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SAFETY WHEN WORKING WITH ELECTRICITY

UNDERSTANDING ELECTRICITY

A brief discussion of Ohm's Law is necessary to fully understand the seriousness of electrical hazards. Ohm's Law simply states that one volt (unit measure for pressure or force that pushes electricity) will cause a current of one ampere (unit measure for the electron flow) to flow through a resistance of one ohm (unit measure for the resistance to the flow of electrons).

The relationship is represented by E (volts) = I (amps) \times R (ohms).

The human body is essentially resistive and thus can ignore other factors such as capacitance and inductance when dealing with alternating current (AC) usage. To demonstrate an understanding of Ohm's Law the following example will illustrate the lethal effects of electricity on the human body:

Physiological Effects of Electrical Energy on Humans

Electricity flowing through the human body can shock, cause involuntary muscle reaction, paralyze muscles, burn tissues and organs, or kill. The typical effects of various electric currents flowing through the body on the average 150-lb male and 115-lb female body are given below.

Effects of electric current on the human body

Assume a person is working and perspiring and has a hand-to-hand resistance of 1,000 ohm. The person contacts 120 volts with one hand and touches a grounded surface with the other. This in effect completes a loop to the voltage source or in other words completes a circuit.

To solve for the current flowing through the body in and in this case.... the heart, use the equation:

$$E \text{ (Volts)} = I \text{ (amps)} \times R \text{ (ohms)}$$

$$120 \text{ volts} = I \times 1,000 \text{ ohms}$$

$$I = 120/1,000 = 0.120 \text{ Amps}$$

$$i = 120 \text{ milliamps}$$

Life Threatening Effects. Charles F. Dalzeil, Ralph H. Lee, and others have established the following criteria for the lethal effects of electric shock.

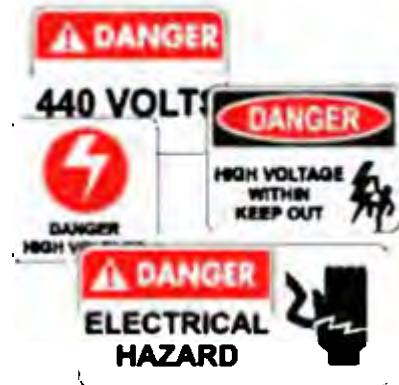
- Currents in excess of a human's "let-go" current ($>=16$ mA at 60 Hz) passing through the chest can produce collapse, unconsciousness, asphyxia, and even death.
- Currents ($>=30$ mA at 60 Hz) flowing through the nerve centers that control breathing can produce respiratory inhibition, which could last long after interruption of the current.
- Cardiac arrest can be caused by a current greater than or equal to 1 A at 60 Hz flowing in the region of the heart.
- Relatively high currents (0.25-1 A) can produce fatal damage to the central nervous system.
- Currents greater than 5 A can produce deep body and organ burns, substantially raise body temperature, and cause immediate death.
- Delayed reactions and even death can be caused by serious burns or other complications.

The most dangerous current flow via the chest cavity is through the heart when the shock occurs in the time relative to

Effect/Feeling	Direct Current (mA)		Alternating Current (mA)		Incident Severity	
	150 lbs	115 lbs	60 Hz			
			150 lb	115 lbs		
Slight sensation	1	0.6	0.4	0.3	None	
Perception threshold	5.2	3.5	1.1	0.7	None	
Shock not painful	9	6	1.8	1.2	None	
Shock painful	62	41	9	6	Spasam, indirect injury	
Muscle clamps source	76	51	16	10.5	Possible fatal	
Respiratory arrest	170	109	30	19	Frequently fatal	
$\geq 0.03\text{-s}$ vent. fibrillation	1300	870	1000	670	Probably fatal	
$\geq 3\text{-s}$ vent. fibrillation	500	370	100	67	Probably fatal	
$\geq 5\text{-s}$ vent. fibrillation	375	250	75	50	Probably fatal	
cardiac arrest	---	---	4000	4000	Probably fatal	
Organs burn	---	---	5000	5000	Fatal if it is a vital organ	

the normal heart rhythm. This current may cause ventricular fibrillation, which is defined as repeated, rapid, uncoordinated contractions of the heart ventricles. Ventricular fibrillation that alters the heart's normal rhythmic pumping action can be initiated by a current flow of 75 mA or greater for 5 seconds (5-s) or more through the chest cavity.

While most of us keep our distance from transformers and equipment that requires large amounts of electricity, we tend to overlook other situations —a small light bulb, for instance. The current used by a 7 1/2 - watt Christmas tree light bulb is only 60 millamps. This is much more than the 8-10 millamps that does not allow a person to let go of a wire with current running through it. One can imagine the results from 20 or 30 amperes, the sizes of the smallest fuses or breakers commonly in use. While it is true that a person can survive a much higher current, that possibility is not something that should not be counted on.



Burns:

Although a current may not pass through vital organs or nerve centers, internal electrical burns can still occur. These burns, which are a result of heat generated by current flowing in tissues, can be either at the skin surface or in deeper layers (muscles, bones, etc.), or both. Typically, tissues damaged from this type of electrical burn heal slowly.

Burns caused by electric arcs are similar to burns from high temperature sources. The temperature of an electric arc, which is in the range of 4,000-35,000°F, can melt all known materials, vaporize metal in close proximity, and burn flesh and ignite clothing at distances up to 10 ft from the arc.

Electrical Panels:

Electricity enters buildings through a control panel and a main switch where a person can shut off all the power in an emergency. This control panel contains either fuses or circuit breakers. Always use the correct fuse for the panel. Never use a greater number, or replace fuses with items like pennies. If there is a stoppage in power, check the control panel. If fuses are used, look for the broken metal strip in the top of a blown fuse. Replace the fuse with one that is marked with the correct amperage. If circuit breakers are used, reset them from off to on.



Install a lockout switch. This can turn off all power from one area. This is important if there is an emergency or when working on the electrical system. Do not have a switch turned on while you are working on the electrical system.

PROTECTION OF EMPLOYEES -

1. No employer shall permit an employee to work in such proximity to any part of an electric power circuit that the employee could contact the electric power circuit in the course of work, unless the employee is protected against electric shock by deenergizing the circuit and grounding it or by guarding it effectively by insulation or other means.
2. In work areas where the exact location of underground electric powerlines is unknown, employees using jackhammers, bars, or other hand tools which may contact a line shall be provided with insulated protective gloves.
3. Before work is begun the employer shall ascertain by inquiry or direct observation, or by instruments, whether any part of an energized electric power circuit, exposed or concealed, is so located that the performance of the work may bring any person, tool, or machine into physical or electrical contact with the electric power circuit. The employer shall post and maintain proper warning signs where such a circuit exists. The employer shall advise employees of the location of such lines, the hazards involved, and the protective measures to be taken.

Passageways and open spaces:

1. Barriers or other means of guarding shall be provided to ensure that workspace for electrical equipment will not be used as a passageway during periods when energized parts of electrical equipment are exposed.
2. Working spaces, walkways, and similar locations shall be kept clear of cords so as not to create a hazard to employees.

Load ratings:

In existing installations, no changes in circuit protection shall be made to increase the load in excess of the load rating of the circuit wiring.

Fuses:

When fuses are installed or removed with one or both terminals energized, special tools insulated for the voltage shall be used.

Cords and cables:

1. Worn or frayed electric cords or cables shall not be used.
2. Extension cords shall not be fastened with staples, hung from nails, or suspended by wire.

[REF: OSHA Safety and Health Regulations for Construction
Section 1926.416]

WORKING NEAR UTILITIES

Overhead Powerlines:

Workers shall not be required or permitted to perform any function in proximity to energized high voltage lines. Any activity where any parts of tools, machinery, materials or any part of an employee's body will come closer than the minimum clearances from energized overhead lines set forth in the following table is prohibited.

Boom equipment must not be operated where the boom could come within the minimum required clearance set forth in this table. Hoisting over energized lines is prohibited.

Nominal Voltage Phase (phase to phase)	Minimum Required Clearance (Feet)
600.....50,000	10
Over 50,000.....75,000	11
Over 75,000.....125,000	13
Over 125,000.....175,000	15
Over 175,000.....250,000	17
Over 250,000.....370,000	21
Over 370,000.....550,000	27
Over 550,000.....1,000,000	42

Any overhead conductor shall be considered to be energized unless and until the person owning or operating such lines verifies that the line is not energized and the line is visibly grounded at the work site.

If downed power lines are located, workers shall not try to move or repair them. They shall stay clear and call the experts; normally, the local power company will respond.

[REF: 1926.952 - Overhead Power Lines]

Trenching, Digging and Augering:

Trenching, digging, and augering, because of their possible disturbance of underground utilities and danger to employees and the public, require considerable pre-job planning and advance notice to others. The following procedures shall be followed:

- Prior to any trenching, digging, or augering for depths greater than that required for routine maintenance or the installation of any new signs, call Underground Service Alert (USA) 800-642-2444 in order to have all affected utility companies locate and mark their facilities.
- Contact affected utilities at least 48 hours in advance and tell them what is planned. They may wish to have a representative on hand during the excavation.
- Excavations greater than five (5) feet in depth shall be sloped, braced, shored, or otherwise supported. When soil is less stable than normal, these measures shall be taken at less than five (5) feet. Under normal conditions, in firm compact material, side slopes of 1:1 are satisfactory.
- When in doubt about the stability of excavations of less than five (5) feet, and in all cases over five (5) feet, one of the Department's registered civil engineers shall be contacted prior to proceeding. The recommendations of the engineer shall be followed.
- Trenching equipment shall be kept far enough from the edge of the excavation to avoid instability. Waste material shall be placed at least two (2) feet from the edge of the trench and piled so that it does not spill into the trench.

- The trench shall be backfilled as soon as possible, preferably prior to the end of the shift. Open trenches left unattended shall be properly marked and cordoned off. Adequate warning devices for traffic shall be installed.

[REF: 1926.652 - OSHA Regulations]

LOCKOUT/TAGOUT

When Cleaning, Repairing, Servicing, and Adjusting PrimeMovers, Machinery and Equipment:

- Machinery or equipment capable of movement shall be stopped and the power source de-energized or disengaged, and, if necessary, the moveable parts shall be mechanically blocked or locked to prevent inadvertent movement during cleaning, servicing or adjusting operations unless the machinery or equipment must be capable of movement during this period in order to perform the specific task.
- Every prime mover or power driven machine equipped with lockable controls shall be LOCKED OUT or positively sealed in the "off" position during repair work and setting-up operations.
- During repair prime movers, machines, or equipment shall be effectively blocked or otherwise secured to prevent inadvertent movement if such movement can cause injury to employees.
- Only authorized personnel are allowed to repair electrical circuits or equipment. All employees must exercise caution around electrical components. See Electrical Hazards section in this Code of Safe Practices for more information about the hazards of working with electricity.

To accomplish the above requirements, all employees shall comply with the LOCKOUT/TAGOUT POLICY.

Lockout/Tagout means that any energy source, whether it is electrical, hydraulic, mechanical, compressed air, or any other source that might cause unexpected movement, must be disengaged or blocked and electrical sources must de-energized and locked or positively sealed in the off position.

LOCKOUT/BLOCKOUT POLICY

Purpose:

This procedure establishes the minimum requirements for lockout of energy sources that could cause injury to personnel.

All employees shall comply with the procedure.

Responsibility:

The responsibility for seeing that this procedure is followed is binding upon all employees. All employees shall be instructed in the safety significance of the lockout procedure by the supervisor. Each new or transferred employee shall be instructed by the supervisor in the purpose and use of the lockout procedure.

Preparation for Lockout:

Employees authorized to perform lockout shall be certain as to which switch, valve, or other energy isolating devices apply to the equipment being locked out. More than one energy source (electrical, mechanical, or others) may be involved. The employees shall clear any questionable identification of sources with their supervisors. Before lockout commences, job authorization should be obtained.

Sequence of Lockout Procedure :

- Notify all affected employees that a lockout is required and the reason therefore.
- If the equipment is operating, shut it down by the normal stopping procedure (such as: depress stop button, open toggle switch).
- Operate the switch, valve, or other energy isolating devices so that the energy source(s) (electrical, mechanical, and hydraulic) is disconnected or isolated from the equipment. Stored energy, such as that in capacitors, springs, elevated machine members, rotating fly wheels, hydraulic systems, and air, gas, steam or water

pressure, must also be dissipated or restrained by methods such as grounding, repositioning, blocking, bleeding down.

- Lockout energy isolating devices with an assigned individual lock.
- Insure all personnel are clear and then, operate the push button or other normal operating controls to make certain the equipment will not operate. CAUTION: Return operating controls to neutral position after the test.
- The equipment is now locked out.

Restoring Equipment to Service:

- When the job is complete and equipment is ready for testing or normal service, check the equipment area to see that on one is exposed.
- When equipment is clear, remove all locks. The energy isolating devices may be operated to restore energy to equipment.

Procedure Involving More Than One Person:

In the preceding steps, if more than one individual is required to lock out equipment, each shall place his/her own personal lock on the energy isolating device(s). One designated individual of a work crew or a supervisor, with the knowledge of the crew, may lock out equipment for the whole crew. In such cases, it may be the responsibility of the individual to carry out all steps of the lockout procedure and inform the crew when it is safe to work on the equipment. Additionally, the designated individual shall not remove a crew lock until it has been verified that all individuals are clear.

Rules for Using Lockout Procedure:

All equipment shall be locked out to protect against accidental or inadvertent operation when such operation could cause injury to personnel. Do not attempt to operate any switch, valve, or other energy-isolating device bearing a lock.

[REF: 1910.147 - OSHA Regulations]

TRENCHING

A. Protection of employees in excavations.

1. Each employee in an excavation shall be protected from cave-ins by an adequate protective system except when excavations are made entirely in stable rock or excavations are less than 5 feet (1.52 m) in depth and examination of the ground by a competent person provides no indication of a potential cave-in.
2. Protective systems shall have the capacity to resist without failure all loads that are intended or could reasonably be expected to be applied or transmitted to the system.

[REF: OSHA Safety and Health Regulations for Construction Section 1926.652]

WATER SAFETY POLICY

It shall be the policy of Butte County Department of Public Works to promote and ensure safety for all employees while engaged in activities near or on the water. With this concept in mind, all employees shall be trained so he/she has a basic understanding of:

1. Self Rescue;
2. Water and its corresponding hazards;
3. Proper protective equipment to be worn at all times near or on the water;
4. Providing assistance within his/her capabilities while assisting another employee or person who is a victim (not a rescue);
5. When and who to contact in the event of a water rescue emergency which is beyond the expertise of the employee.

[REF: 1926.106 - OSHA Regulations]

EMERGENCY RESCUE

It shall be the Policy of Plumas County Department of Public Works to ensure that NO EMPLOYEE enters the water, at any time, for the purpose of attempting an emergency water rescue.

It shall be the employee's responsibility, once a victim is located, to summon the local Dive Team/Swift Water Rescue Team through the Fire Department or Search and Rescue. EXCEPTION:

Employees may attempt to reach a fellow employee or victim with a rake, shovel, stick, etc..

Employees may also attempt a water rescue by using a throw rope bag for purposes of assisting a fellow employee or victim in / near the water.

MANDATORY/NECESSARY WATER SAFETY EQUIPMENT

The following is a list of equipment that shall be issued to Plumas County Public Works employees assigned to work over or near water.

- A. Public Works shall issue one Class III Personal Flotation Device (PFD), equipped with whistle, to every employee working on a Road Crew and Engineer Crew that routinely works over or near water. The Department shall maintain an adequate supply of various sizes of PFDs. Employees who do not routinely work over or near water shall be issued a PFD whenever they are assigned to work within 10 feet of deep or swift moving water.
- B. At a minimum, one 75 ft. 3/8" poly-rope throw bag per vehicle at the site where work over or near water is assigned.
- C. Two flashlights per vehicle.
- D. A radio, cellular phone or some other form of communication which allows employees to contact emergency services. Employees assigned to work in the field after normal work hours shall contact Sheriff Dispatch to notify them to monitor the Public Works radio frequency in order to maintain a line of communication. The employees shall notify Sheriff Dispatch when work is completed so Dispatch can return to their normal radio frequency monitoring.

BASIC KNOWLEDGE REQUIREMENTS

1. Each employee will be required to understand the Basics of the I.C.S. (Incident Command System) and his/her role within this system;
2. During emergency water rescue, each employee will attempt to locate victim or fellow employee involved in the water emergency and, once located, will make every effort to keep said person in his /her sight;
3. Each employee will be required to wear their issued PFD when working in close proximity (10 feet) of deep or swiftwater and where employees work exposes them to the hazard of drowning.
4. Employees should be attentive to potential water hazards when detouring traffic and/or placing barricades;
5. Always call for HELP, water emergencies can quickly claim the 'helper or assistant' as a victim;
6. Observe the Priorities for Safety:
 - A. Protect yourself first;
 - B. Help fellow workers second;
 - C. Help victim within your trained capabilities.
7. WHEN IN DOUBT - STAY OUT!

POLICY FOR OPERATING IN FLOODED AREAS

1. No employee shall be closer than 10 feet from the waters edge unless they are wearing their issued PFD.
2. No employee shall walk in/through water were he/she is unable to see the bottom; unless they have probed ahead with a shovel or similar tool to ensure they are not stepping into a washout area or unfamiliar terrain that slopes drastically and would cause someone to fall into swift moving water.
3. Employees aware of problem areas should inform other employees, that are not familiar with these areas, about any potential hazards. IF IN DOUBT - STAY OUT!
4. Always use a spotter when operating mobile equipment around hazardous water conditions.

SELF RESCUE TECHNIQUES.

All employees shall be taught the principles and techniques of self-rescue.

1. Positioning. If an employee is swept off his/her feet in a water emergency or in watery conditions, he/she shall immediately assume a floating position with face and front of body facing upward and feet pointing downstream. This allows victim to push away from objects and obstructions;
2. Safe Areas. Find an 'Eddy' to swim for to initiate self rescue;
3. Rope Bags. Be ready to catch a rope bag so you may be towed to shore;
4. Dangerous Conditions. When approaching a strainer, begin swimming rapidly toward strainer and push or catapult body over the top of strainer, then assume position explained in paragraph 1 above.

COMMUNICATIONS

A. Hand Signals: The following hand signals will be used any time employees are operating near the water:

1. One hand extended above head = DISTRESS ...NEED ASSISTANCE;
2. Two hands forming "O" over head or one hand patting head = OKAY;
3. Two hands extended above head motioning left or right = MOVE or SWIM the direction indicated;
4. Both arms crossed in front of chest = NEED MEDICAL KIT and HELP.

B. Whistle Blast Communications:

1. One Blast = STOP, LOOK, LISTEN or ATTENTION;
2. Two Blasts - LOOK UPSTREAM;
3. Three Blasts = LOOK DOWNSTREAM;
4. Four Blasts Repeatedly = EMERGENCY.

C. Radio Communication: Whenever attempting to broadcast a report of any life-threatening emergency, the message shall start with the words:

PRIORITY TRAFFIC:

All employees using the radios shall cease using the radios to allow uninterrupted broadcast of the emergency message. No one shall use the radio unless specifically called for on the radio by the reporting individual broadcasting the priority traffic message.

Employees will be allowed to use the radios only after the PRIORITY TRAFFIC- CLEAR is announced.

REFERENCE: Sections 1602 and 3389, Title 8 of the California Code of Regulations

CONFINED SPACE ENTRY

Work performed in confined-spaces present special dangers to employees such as toxic, explosive, or asphyxiating atmospheres. The hazards encountered and associated with entering and working in confined spaces are capable of causing bodily injury, illness, and death to the worker. Accidents occur among workers because of failure to recognize that a confined space is a potential hazard. The potential hazards and mishaps can be minimized through training, an entry permit system, classification of confined-space operations, communication, and forms associated with confined-space entry.

Employees shall follow the written confined-space entry procedures in the Plumas County Confined-Space Policy that is designed to minimize the hazards identified above.

The first step in complying with the confined-space entry program is to determine if you have a confined space. You can determine if you have a confined-space by asking yourself the three following questions:

1. Is the space large enough and so configured that an employee can bodily enter and perform assigned work?
2. Does the space have limited or restricted means for entry or exit?
3. Is the space designed for continuous employee occupancy?

If you answer yes to all three of the questions, you have an OSHA-defined "confined-space."
[Ref: 1910.146 - OSHA Regulations]

CONFINED SPACE POLICY AND PROCEDURES

I. Non-Permit Confined Space Entry:

- a. All spaces shall be considered permit-required confined spaces until the pre-entry procedures demonstrate otherwise. Confined spaces may be entered without the need of a written permit or attendant provided that:
 - (1) the space is determined not to be a permit required confined space, or
 - (2) the space can be maintained in a safe condition for entry by mechanical ventilation alone.
- b. Each employee expected to enter confined spaces shall be trained in the safety and health aspects of the work they will perform.
- c. Prior to entry, a Confined Space Pre-Entry Check List shall be completed by a supervisor and conspicuously posted near work access to confined space. This list verifies completion of items listed below.
 1. When entrance covers are removed or opened, the opening shall be guarded by temporary barriers such as yellow tape, red cones, etc., that will prevent an accidental fall through the opening or prevent objects from falling on the entrant(s) while in the space.
 2. Disconnect or block off any pumps and lines which could carry dangerous substances into the space.
 3. The space's internal atmosphere is tested with a calibrated direct-reading instrument for the following conditions in the given order:
 - i. Oxygen content,
 - ii. Flammable gases and vapors, and
 - iii. Potential toxic air contaminants.
 4. The atmosphere is continuously tested while the entrant(s) remain in the confined space and results recorded.
 5. A "No Smoking" policy will be in effect during confined space entry.
- d. If all of the questions are answered "yes" on the "Pre-Entry" checklist then the space can be reclassified as a non-permit confined space as long as physical and atmospheric conditions pose no danger to the entrant(s). Entry may proceed into the space without a permit.
- e. If the atmosphere tests hazardous, mechanical ventilation may be implemented to eliminate hazardous condition and entry may proceed without a permit as long as forced air ventilation continuously operates while entrant(s) is in the space and continuous testing does not detect hazardous air contaminants.
- f. "Hot Work" or a source of ignition will be allowed if the space has been tested and found to be free of all flammable or explosive substances.

II. PERMIT-REQUIRED CONFINED SPACE ENTRY:

This safety practice applies to work in a confined space when the dangerous atmosphere cannot be purged and to emergencies when there is not enough time to purge the space.

- a. No employee shall enter a confined space if the permit is incomplete, not prepared by a supervisor, or if "no" is marked on any items of the permit.
- b. No employee shall be allowed to enter a confined space unless they have been trained in the use of equipment necessary for safe entry into permit required confined spaces. Required training includes but is not limited to:
 1. The use of self-contained breathing apparatus SCBA).
 2. Communications equipment necessary to monitor entrant's status.

3. The use of direct-reading tri-gas meter.
4. Rescue equipment and personal protective equipment necessary for making rescues from permit spaces.
- c. When entering from the top and no side entry exists, a safety belt with an attached line must be worn by the worker entering the confined space. The line must be 1/2" in diameter and capable of supporting 2000 lbs.
- d. A hoisting device must be used to lift the worker from the space, and he/she must remain upright.
- e. Have at least one attendant remain outside the confined space to continuously maintain an accurate count of entrants and monitor activities inside and outside the space to determine if it is safe for entrants to remain in the space. The attendant must be equipped with an SCBA. The attendant will only enter the confined space in an emergency and only after he/she summons rescue and other emergency services.
- f. Communication between the entrant and attendant shall be maintained at all times and may require the use of special communications equipment.
- g. Each member of the rescue service shall be trained in basic first-aid & CPR. At least one member of the rescue crew holding current certification in first-aid & CPR shall be available.
- h. Each member of the rescue crew shall practice making permit space rescues at least once every 12 months.
- i. The confined space will be tested continuously near the workers head. Keep a written record of all test results.
- j. Use only approved lighting and electrical equipment.
- k. Exit from the confined space as quickly as possible whenever an order to evacuate is given by the attendant or if the entrant recognizes a dangerous situation.
- l. "Hot Work" will be allowed if an additional permit has been issued to authorize work in the permit space and it is indicated on the entry permit.

III. RESCUE ENTRY

- a. Under no circumstances will the attendant enter the confined space unless help is present.
- b. The person attempting the rescue will wear a harness with lifeline attached and held by a standby person utilizing an "A" frame and hoisting device.
- c. Put on a fully charged, positive pressure, self contained breathing apparatus.
- d. Immediately call for emergency rescue help.

GAS DETECTORS

Harmful gases may cause irritation of the eyes, nose, throat and lungs. Higher concentrations may cause permanent injury or death. Flammable gases may explode.

Before entering vessels or confined spaces, your departments Confined Space Entry procedures should be read and strictly adhered to.

1. Ensure that all safety equipment is operating properly:
 - Gas detectors have been calibrated and checked before using.
 - The detector is appropriate for the specific gas.
 - The gas detector has fully charged batteries.
 - Turn instrument on in a clean air area.
2. Ensure combustible gas levels are 10% or less of Lower Flammability Limit (LFL) or Lower Explosive Limit (LEL) before entry.
3. Test at entrance and use a probe to test inside the space before you enter.
4. Do not enter any atmosphere that has not been properly tested. Enter only when readings are within permissible limits.
5. Continue testing after entrance with special attention to the bottom and areas where pockets of gases may gather.
6. Test the space every 30 minutes and record readings.



DANGEROUS GASES

Dangerous gases that you may encounter in confined spaces, especially in sewer collection systems are:

- **Hydrogen Sulfide (H₂S)**

Hydrogen Sulfide is by far the most life-threatening gas found in sewers and is lethal in even low concentrations. It is the most common malodorous gas emanating from domestic wastewater. The gas is colorless, and below a concentration of 200 ppm it smells like rotten eggs. After one or two inhalations the odor is difficult to detect. Above 200 ppm the gas deadens the sense of smell. At low concentrations (>10ppm) hydrogen sulfide irritates the eyes and causes coughing. At higher concentrations (>300ppm) hydrogen sulfide causes respiratory paralysis and death. If breathing has stopped, always perform CPR (without becoming a casualty yourself).

- **Methane (CH₄)**

Methane is a colorless and odorless gas and is highly explosive at 6 percent concentration by volume. The gas is lighter than air and tends to accumulate initially at the top of a manhole. Methane is also known as sewer, marsh, or natural gas. At very high concentrations, it can cause asphyxiation.

- **Ammonia (NH₃)**

Ammonia is a colorless gas which possesses a penetrating, pungent odor. The gas is lighter than air and therefore would accumulate first at the top of a manhole. At 16 percent concentration by volume it is flammable. Ammonia is a severe irritant of the eyes, respiratory tract and skin.

- **Carbon Dioxide (CO₂)**

Carbon dioxide is a colorless and odorless gas. The gas is heavier than air and therefore settles first at the bottom of a manhole. The gas is not flammable or explosive, but a 10 percent concentration by volume for a few minutes can produce asphyxiation.

- **Combustible Gases**

In industrial areas serviced by a collection system, accidental discharges or leaks of gasoline and solvents can release hydrocarbon gases which are toxic and explosive. When mixed with oxygen in certain proportions, flammable gases will explode violently upon ignition.

- **Oxygen (O₂)**

Oxygen deficiency is the most common adverse atmosphere found in sewers and is usually associated with stagnant sewage and the formation of carbon dioxide. An oxygen level less than 19.5% is UNSAFE.

