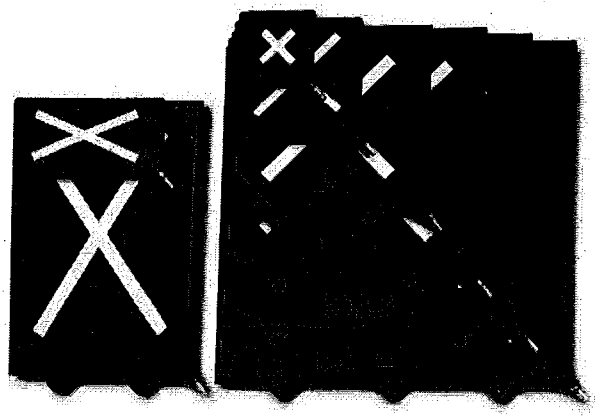
Hose couplings are often manufacturer specific. This prevents a specific manufacturer's air bag from being used with inappropriate or non-rated equipment.



Air Bags

High Pressure Bags

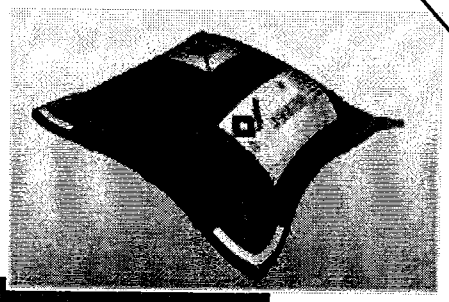
Capacities and Sizes

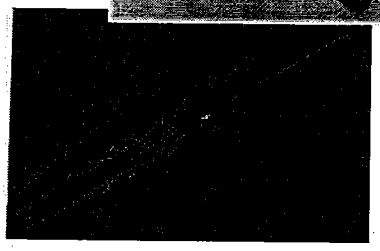


The bag is the component in direct contact with the load and is the component performing the actual lift. Air bags range in capacities from 1 to more than 90 tons and have lifting heights from 3" up to multiple feet. Bags are constructed in different shapes and sizes. Some of the smallest bags measure 5.1" x 5.5" while some of the largest bags measure 37" x 37". High pressure airbags are anti-static, self-extinguishing, oil and ozone-resistant, have a good resistance to chemicals, cold resistant to 40°F and heat resistant to 239°F on a short term basis. High pressure airbags have a bursting pressure between 32.5 bar and 74.3 bar (471 - 1,077 psi) giving them a safety factor of 4 to 9.3 times the maximum operating pressure.

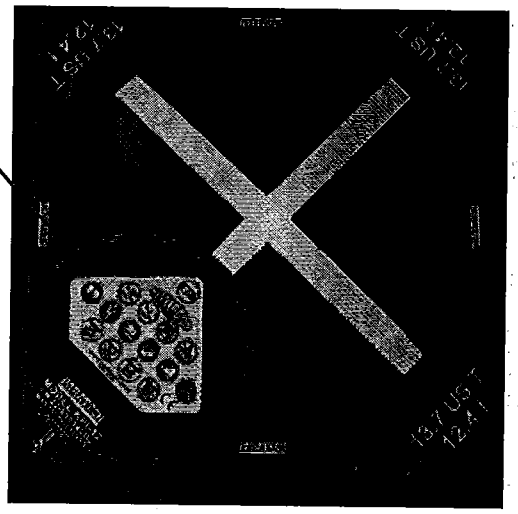
Construction

The bags are made of Neoprene, a family of synthetic rubbers, and are molded in a way to provide grip and slip resistance. They are reinforced with layer(s) of either steel wire (similar to steel-belted radial tire construction) or in the case of newer bags, Aramid fibers. By using Aramid fibers, such as Kevlar™, the bag becomes stronger, lighter, and more flexible than a bag made with steel wire. All capacities, operating pressures and lifting heights are permanently vulcanized to the surface of the bags so it is available for reference as needed.



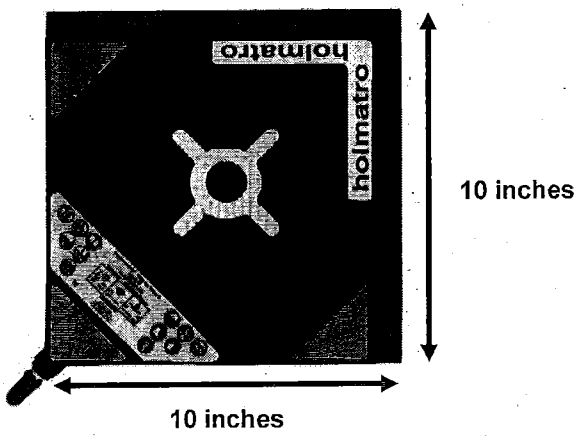


The nipple has a small orifice in order to allow the bag to deflate slowly.



Operation

Air bag capacities are determined by their surface area and operating pressure. To determine the maximum lifting capacity, the bag's surface area is multiplied by its operating pressure. Operating pressure for high pressure air bags is either 8 bar/116 psi or 10 bar/145 psi.



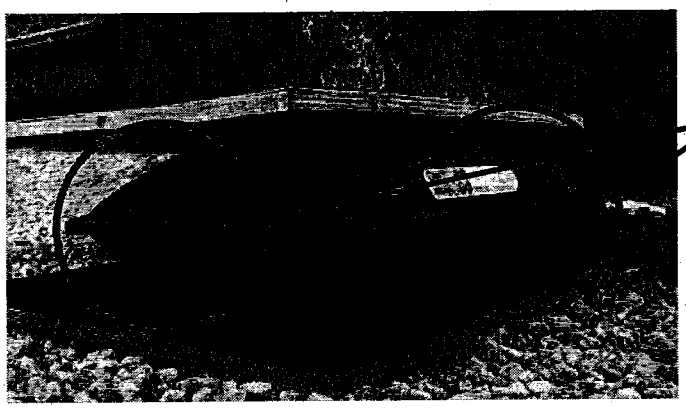
Surface Area (A) = Length (L) x Width (W)

A = 10 inches x 10 inches
A = 100 in^2 (square inches)

Operating Pressure = 8 bar = 116 lbs/in^2 (psi)

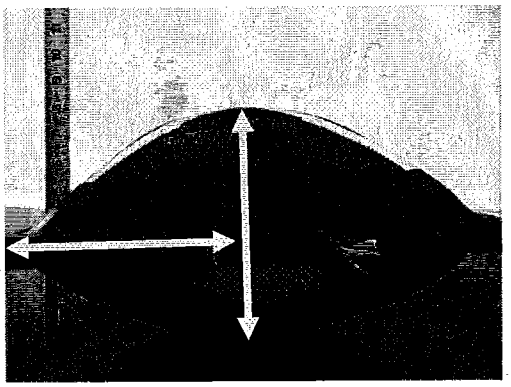
Capacity = Surface Area x Operating Pressure
Capacity = 100 in^2 x 116 lbs/in^2
Capacity = 11,600 lbs = 5.8 U.S. tons

High pressure air bags are **rated at one inch of lift**. The air bag is only capable of lifting its rated capacity if the entire surface of the bag is in contact with the object being lifted. Once air is introduced to the bag, it starts taking the shape of a pillow thus, reducing the surface contact with the object being lifted, and decreasing its capacity. Once the bag reaches its maximum height, the rated capacity is reduced by roughly 50%. Surface contact is paramount when calculating lifting capacities and when operating with air bags.

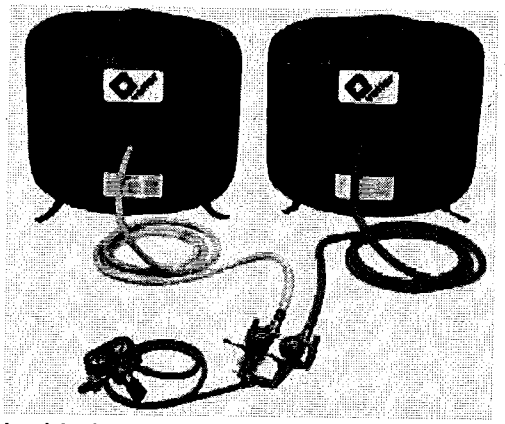


The bag has lost surface contact with the ground and the object. As a result, the lifting capacity at this height is reduced

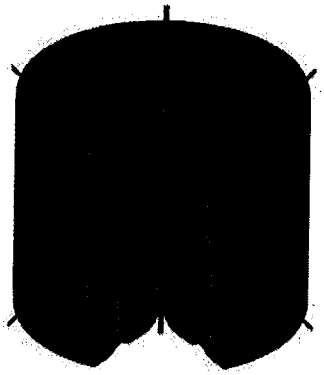
As a rule of thumb, the maximum inflation height of a high pressure air bag is equal to half of the length of the shortest side of the bag.



Medium pressure bags



The walls or sides of the medium pressure bags are made of hermetic, Kevlar™ impregnated or nylon reinforced Neoprene. The top and bottom external surfaces are made of reinforced fabric with a gripping surface in order to reduce slippage. Some manufacturers claim that, due to the manufacturing process, the seams are the strongest part of the bag.



Inside low and medium pressure air bags, running from the top to the bottom surfaces, are vertical reinforcing straps. These straps help the bags keep lateral movement to a minimum and at the same time prevent the surfaces of the bags from bulging out.

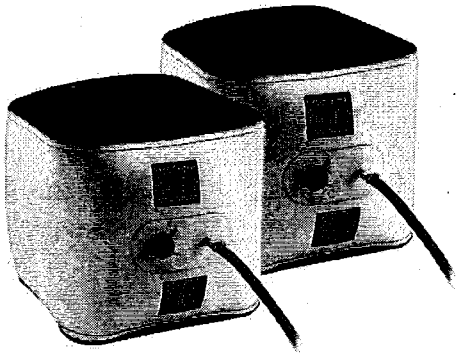
Medium pressure bags are offered in a number of sizes and styles. Some have cylindrical shapes. Others are multi-cell, which is similar to three bags stacked on top of each other.

Some applications for medium pressure air bags include lifting or stabilizing overturned vehicles, especially in situations dealing with thin metal walls like on tractor-trailers. They provide a large footprint for the area being lifted and minimize the possibility of punch-through or collapse of the surface being lifted/pushed. They are also used to fill voids in trench rescue operations.

Medium pressure bags provide their rated capacity during the entire lift. As long as surface contact is maintained with the bag, it will lift the rated capacity. Medium pressure bags that are cylindrical in shape will reach their maximum stability at full inflation. Lifting capacities range from 3 to 13 tons. Air consumption varies from 10 to over 100 cubic feet. As with the high-pressure system, to operate the medium pressure bags you need an air source, an air pressure regulator, a controller with relief valves, and hoses.

Because of the pressure difference between systems, these components are not interchangeable with the high pressure systems. Medium pressure systems are designed to operate at 1 bar/14.5 psi. They have a much higher air consumption rate than high pressure bags. For that reason, the air hoses have a larger diameter.

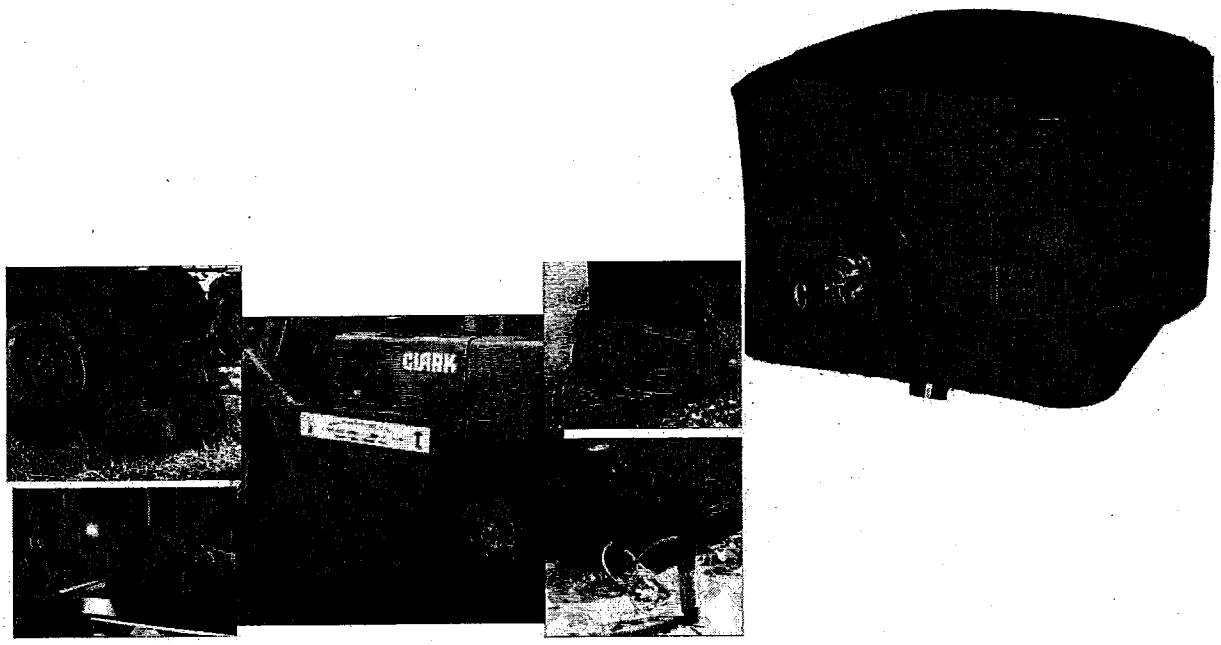
Low pressure bags



This type of bag is constructed of reinforced Neoprene, very similar to medium pressure bags. The top and bottom surfaces are made of multi-layer rubber to provide abrasion resistance. Inside the bag there are reinforcement straps running from the top to the bottom plate. They keep the bag from bulging and prevent some lateral movement. Sizes and capacities are comparable to those of the medium pressure system. Some applications for low pressure air bags include lifting or stabilizing overturned vehicles, especially in situations dealing with thin metal walls such as aircraft. Like medium pressure bags, they provide a large footprint for the area being lifted and minimize the possibility of punch-through. They can also be used to fill voids in trench rescue operations.

As with medium pressure bags they provide the rated capacity during the entire lift. As long as maximum surface contact is maintained with the bag, it will lift the rated capacity. Low pressure bags, like medium pressure bags, reach their maximum stability at full inflation.

Operating pressure for low pressure bags is around 0.5 bar or 7-8 psi. The same components as medium pressure bags are needed to operate these bags (air source, pressure regulator, controller, relief valves, and hoses). Some manufacturers build their low and medium pressure systems with interchangeable components.



Setup and Operation

Establish safe zones

When lifting heavy objects there is always the risk of the load shifting or falling. In order to prepare for this event, identify the area that might be affected if the load was to fall or shift and keep personnel and equipment clear from that area as much as operationally possible. When operating around air bags and lifting loads, always pay attention to the load and maintain a stance that will allow for a rapid egress from the danger area should the load shift or fall. Maintain all equipment not being utilized in a centralized area, in the safe zone in order to minimize trip hazards. Whenever possible, work on a flat surface to avoid slippage and shifting of the air bags and or the load.

Cribbing

Whenever a load is lifted from the ground by any means it must be supported by some type of cribbing material. (See the "Stabilization" module of this manual for more information on cribbing.) When using cribbing in combination with air bags, it is used in two different ways: supporting the load and supporting the air bags.

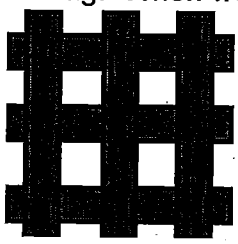
Supporting the load

"Lift an inch, crib an inch." This is a critical part of the overall lifting process. As you lift the load, you must simultaneously crib as you go. This is done in order to prevent the load from traveling unsupported. In the event of a failure somewhere in the lifting system, the load still needs to be supported to prevent dropping the load and causing damage to equipment, the load, and harm to personnel.

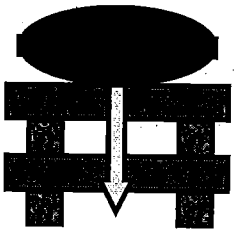
Supporting the Bags

As stated previously, high pressure air bags are rated for their maximum lifting capacity at 1 inch of lift. As the air bag inflates beyond 1 inch, it begins to lose surface contact with the ground and the load. To help alleviate this problem, the air bags must be as close to the load as possible. This can be accomplished by cribbing up to the load prior to inserting the airbag.

Additional factors must be considered when constructing a box crib to support a lift rather than simply supporting the load. The top of the box crib needs to be a solid layer of cribbing to maintain full surface contact with the air bag. When working on soft ground, the bottom layer should be solid as well to help distribute the load. When constructing the box crib, a minimum of 3-by-3 crib layout should be used. When a standard 2-by-2 layout is used, the center of the box crib is empty and is therefore not supporting the airbag as it inflates. This can lead to decreased box crib capacity and stability.



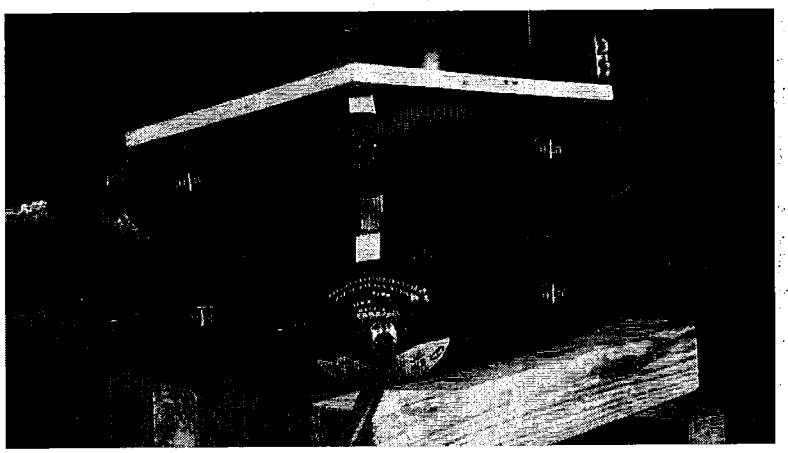
3 by 3 Box Crib



2 by 2 Box Crib

Applications

Stacking Air Bags



High-pressure air bags can be stacked to a maximum of two bags. By stacking bags, we increase our overall lifting height. Recall that the maximum bag height is approximately half the length of its shortest side. When two bags are stacked, their useable heights are added together to provide the total lift height. The larger bag is always placed on the bottom and the smaller bag on the top. The bag with the smaller capacity will dictate the total lifting capacity (e.g. a 19-ton bag stacked on a 26-ton bag would only yield a maximum capacity of 19 tons). Use caution when stacking bags, the more inflated the bags, the more susceptible they are to kicking out. If the load is at an angle, it is recommended that only one airbag be used.

Using bags in tandem

When two bags are sharing a load at two different points, they are said to be working in tandem. Two bags working in tandem can have their capacities added together in order to determine the total lifting effort, however the bags MUST be lifting the same part of the load. Also, the portion of the load on each bag cannot exceed bag capacity.

For example, a 7-ton air bag and 3-ton bag can theoretically be placed in tandem to lift a 10-ton load. However, the 7-ton bag must only see 7 of the 10 tons and the 3-ton bag must only see 3 of the 10 tons. If each bag is responsible for lifting an equal share of the 10 tons (5 tons each), the lift will not be possible. One solution would be to use two 7-ton bags in tandem (each capable of lifting half of the 10-ton load).

Recall that air bags are rated at 1 inch of lift. The maximum tandem lifting capacity will be achieved only at that height. This method is useful when presented with a load that exceeds the capacity of the largest bag on hand.

Other Lifting Considerations

- Another point to consider when lifting a load, especially if it is resting on a patient, is that when lifting, every action has an equal and opposite reaction. In the event of a patient being pinned under a load, you must crib the opposite side that you are lifting in order to provide a hinge point for the load and prevent sway, which could cause further harm to the individual.
- To maintain control of the load and to keep it from shifting, bags should be inflated slowly. This is called "feathering". Air that is rapidly introduced into the bag will jolt the load and create a chain reaction that may be very difficult to control and could cause the load to shift or fall.
- If more than one bag is used for the lift, it may be necessary to inflate one bag at a time to maintain control: lift one bag one inch then the next bag one inch. Inflate each bag at small increments and stagger the inflations. This will allow for maximum surface contact and therefore maximum stability and strength in the bag.
- Place the uninflated bags as close to the load as possible to help maximize the lifting height. When the bags are slid under the load they should be just barely touching the load. There should not be a large space between the bag and the load.
- Locate a solid surface under the load and use this area as the lifting point, cribbing on both sides of the bags as you lift. Again, the rule is to lift an inch, then crib an inch.

- The nipples on the bags can be stacked on top of each other or they can be staggered for easier manageability of the hoses.
- In-line relief valves can be placed either at the controller or at the bag. By placing the relief valve at the controller, the person operating the controller has the ability to shut off the air flow to the bag, remove the controller from the system while maintaining bag inflation, and deploy another set of bags in a different location if needed. This is the preferred method because the person operating the shutoff valve will be away from the load. Position the controller in an area with a full view of the lift but in the safe zone if possible.
- When lifting the load, one person is responsible for operating the controls on the controller. A second person will be responsible for directing the rescuer at the controller as to which bag to inflate or deflate. The rescuer at the controller will only take commands from this person and those commands should simply be "Up", "Down", and "Stop". Follow each command with the color of the air hose connected to the bag being inflated/deflated (e.g. "Up on red" or "Down on yellow").
- Air hoses are typically stored in a rolled fashion and tend to develop a "memory" in that shape. For that reason, and to prevent kinks and air flow restriction, they should be completely uncoiled and extended before inflation. Using different color hoses for different bags will aid in identification during the lifting operation.

Maintenance

- Inspect the bags after every use.
- Inflate the bags to half of their working pressure and apply a mixture of soap and water. (It is NOT recommended to inflate an air bag that is not under load to its maximum operating pressure.) Look for leaks or air bubbles.
- Check the surface of the bags for cuts, abrasions or any signs of structural damage.
- Check that the nipple is firmly attached to the bag and it does not swivel.
- Leave the bags inflated for several minutes monitoring for any leaks, this can be seen in the inflation of the bag or on the pressure gauge on the controller.
- Inflate and deflate the bags repeatedly in order to exercise the bags and keep them from developing a memory in one position and to provide stretch and movement to the different layers.
- Place the bags under an appropriate load and inflate them to their maximum operating pressure, allowing the relief valves to vent and reset. Note the pressure when the relief valve vented and the pressure when it reset. Compare those pressures with the manufacturer's recommendations.
- Air bags should be hydrostatically tested every five years by a qualified service technician.

Air bag manufacturers have a stringent battery of tests and standards that must be followed when manufacturing air bags. Some of these tests include bursting tests, abrasion tests, piercing, penetration, and wear resistance, among others. After meeting the requirements of all of these tests some manufacturers may submit their bags to a pressure test of 1.5x their working pressures for a number of minutes. Air bags have a working life of approximately ten years based upon use, storage, and maintenance.