Utilities

22

Section III - Truck Company Operations

Electricity

Flammable Gas

Water

Sewer & Storm Drain Systems

HVAC Systems

Phone, Data, Communication Sites

Revised - December 2019

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Objectives

- Understand basic components of electricity.
- Explain the City of San Diego's power grid.
- Describe both residential and commercial electrical systems.
- Describe Step Potential.
- Understand how to mitigate various electrical emergencies.
- Understand Photovoltaic systems.
- Describe properties of flammable gasses.
- Understand natural gas distribution systems and meters.
- Understand properties of LPG.
- Explain how to mitigate flammable gas related emergencies on both the supply (before meter) and consumer (after meter) sides.
- Explain the City of San Diego's municipal water delivery system.
- Describe how to control water –related utility emergencies.
- Describe a basic storm drain system and its function.
- Understand steam systems.
- Become familiar with HVAC systems.
- Understand phone/cable/communication site related hazards.

Introduction

Utilities are the core services provided to us in order to function in our everyday lives. Utilities include electricity, gases, water, phone, cable, heating ventilation and air conditioning (HVAC) systems. Firefighters are often found in emergency situations that require the mitigation and securing of utilities. If not handled properly, they can present significant hazards to both life and property. Emergencies involving utilities may occur both during fire and non-fire conditions.

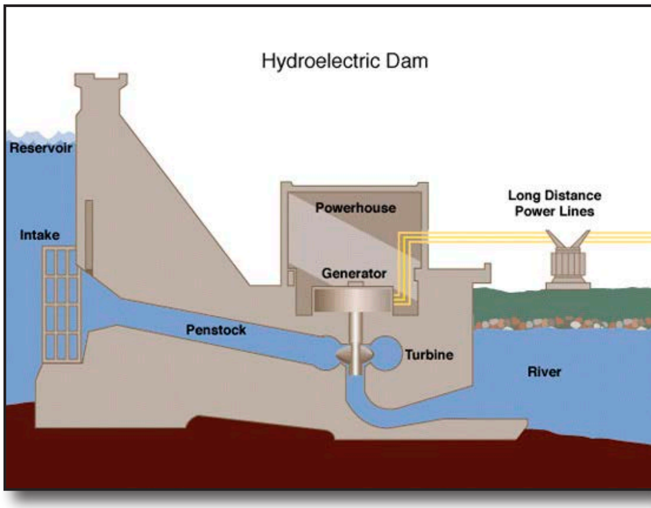
If correctly designed, installed, and maintained, utilities are both safe and useful. However, firefighters will encounter emergencies that are a direct result of poor installation and maintenance. For example, poorly maintained electrical systems can cause fires by arcing, short-circuiting, overheating, improper use, and accident. Firefighters should be able to identify the hazards that may be associated with electrical systems and the common causes of electrical fires.

Flammable gases are subject to many of the same hazards as electricity. Old gas mains can rupture, allowing natural gas to escape. This is dangerous under any circumstances because the gas has the capability to ignite a considerable distance from its source and can be quite difficult to extinguish. Also, gas leaking in an enclosed space can accumulate to an explosive level. As it displaces air, it can suffocate the occupants. Firefighters should be aware of procedures that will decrease and/or eliminate life or property hazards associated with gas and electrical systems.

In most utility emergencies, excluding life-threatening situations requiring immediate action or rescue, the responsibility of the San Diego Fire Department is to call the Fire Communication Center to request assistance from the proper utility company. The fire company shall then secure or evacuate the surrounding area to prevent life and property hazards and assist the utilities emergency crew upon their arrival.

Both training and pre-fire planning can be used to reduce the chances of incident occurrence and to identify the locations of shut-off valves and switches for utilities. Firefighters should be able to find all utility shut-off points for any building: if there are pre-fire plans for an occupancy, firefighters should be able to identify symbols to help locate electrical shut-offs, circuit breakers, and electrical panels. Firefighters should also be able to perform basic procedures to secure electricity, gas, and water safely.

Electricity



Electricity is created through the use of large generators located at hydroelectric dams, Figure 22-1, steam plants, or nuclear facilities. A simple analogy for an electrical generator is to compare it to a water pump pushing water through hose lines. The electricity is then delivered to customers via transmission lines and a power distribution system or grid.

Basic Components of Electricity

To understand how to safely work with electricity, you must first understand the basic properties and characteristics of electricity. These include alternating versus direct currents, voltage, amperage, resistance, and wattage.

Figure 22-1 Hydroelectric Dam & Generators

Alternating & Direct Current (AC/DC)

Batteries, Figure 22-2, fuel cells and solar panels all produce something called direct current (DC). The positive and negative terminals of a battery are always, respectively, positive and negative. Current always flows in the same direction between those two terminals.

The power that comes from a power plant is called alternating current (AC). The direction of the current reverses, or alternates, 60 times per second (in the U.S). The power that is commonly available at a wall socket in the United States is referred to as 120-volt, 60-cycle AC power. The big advantage that alternating current provides for the power grid is the fact that it is relatively easy to change the voltage of the power, using a device called a transformer. Power companies save a great deal of money this way, using very high voltages to transmit power over long distances.

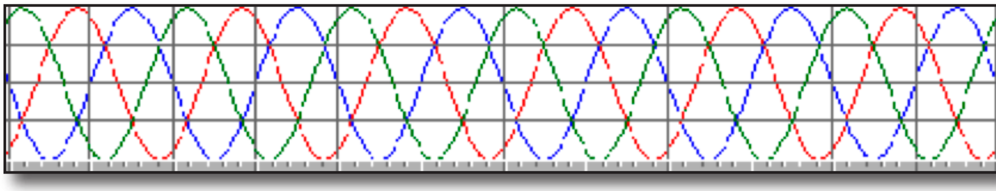
Single Phase Power

Single-phase power is what you have in your house. You generally talk about household electrical service as single-phase, 120-volt AC service. If you use an oscilloscope and look at the power found at a normal wall-plate outlet in your house, what you will find is that the power at the wall plate looks like a wave. The rate of oscillation for the wave is 60 cycles per second and represents the alternating current flowing.

Figure 22-2 12 V Battery

Three Phase Power

A power plant produces three different phases of AC power simultaneously, and the three phases are offset 120 degrees from each other. There are four wires coming out of every power plant: the three phases plus a neutral or ground common to all three. In 3-phase power, at any given moment one of the three phases is nearing a peak. High-power 3-phase motors (used in industrial applications) and things like 3-phase welding equipment therefore have even power output. There is nothing magical about three-phase power. It is simply three single phases sources of power synchronized and offset by 120 degrees.



Ground

The power company essentially uses the earth as one of the wires in the power system. The earth is a good conductor and it is huge, so it makes a good return path for electrons. (Car manufacturers do something similar; they use the metal body of the car as one of the wires in the car's electrical system and attach the negative pole of the battery to the car's body.) "Ground" in the power distribution grid is literally "the ground" that's all around you when you are walking outside. It is the dirt, rocks, groundwater, etc., of the earth, Figure 22-3.

Figure 22-3 Grounding Rod and Cable

Voltage

Voltage, sometimes referred to as "electrical potential," is the force that causes the flow of electricity. In an electrical system the force behind the flow is termed voltage and is measured in volts. For fire fighting purposes, voltage can be classified as either high or low. As a general rule, the larger the insulator and the more insulators there are, the higher the voltage. Any voltage higher than the normal residential supply (240), is considered high voltage and beyond the capabilities of firefighters to handle safely. However, low voltage is still dangerous and can deliver significant shocks and cause physical injuries. Voltage is comparable to a water system where the force behind the flow is termed pressure and is measured in pounds per square inch (psi).

Amperes

Current is the flow of electricity through a conductor and is measured in amperes and referred to as amperes or amps. A conductor is any material or equipment that will allow electrical energy to be transferred or pass through it. Metals, water, and the body are all excellent conductors of electricity. The current of electricity is very dangerous. As little as 60 milliamperes (mA) of alternating current (AC) can cause ventricular fibrillation. "Current Kills." Amperes can be compared to the flow of water in a system that is measured in gallons per minute (gpm).

Watts

Watts or wattage is the amount of electrical power needed to run an appliance or piece of electrical equipment. Watts are determined by multiplying the rated voltage by the rated amperage of a piece of electrical equipment (Volts x Amps).

Figure 22-4 Electrical Transmission Lines

Ohms

As electricity flows through a conductor, it is susceptible to resistance. An Ohm is the measurement of this resistance. The smaller the conductor, the greater the resistance; which equates to an increase in heat energy. This is a common reason for electrical fires, too much electricity flowing through too small of a conductor or wire. Ohms can be compared to the friction loss that is encountered when pumping water through a hose line.

Power Grid

In order to bring power from the generators to an outlet in your house, the electricity must safely be delivered, often over great distances. Power is delivered by means of a complex and sophisticated system of transmission lines, distribution lines and sub-stations referred to as the power grid, Figure 22-5.

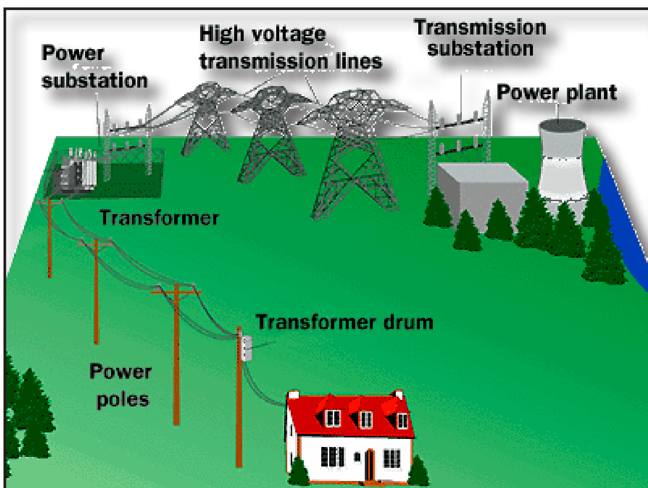


Figure 22-5 Power Grid

Transmission Lines

Once AC electricity is generated at a power plant, three-phase power leaves the generator and enters a transmission substation at the power plant. This substation uses large transformers to convert the generator's voltage (which is at the thousands of volts level) up to extremely high voltages for long-distance transmission on the transmission lines, Figure 22-4.

Typical voltages for long distance transmission are in the range of 155,000 to 765,000 volts in order to reduce line losses. A typical maximum transmission distance is about 300 miles (483 km). High-voltage transmission lines are quite obvious when you see them. They are normally made of huge steel towers and have three wires for each of the three phases. Many towers have extra wires running along the tops of the towers. These are ground wires and are there primarily in an attempt to attract lightning.

Figure 22-6 Power Substation

Power Substation

For power to be useful in a home or business, it comes off the transmission lines and is stepped-down to the distribution lines. This may happen in several phases. The place where the conversion from "transmission" to "distribution" occurs is in a power substation, Figure 22-6. A power substation typically does two or three things:

- It has transformers that step transmission voltages (in the tens or hundreds of thousands of volts range) down to distribution voltages (typically less than 10,000 volts).
- It has a "bus" that can split the distribution power off in multiple directions.
- It often has circuit breakers and switches so that the substation can be disconnected from the transmission grid or separate distribution lines can be disconnected from the substation when necessary.

Distribution Lines

Once the power has been stepped down in a substation, it is delivered to the customers via a network of underground cables or wooden power poles known as distribution lines, Figure 22-7. Distribution lines continue to deliver 3-phase power, which is why the wooden poles have three wires strung on each. A fourth wire lower on the poles is the ground wire and in many cases there will be additional wires, typically phone or cable TV lines riding lower on the same poles.

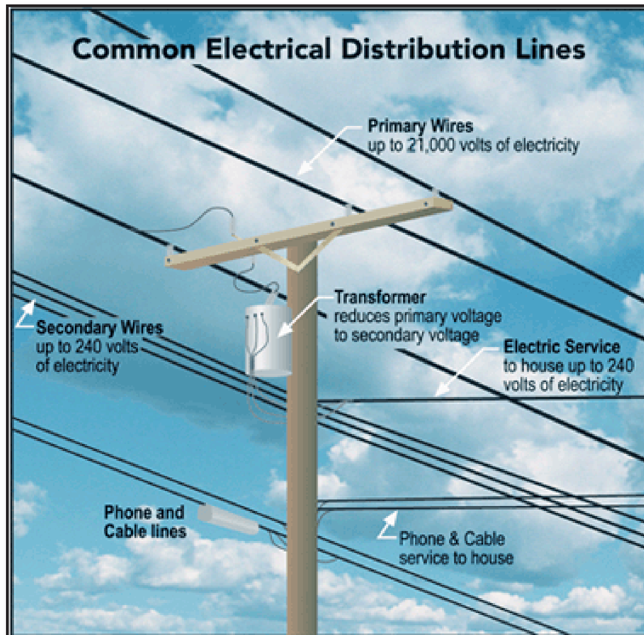


Figure 22-7 Electrical Distribution Lines

Transformers

Once power has reached it destination, the voltage must be stepped down again for customer use. This is accomplished through the use of small transformers mounted directly to the power pole, or green transformer boxes at street level for underground systems.

Live Front Terminator Boxes

Live front terminator boxes are used throughout San Diego County in order to place electrical lines underground. These boxes serve as a junction point for connecting consumers to the underground distribution system, Figure 22-8. The minimum voltage carried by these metal pad mounted cabinets ranges from 4KV to 12KV. They are usually green in color, and should not be confused with telephone junction boxes. If a circuit is tripped, a computer will isolate the circuit and automatically try to re-energize two times within the first forty-five seconds. Be aware, if the computer is unsuccessful in turning the circuit back on, then after ten minutes, a "Trouble Shooter" located at a switching station may over-ride the computer and manually turn on the circuit.

Figure 22-8 Live Front Terminator Box (above 2 images)

Residential & Commercial Electrical Systems

Now that power has been stepped down to the appropriate voltage for customer use, an insulated cable is connected directly to the power pole and run to the customer. This is known as a tap line. For most residential occupancies, only one phase of power is required, therefore only one power line runs from the pole to the house. For industrial and commercial applications, you may encounter one, two, or three cables depending on how many phases of power they require.

The power cable which runs from the pole to the occupancy, is attached to a non-insulated steel cable to keep it tight, known as a guide wire. This guide wire does not carry electricity.

For underground electrical services, electricity is delivered via an insulated power cable, which is run through a non-conductive conduit. The underground power is typically buried three feet deep and surfaces in the vicinity of the service panel.

Figure 22-9 Drip Loops

Drip Loop

Once the power cable reaches the occupancy, a sag, or drip loop is placed in the line to prevent rain water from running down the cable into the building or electrical panel, Figure 22-9. The power line then enters the structure through a weather head and is connected to a service panel.

Figure 22-10 Service Panel

Service Panels

A service panel is responsible for creating a shut-off point for electricity to the structure as well as to distribute the power via circuits throughout the occupancy. The service panel is also where the electrical meter is attached to monitor and bill for electricity usage. Within the service panel, circuit breakers can be found, Figure 22-10.

Circuit Breakers

Circuit breakers are essentially safety devices, Figure 22-11. They are designed to interrupt the flow of electricity if too much amperage is being drawn. Remember, if too much electricity flows through too small of a conductor (wire) it will overheat and can cause a fire. A circuit breaker uses the heat from an overload to trip a switch and is resetable. Most service panels have a main breaker, which shuts off electricity to the entire occupancy and several individual circuit breakers for each wiring circuit in the occupancy.

Figure 22-11 Circuit Breaker

Fuse

Fuses are typically found in older homes constructed prior to WWII. A fuse serves a similar purpose as a circuit breaker, only they are not resetable. In a fuse, a thin piece of foil or wire quickly vaporizes when an overload of current runs through it, Figure 22-13. This kills the power to the wire immediately, protecting it from overheating. Fuses must be replaced each time they burn out.

Sub-Panels

Sub-panels are simply a smaller version of a service panel and they are installed on the user's end of the meter, Figure 22-12. Sub-panels are often found installed for appliances such as pool or hot tub equipment, solar panels, or may be used for add-ons to a structure.

Figure 22-12 Sub-Panel

Step Potential

Step potential kills. Step potential refers to the electrocution risk based on the possible amount of voltage running through the ground. For example, if a power line falls down and touches the ground, it may be able to cause a "pool" of electricity for 10 feet (hypothetical example, distance varies upon the type of ground and voltage). As electricity flows out through the ground from the source, the voltage dissipates. If a person were to take a step toward the source, their right foot may be contacting the ground where the voltage is 1000 volts and their left foot may be contacting the ground where the voltage is 800 volts. Because electricity flows from higher to lower voltages, the variance between each leg may be up to 200 volts, which will then try to travel through the person's body.

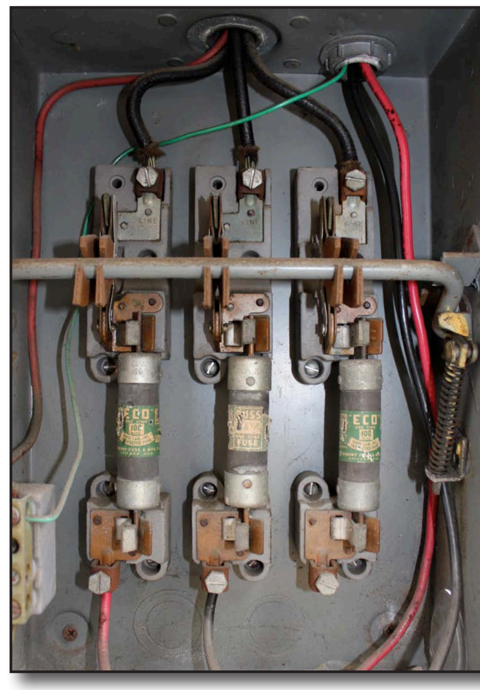


Figure 22-13 Fuses (above 2 images)

This is the primary reason you must stay clear of downed electrical lines. Step voltage is invisible and can strike without warning. You do not actually have to make direct contact with the electrical or power source to suffer a shock or electrocution.

Mitigating Electrical Emergencies

As a general guideline, firefighters should deal with electrical fires and emergencies in the following manner:

- Perform immediate rescue and evacuations.
- Confine and extinguish any associated fire if safe to do so.
- Standby and call for SDG&E to let their emergency crews handle the problem on all electrical emergencies that occur on the supply or SDG&E side of the meter.
- Disconnect the source of electricity on the customer side of the meter by switching off breakers, circuits, fuses, or by unplugging appliances if safe to do so.

General Safety

It must be understood that low voltage does not mean safe voltage. Minor shocks can cause physical reactions and injury, which may not be noticed until after the shock has passed.

High and low voltage power systems can create arcing if they come in and out of contact with a conductor. Never look directly at an electrical arc as it can cause damage to your eyes.

When firefighters are in a building where visibility is impaired and electricity is a suspected problem, they should keep arms up with palms facing inward. Using this method will knock you away from, instead of into, the electrical hazard if contact is made. Because electricity causes your muscles to contract, keeping your palms inward will keep you from locking your grip on to electrical wires if you become energized.

Figure 22-14 Electrical Fire in a Substation

As water moisture falls through wires, it may carry electricity to the ground and individuals standing below where moisture is present. Water streams may even conduct electricity to the hose a firefighter is holding; therefore, firefighters must never direct water streams through, between, or over high voltage wires.

Smoke is also a conductor of electricity due to its particle content and hot ionized gases. As smoke rises, it may provide a conductive path until it contacts some other electrically conductive material, such as a water stream, equipment, or people. Keep clear of power lines where heavy smoke is passing through.

Power Plants and Substations

If a fire occurs at either a power plant or substation, do not extinguish it until utility authorities have been consulted. In the case of an unattended substation, the hazardous area should be secured to protect the surrounding property and the electric company should be notified. Firefighters must stay out of the substation until SDG&E emergency crews arrive, Figure 22-14.

The insulating oil found in power plants and substations is a non-lubricating paraffin-base oil used in transformers, circuit breakers, and other electrical equipment. It is not volatile or explosive unless heated above its flash point (294 F), or unless it is vaporized by an explosion. Fire fighting procedures for this type of fire are the same as for any Class B fire once the system has been shut off and grounded. Fire fighting measures should not be conducted until it has been confirmed by SDGE that all power has been secured.

WARNING - While PCBs (polychlorinated biphenyls) have been removed from all utility poles in the San Diego area; some schools and private structures still contain them, (i.e., Qualcomm Stadium). Use extreme caution to avoid contact with transformers containing PCB's and always wear an SCBA. In addition, contact the Hazardous Incident Response Team for assistance.

Figure 22-15 Traffic & Street Lights are Considered High Voltage

Street & Traffic Lights

Street & traffic lights should always be considered high voltage devices and energized at all times, Figure 22-15. 240 volts feed newer streetlights with photoelectric cells. Older street lights without a photoelectric cell can be fed by up to 6,800 volts. Ornamental street lamps and overhead streetlights are often connected in series. Consequently, while the currents input into the system is constant, the voltage in any one lamp will vary. Therefore, if any wires are severed, there may be a dramatic increase in voltage.

Neon signs operate with an electric current through a glass tube filled with gas. High potential voltage must be used when starting a neon lamp. Often transformers form part of the lighting equipment, increasing the electricity to as high as 15,000 volts. Although the voltage of these units is very high, the current flow is low.

The San Diego Trolley utilizes 600 volts DC power and can only be de-energized by trolley repair crews. Personnel should stay a minimum of 10 feet from trolley lines. (Refer to Chapter 25 - Vehicle Extrication for further information on trolley emergencies)

Underground Conductors

Electric cable and conductors running through underground ducts and manholes seldom cause trouble. Occasionally, different factors may cause combustibles in vaults to ignite or gases present to explode. The resulting explosion may set off a block-by-block chain of explosions. Keep the areas surrounding manholes clear for several blocks on each side. The most appropriate action firefighters can take under such circumstances is to call for SDG&E, perform any rescue, evacuate the hazardous area, and standby until the utility company arrives.

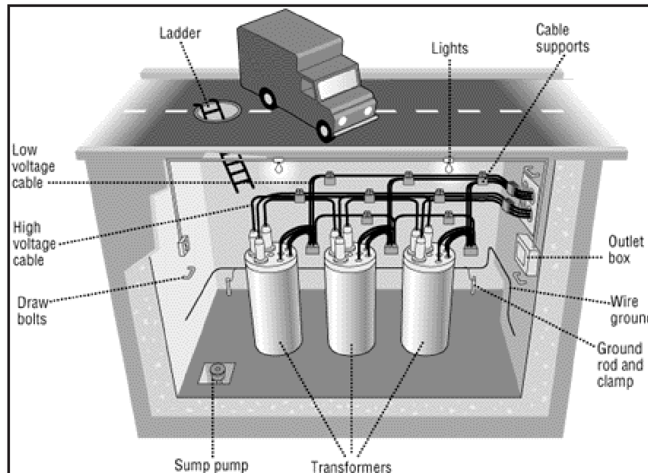


Figure 22-16 Undeground Electrical Vault

Firefighters should never enter an underground manhole or vault during an underground fire until SDG&E has deemed it safe to do so. Maximum damage will occur at the time of electrical failure and/or explosion and in most situations life hazards are minimal. To extinguish the fire, firefighters should use only non-conducting agents until clearance has been given by the utility company. CO2 discharged into a manhole will usually extinguish smoldering and burning insulation if the manhole cover is replaced afterwards.

Overhead Wires

Overhead wires and utility poles can become hazardous when they catch fire, sag, or fall. Firefighters should use extreme caution whenever dealing with overhead wires under any conditions. In most cases, the best procedure to follow when dealing with overhead wires is to call for SDGE and evacuate the immediate area in question. Apparatus, equipment, and personnel should be kept one pole-span from the potential hazard. Heat quickly anneals the conductors and may cause them to weaken and fail.

If a vehicle becomes energized from contact with low voltage wires, firefighters can safely leave the vehicle by JUMPING - NOT STEPPING FROM IT. If you are unable to jump from the vehicle, remain in a stationary position and avoid touching anything unnecessarily. Never attempt to touch or reenter an electrically- charged vehicle. If high voltage wires are in contact with the vehicle do not attempt to jump from it, as the ground around it may be energized. Stay in the vehicle, and jump only if the vehicle is on fire.

Rubber tires will not always act as insulators because they may be steel belted in construction. Rubber boots are not a dependable insulator either. Substances used in the manufacture of rubber goods to make them wear longer and repel water are often conductors of electricity.

Do not allow ladders or water streams to come near or in contact with overhead wires. If a ladder or water stream comes into contact with an overhead wire it may push two wires together, or create an electrical path between the wires (due to the water's conductivity), possibly shorting out the wires. This can cause a fire in the transformer and/or the wires may fall, starting fires on the ground.

Pole Fires, or Pole-Mounted Equipment Fires

If firefighters encounter poles or pole equipment (e.g., transformers, potheads, capacitors, etc.) on fire, they should evacuate and secure the area upon arrival. They should request FCC to call for electric company representatives and provide them with a size-up of the situation. Do not attempt to extinguish the fire; sometimes it may be best to let the fire just burn itself out. Protect exposures, including surrounding and adjacent property. The fire fighting company should standby until the electric company service personnel arrive at the scene, and then be guided by their recommendations.

Figure 22-17 Pole Fire - Stay back 2 pole spans

If necessary, a fog stream can be used intermittently to cool pole fires; never use a straight stream directly on any electrically charged fire. If the pole is burning, extinguish the fire only within 2 feet of the capacitor. If the capacitor is burning stay a minimum of 2 pole spans from the fire. Water that is absorbed by a power pole, or running down a pole, may actually make the situation worse by grounding the electrical equipment. Always use extreme caution when dealing with energized wires, equipment, and poles, which have been seriously weakened due to significant heat or flame impingement from a fire.

Oil switches, oil-filled transformers and other electrical equipment containing oil (most sealed units contain oil) involve the additional hazard of oil fires. The oil used has a relatively high flash point, but it may be heated and ignited by excessive current flow or by an electric arc. Under no circumstances should any attempt be made to extinguish this type of fire until an on-scene utility representative determines it is safe (i.e., current off and grounded). After the current is shut off and grounded, such fires can be extinguished by any of the methods used for extinguishing oil fires (i.e., portable extinguishers of the Class B: C type may be used effectively). Water applied with a fog or spray nozzle may also safely contain this type of fire.

Wires Down

When responding to wires down, the first-in company should call for SDG&E. When contacting FCC, the fire company should state the pole number and whether the wires involved are from pole-to-pole or from pole-to-structure. Wires adjacent to the downed or sagging wire may be weakened so firefighters should secure a "hot" zone around the incident of at least one pole-span from the broken or sagging wire. KEEP THIS AREA CLEAR. Any movement at the source of the trouble may cause wires to fall, burn, and/or whip. Do not attempt to move grounded, slack, or dangling wires.

Firefighters must be extra cautious in rainy conditions not to touch a wet pole and the ground when wires are down or sagging. It is possible to draw an arc and shock from a pole under these conditions. When confronted with arcing wires in trees, keep in mind that the area around the tree will be energized. If electrical service lines contact TV wires, metal gutters and plumbing may become energized. Wires falling on fences can cause the entire span of the fence to be energized. While fighting wildland fires, care must be taken to avoid staging or parking underneath power lines. If retardant is dropped near high voltage lines, exercise extreme caution due to the hazard of short-circuiting.

Victim in Contact with Wires

If a victim is found to be in contact with wires, the wires should be considered hot until confirmed otherwise. SDFD does not have the proper training or equipment to safely remove a victim from a live wire or electrical source at this time.

Cutting Wires

If wires must be cut to free the victim, cutting operations should be performed, whenever possible, by the electric company.

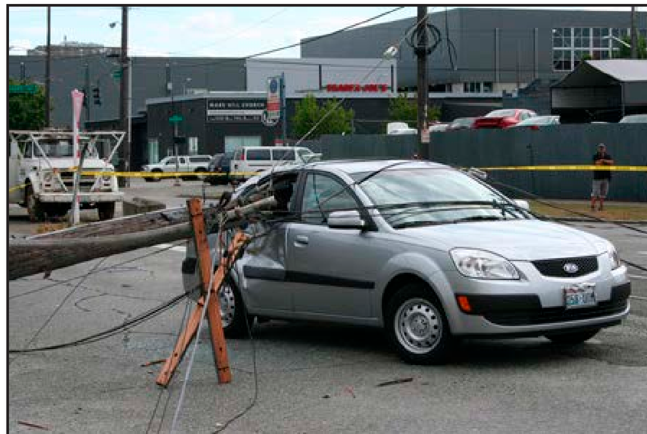


Figure 22-18 Keep victim in the vehicle until power can be secured

Vehicle in Contact with Wires

When there is a vehicle in contact with wires, the appropriate action is to call for the electric company and standby until they arrive.

If the victim is conscious, persuade the individual to remain in the vehicle, Figure 22-18. If there is danger of fire or the victim panics, explain that they must jump clear of the vehicle, feet together and hands in, making sure not to contact any part of the charged vehicle and the ground simultaneously.

Vehicle in Contact with Live Front Terminator Box

Figure 22-19 Vehicles can become enegized when contacting Live Front Terminator Boxes

Any vehicle involved in an accident with green pad-mounted electrical equipment, also known as a live front terminator box, must be considered energized with high voltage, Figure 22-19. The minimum voltage carried by these cabinets is from 4KV to 12KV. They are usually green in color, and should not be confused with telephone junction boxes. Care should be taken to check for wires underneath the vehicle. Victims should be encouraged to remain in the vehicle until electric company crews can de-energize the equipment. Remember, these boxes may re-energize without warning. A computer will automatically try to reset the breaker to re-energize the box twice. If unsuccessful, an operator may remotely override the breaker and re-energize the box, thereby energizing the vehicle. These incidents present a very dangerous situation for firefighters.

In the event you are called to an incident involving a Live Front Terminator box your strategy should include the following:

- Assume all electrical lines are hot.
- Notify fire Communication immediately, and inform them you are at an incident involving a Live Front Terminator Box. If possible provide a box number or address. According to Sempra Energy (SDG&E) these numbers are better than an "intersection only". Additionally, the Trouble Shooter is required to check and see if any damage calls have come in before manually turning on the circuit.
- If at all possible wait for SDG&E personnel to arrive before making any contact with the vehicle.

Figure 22-20 GFCI Outlet

Consumer –Side Electrical Emergencies

When encountering electrical fires or other emergencies involving electricity in residential, commercial or industrial applications, firefighters should take the following actions:

- Request SDG&E assistance.
- Take protective measures to reduce life and property hazards.
- Isolate the electrical hazard by opening switches or throwing circuit breakers.

Firefighters should try to isolate electricity closest to the affected area in order to avoid disrupting the entire service. When it is practical and safe, firefighters should attempt to isolate involved hazards in the following order:

- Fixtures/Switches
- Outlets / Ground Fault Current Interrupter (GFCI), Figure 22-20
- Appliances
- Sub- Panels
- Main Electrical Panels

Figure 22-21 Slater Circuit Tester used to check correct wiring of an outlet

When tasked with securing power to a structure that is on fire or considered an IDLH atmosphere, the safest, fastest, and most practical method is to shut off the breaker at the main electrical panel.

To facilitate locating the circuit breakers or fuse-boxes, ask the owner, occupants, maintenance personnel, building engineers, etc.

If no one is available to help you locate the circuit breakers or fuse box, follow these general guidelines to find the units:

- For underground service, look for the meter and circuit breakers.
- For overhead electrical service, look for a power pole and trace the wires running from the pole to the structure. These wires are connected to the structure by a metal mast that extends above the roofline and carries the wires to the meter. The electric meter is usually located at the base of the mast below the drip loops.
- Circuit breakers in residential and small commercial buildings are usually located in the same box as the electric meter. If it is not, it should be located in the general vicinity of the meter box.
- Residential meters are most commonly located in garages, on service porches, or in interior closets of apartments or units.
- In large multi-family residential buildings, such as apartment complexes and condominiums, it is common to find multiple metered service panels in one location, Figure 22-22. If the meters are well labeled, it may be possible to isolate the power to the individual unit(s). If the meters are not well labeled, you must error on the side of safety and shut them all off at the main disconnect or each panel indiviually.
- In commercial structures, the mast will usually terminate in an electrical junction box. The meter can be found on this box, but the circuit breakers and fuses may be located elsewhere, Figure 22-23. Wires may run from the junction box to a circuit breaker panel or switch box near by. Typically, the meter will be labeled to indicate that the box does not contain fuses or circuit breakers.
- In modern life safety high-rise buildings, electrical panels and sub panels may be found in individual units, at each floor, and in a main electrical room at or below ground level.

Figure 22-22 Multiple Metered Panels

Figure 22-23 Commercial Breaker Panel

Disconnecting a Circuit Breaker

Circuit breaker panels utilize two kinds of breakers, the switch-type, Figure 22-24, or the push-type, Figure 22-25. Before disconnecting a circuit breaker, firefighters should note the condition of the panel (i.e., circuit breakers in the "off" position, spent fuses, panels that have been tampered with, etc., which may aid fire investigators in determining the cause of the fire). A quick visual inspection will usually suffice, but be wary of units that appear to have been tampered with.

Some circuit breakers or switch boxes have main switches that are marked "Main." Actuating this switch will disrupt the entire service and is a quick and

Figure 22-24 Switch Type Circuit Breaker

simple operation (avoid doing this if the incident can be isolated locally). When the handle is in the "on" position, the service is on or energized. Switch boxes come in various sizes depending on the load they are designed to carry. In large commercial structures, hospitals, hotels, high-rise buildings, etc., it is recommended to get the assistance of maintenance personnel when disconnecting electrical services.

Firefighters must never remove electrical meters for any reason, Figure 22-26. Disconnecting or pulling the meter will not necessarily disconnect the electrical service. Rather, it may create electrical hazards by exposing the atmosphere to electricity. The meter is an instrument to measure power usage and is not a switch.

Sometimes, circuit panels are located with transformers on the panel itself. These transformers take a small amount of current and deliver it to the meter for current usage measurement. This is a "CT" circuit with an uninterrupted circuit from the source to the load. The meter is totally out of the circuit, and pulling the meter will not stop current flow to the occupancy. Removal of an electrical meter from an energized meter base is an extremely dangerous practice.

Firefighters should be aware of the difference between "dead" and "isolated" circuits. Isolation prevents any automatic or remote control operation which would energize equipment or wiring from its normal source. A dead circuit has been de-energized by throwing a breaker, but it has not been isolated. The IC must work closely with SDG&E crews to ensure proper isolation of energized equipment.

Figure 22-25 Push Button Type Circuit Breaker

Figure 22-26 The service panel on the left has had it's meter removed and locked by SDGE.

Photovoltaic Electrical Systems

Photovoltaic (PV) systems turn sunlight into direct current (DC) power through the use of solar panels, Figure 22-27. When sunlight hits these panels, they generate an electric current, which is converted into electricity to power homes, businesses, etc. These systems are becoming more and more popular as people are looking for alternative forms of energy and cheaper utility bills. In fact, California is the 3rd largest world market for PV systems behind Germany and Japan. It is important for us as firefighters to be able to identify their presence, understand the components, and know our limitations so we can safely operate around a PV system.

Figure 22-27 Typical Photovolataic Solar Panel

Identifying PV Systems

PV systems are comprised of three main components. A basic layout of a PV system consists of modules, an inverter, and conduit with wire running through it. A PV module (or solar panel) is low voltage and therefore connected to other modules to form a string. When combined, these strings can generate up to 600 volts of DC electricity. There may be multiple strings of modules, which in turn form an array. These modules are most often found on rooftops, positioned to receive the most sunlight in a given day.

In order for consumers to take advantage of the electricity generated, inverters are used to convert the direct current (DC) to an alternating current (AC). AC power is what you find in household electrical outlets. The location of inverters and disconnects will vary with different installs. They may be located near the main electrical panel, in the garage, on the roof, or even underneath the PV modules. There will be a DC breaker (disconnect) on the PV module side of the inverter and an AC breaker between the inverter and house supply, Figure 22-29.

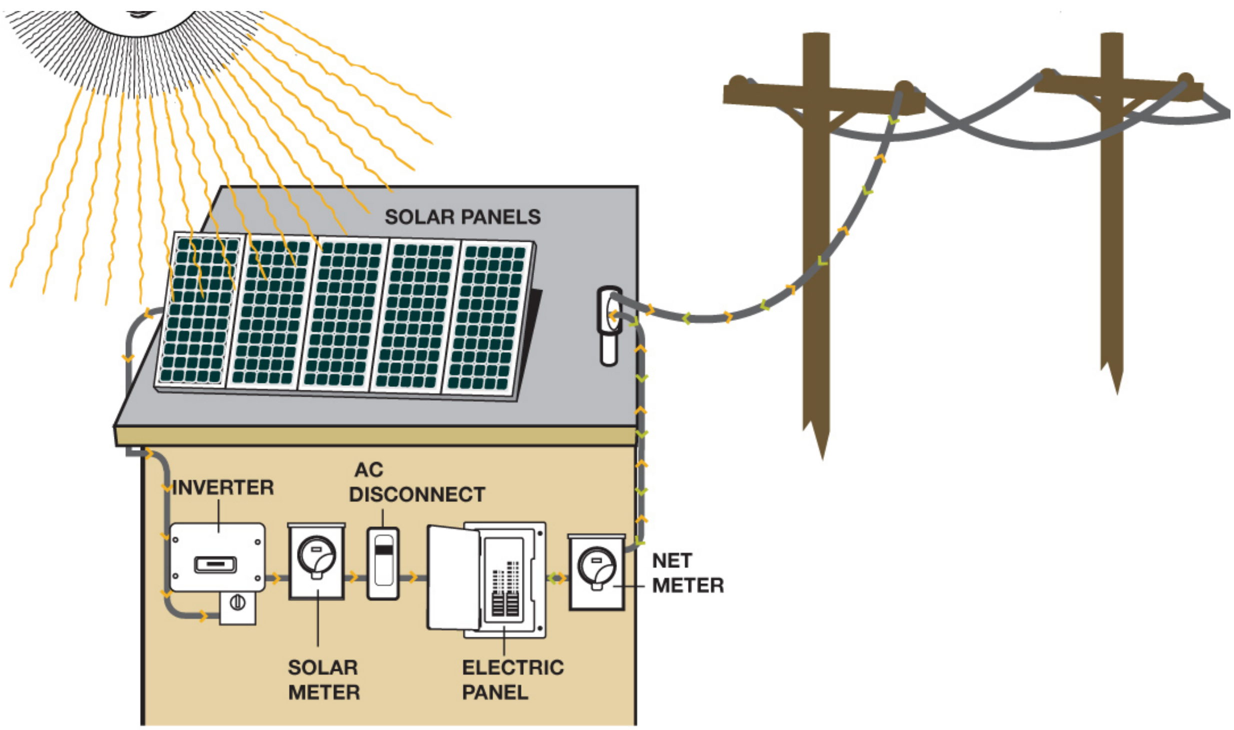


Figure 22-28 Photovoltaic Disconnect

The presence of conduit on a roof or in an attic may indicate the use of a PV system. The conduit connects the PV module arrays to the inverter and finally to the electrical panel. They may run across the roof, be painted, and may even be hidden for aesthetic purposes.

There are no laws to advertise the use of a PV system so we have to look for these different indicators to help us identify their presence. Doing so is the first step towards successfully securing a PV system.

Hazards to Firefighters

PV systems pose problems for firefighters because of several reasons. They have electrical shock potential, the modules and conduit can be trip hazards on a roof, and they add an additional dead load to roofs. These are some issues in regards to disconnecting the PV system:

- Array may still generating electricity and feed power back to the sub-panels
- Inverters have large capacitors. Discharge time may be from 5-15 minutes
- Shutting off one may not work if others are on
- Do not assume power is off until verified by a qualified individual
- Disconnection is primarily for maintenance purposes

Figure 22-29 D.C. Power Disconnect and D.C. to A.C. Inverter

With so many issues, we must always treat PV modules as live and use the same caution around them that we would with a live wire. Currently, there are no building codes with respect to installations. However, the Office of the State Fire Marshal has provided an installation guideline for solar photovoltaic companies. This guideline addresses issues of labeling the PV system as well as providing 3 feet of space along the ridge of the roof.

Strategy and Tactics for Photo-Voltaic Systems

Since a PV system needs a closed circuit to generate electricity, breaking the circuit de-energizes the line. The following are the recommend steps to secure power to a PV system.

- Secure the main service meter/breaker panel
- Secure the breakers on both sides of the inverter (AC and DC)
- Open (disconnect) the inverter to break the circuit
- Secure power to the junction box on the roof if applicable

The inverter acts as a capacitor and may still hold an electrical charge 5-15 minutes after being shutdown, depending on the size. Remember, these components can be anywhere and may sometimes be hidden, so we have to treat every system as live and stay cautious while operating around them. Placing salvage covers over the modules will only reduce the amount of electricity generated by the solar panels. The salvage covers we carry will still allow sunlight to pass through and may provide a false sense of security. When conducting fireground operations at night, be aware that the lights used for scene lighting can be converted to DC power and generate enough current to cause lock-on (40 milliamperes).

If the fire is directly under the panels, roof ventilation is not possible and another location will have to be considered. When a module is on fire, remember that our hose streams can conduct electricity. Photovoltaic panels on fire are to be treated the same as pole mounted transformer fires: avoid direct water application on the involved panels and protect exposures with a hoseline.

After the Fire

SDG&E will not secure privately installed electrical systems. If possible, PV system installation company should be contacted ASAP to respond to the premise. This contact information can sometimes be found on the inverter or main service panel. If the fire is at night, a fire watch may need to be considered for the morning when the sun comes up and energizes the panels.

Figure 22-30 Residential Emergency Generator

Photovoltaic technology is constantly changing and has no set standard in regards to system installation. For this reason, always treat all power equipment as live and be extra cautious around PV systems.

Consumer Generators

Many residences, Figure 22-30, and businesses, Figure 22-31, will have generators for use as an emergency, back-up power supply in case the main power fails. These are gas or diesel powered generators and can be wired into the building's electrical system, or portable units with electrical appliances plugged into them.

A common hazard of consumer generators is the Carbon Monoxide they emit while running. If used an enclosed space, or outside near an open window, Carbon Monoxide can gather to a toxic level and proper ventilation and use of SCBA's become paramount. Most generators will come equipped with a main circuit shutoff, or they will have GCFI that can be tripped to interrupt the power being distributed.

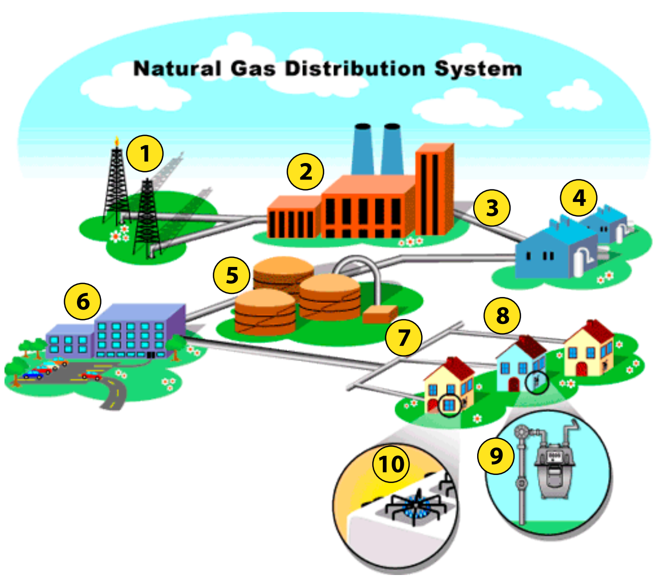
Use caution when you turn off electricity to a building, especially at commercial buildings, and understand that a back-up generator may be in use and the building can have power restored without you knowing it. All the same risks and hazards of operating in a building with live power are still in place if the back-up generator is functioning. Often times there will be select emergency lights that come on once normal electrical service has been interrupted and should alert you that a consumer generator is in use.

Figure 22-31 Commercial Grade Emergency Generator

Flammable Gas

Figure 22-32 Gas Transmission Line Marker

The two most common types of flammable gas used by consumers for everyday applications are Natural Gas (Methane) and Liquefied Petroleum Gas (LPG / Propane). Many residential and commercial buildings utilize these gases for everything from heating and cooking to industrial construction. The objective for firefighters is to contain incidents involving natural gas or LPG while keeping damage and injury to a minimum. The hazards of gases are twofold: they have the ability to displace air, causing asphyxiation in enclosed spaces, and they are highly flammable. Firefighters should be aware of the differences and similarities between these gases and the methods utilized in their distribution. When firefighters encounter incidents where natural gas is a suspected danger, they should call FCC and request the assistance of SDG&E. When encountering an LPG incident, dependent on the size of the incident, firefighters may wish to contact the Hazardous Incident Response Team (H.I.R.T.) for assistance.



1. Gas Well
2. Gas Processing Plant
3. Transmission Pipe Lines
4. Compressor Station
5. Storage Tank Facility
6. Utility Company
7. Distribution Pipe Lines
8. Service Lines
9. Gas Meter
10. Customer Appliance

Natural Gas / Methane

In homes, natural gas is used for cooking, heating water, and heating the house with a furnace. Natural gas is non-toxic and by itself is odorless. A chemical called mercaptan is added by the gas company to give it an unpleasant smell, similar to that of rotten eggs to alert you of any gas leaks. It is noticeable at a one percent concentration in a volume of air. Natural gas is lighter than air and is composed mainly of methane with small quantities of other gases added. Although methane is non-toxic, it is considered asphyxiating because of its oxygen displacement capabilities.

Gas Distribution System

Natural gas is found under ground and under the ocean floor. Wells are drilled to tap into natural gas reservoirs just like drilling for oil. Once a drill has hit an area that contains natural gas, it can be brought to the surface through pipes.

The natural gas has to get from the wells to us. To do that, there is a huge network of pipelines that brings natural gas from the gas fields to the consumer (see figure). From larger transmission pipelines (up to two feet in diameter), the gas goes through smaller and smaller pipes until it reaches your neighborhood.

Natural gas is distributed through pipelines with a pressure range of ¼ to 1,000 psi. Usually, the pressure is kept at 60 psi for distribution in residential areas. In older construction, steel pipes were used to transport the gas. In new construction, polyethylene pipes are laid underground and are usually placed in common ditches with electric lines, cable TV, and telephone lines. These ditches are generally 30 inches deep. The electric line is placed on the bottom and covered by 12 inches of sand. The pipeline, TV cable, and telephone lines are then placed in the ditch above the power lines. In businesses and in your home, the natural gas must first pass through a meter, which measures the amount of fuel going into the building.

Gas Valves & Meters

There are various shut-off valves in a typical natural gas line. At most incidents, firefighters will be able to shut off gas at the service meter, which is usually located on the outside of the building (usually within 10' of the structure). Firefighters are not trained to secure gas on the supply side of the meter; therefore, it is imperative that the utility company responds to these incidents.

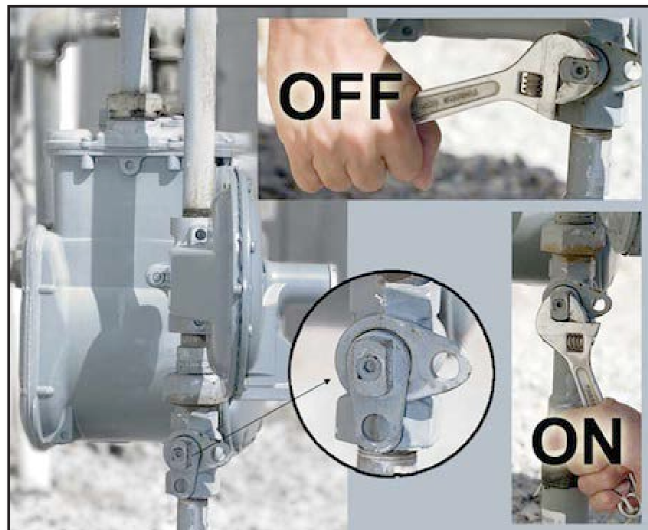


Figure 22-33 Gas Service Meter

Gas Service Meters

The shut off valve for natural gas is located on the supply or intake side of the gas meter, Figure 22-33. The gas meter may be difficult to locate but is usually found within ten feet of the front of the building, on either side of the structure. If the gas meter box is not located as described above, check the remaining perimeter of the building; often the meter box is hidden by shrubs and plants for aesthetic reasons. Gas meters may also be found in alleyways, underground garages, and exterior closets.

The gas shut-off valve will turn ¼ turn in either direction to the off position. This valve often has an indicator mark, which is in line with the pipe when the gas is on. When this mark line (wing) is across or perpendicular to the pipe, the gas is shut off.

On some commercial services there may be a second shut-off, a large valve on the low pressure or discharge side of the meter. By turning this valve clockwise ¼ turn, its maximum turning radius, the service is shut off. This valve should only be used when you are unable to turn the gas off at the intake side of the meter. A large crescent wrench is best to turn off gas service. NEVER turn gas service back on once it has been secured. A certified utility company can only restore gas service once it has been secured.

Curb Gas Valves

If the meter is located within the building, there will be a shut off valve in a concrete or metal vault outside the building with a cover over it marked "GAS" located at, or in the sidewalk along the perimeter of the structure, Figure 22-34. Under this cover is an auxiliary valve, called a curb valve because of its proximity to the curb. Curb valves are required at hospitals, schools, and many other structures of public assembly as a second gas shut-off. Curb valves can be either ¼ turn valves or multi-turn valves.

Figure 22-34 Curb Gas Valve

Liquid Petroleum Gas (LPG)

Liquefied Petroleum Gas (LPG) is usually composed of butane and/or propane. This gas is similar in nature to natural gas in that it is non-toxic, asphyxiating, and odorless. Similar to natural gas, an odor such as mercaptan is added to help identify a presence of LPG. During transport, the added odor may not be present and firefighters should always be cautious when approaching incidents where hazardous material is suspected. When in doubt, consult the Emergency Response Guide book and call H.I.R.T.

LPG is 1½ times heavier than air and tends to remain in low places due to its higher vapor density. This makes LPG dangerous in both enclosed spaces and in areas such as ditches. LPG is typically stored in containers that are above ground. Examples include: residential homes, industrial, vehicles, and house trailers. The shut off valve for LPG is usually located on the storage tank.

Flammable Limits and Ignition Points

Both LPG and natural gas are highly flammable. The difference between them is their flammable limits. Natural gas is explosive in concentration of 4 to 14 percent, while LPG is explosive from 2.1 to 10.1 percent of air volume. At these percentages, these gases can be ignited very easily. The explosive potential is significantly reduced when the gases exceed their upper explosive limit. Remember, these gases are still dangerous above the explosive limit because of their ability to displace oxygen and asphyxiate.

Figure 22-35 LPG (Propane) Tanks

BLEVE

LPG containers are equipped with relief valves located on top. Under normal conditions, these relief valves keep the tank from reaching its burst pressure, Figure 22-36. In the event of an accident, disaster, fire, etc., the structural integrity of the container and the effectiveness of its relief valve can be compromised. When LPG containers are exposed to a fire, they have the added danger of a possible explosion. The added heat causes an increase in pressure within the container. When this pressure increases and exceeds the strength of the weakened steel, the container will separate and release the contents. This release is otherwise known as a Boiling Liquid Expanding Vapor Explosion or BLEVE. When BLEVE's are a possibility, the best tactic is to cool the container using unstaffed master stream appliances, such as aerial ladders, deck guns or portable monitors from a distance so it never reaches its burst pressure.

All personnel shall be at least a ½ mile away when an LPG container is involved.

Carbon Monoxide

Figure 22-36 Venting LPG Tank

Carbon monoxide, also known as CO, is a toxic, colorless, odorless, and combustible gas which is the result of the incomplete combustion of natural gas and any other material containing carbon. CO has a wide explosive range of 12.5% to 74% and is the most widely encountered toxic gas. Carbon monoxide is an intense poison when inhaled because it displaces the oxygen in the blood. Even in small amounts, CO can deprive the heart, brain and other vital organs of oxygen.

Common sources of CO poisoning include:

- Gas heating systems
- Natural gas heating systems
- LP gas heating
- Coal/wood heating systems
- Kerosene/oil heating
- Diesel fuel

A common time for firefighters to be exposed to high levels of carbon monoxide is during the overhaul phase of fires. It is important to use the multi-gas detectors to monitor the air to determine the level of CO. The use of SCBA's is required throughout overhaul operations at all fires, excluding wildland fires.

Signs and symptoms of CO include:

- Shortness of breath
- Nausea
- Headaches
- Dizziness
- Vomiting
- Loss of consciousness

Carbon Monoxide Detectors

As of July 2011, California homeowners are required to install carbon monoxide detectors. All existing single –family homes that have fossil fuel burning appliances, fireplaces and/or attached garages are required to install and maintain carbon monoxide detectors. The law will require all other types of residential units to have carbon monoxide detectors by January 2013. According to the California Air Resources Board, 30-40 people die every year because of carbon monoxide poisoning.

Figure 22-37 CO Detector

Carbon monoxide detectors trigger an alarm based on an accumulation of CO over time. Detectors may be based on a chemical reaction causing a color change, an electrochemical reaction that produces current to trigger an alarm, or a semiconductor sensor that changed its electrical resistance in the presence of CO, Figure 22-37. Most carbon monoxide detectors require a continuous power supply, so if the power cuts off the alarm becomes ineffective, so models are available that offer back-up battery power. CO can harm you if you are exposed to high levels of it over a short time, or low levels of it over a long time. There are different types of detectors depending on how the level of CO is measured. Like smoke detectors, carbon monoxide detectors should be in every room in the home, high on walls and out of the reach of children to avoid tampering.

Gas Emergencies Procedures (SIN, CIA)

There are several different kinds of incidents that may occur involving gas. Firefighters should always advise FCC to notify the gas company whenever natural gas is involved. If LPG is involved, H.I.R.T. resources may be utilized depending on the size of the incident.

Safety

The first consideration during a gas emergency is to provide for personal safety. Park the apparatus upwind and a safe distance away from the emergency. Full PPE including SCBA should be worn, a charged hose line for crew protection should be laid and all SOP's associated with an IDLH atmosphere should be implemented. Gas vapors can completely displace air and may cause asphyxiation.

Figure 22-38 Gas Emergency

Isolate & Deny Entry

Evacuate all persons within the immediate area and establish a "hot zone." The size of the hot zone should be at least 200' in radius around the leak including any adjacent homes or buildings. If a tank, rail car or tank truck is involved, increase size of hot zone for ½ mile in all directions. Depending on the magnitude of the leak, the size of the hot zone may be increased. No persons shall be permitted to enter the "hot zone" unless directed by the incident commander.

All possible ignition sources must be extinguished or removed to avoid igniting the gas. This includes but is not limited to the following:

- Prohibit smoking
- Stop all machinery
- Reroute vehicular traffic
- Contain all electrical switches (although not visible, many light switches create a spark when they are operated)
- Avoid any conditions that can cause sparks

Notifications

The proper notifications and resources shall be requested through FCC and the incident commander. These resources may include additional fire units, SDG&E, PD for assistance with evacuations and traffic control, HIRT, County HazMat, and Red-Cross for displaced residents.

Command, Identification, Action Plan

The first arriving officer shall establish command and attempt to identify the leaking gas through personnel at scene, visual indicators, placards, or the Emergency Response Guide book (ERG). Firefighters should use a Multi-Gas Detector anytime there is a suspected hazardous atmosphere to identify which type of gas release is present. Once the gas has been identified an action plan can be put together to mitigate the emergency.

Supply Side Gas Emergency Procedures (Before Meter)

Once the above criterion has been satisfied (SIN, CIA), the following procedures shall be conducted by firefighters for gas emergencies that are found on the supply side of the gas meter. The supply side of the meter will have larger, two inch and larger steel or polyethylene pipes.

Gas Line Leaks (Before Meter)

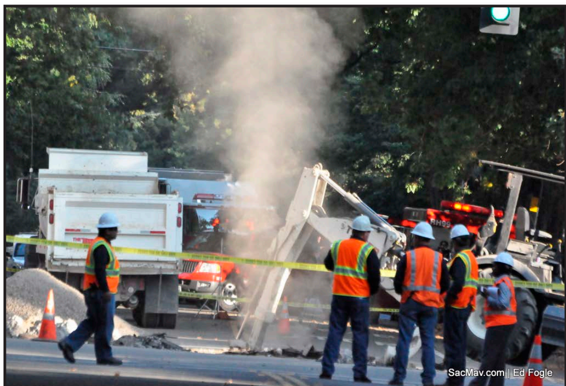


Figure 22-39 Vertical Column of Escaping Gas

- Always wear full protective clothing, SCBA's and consider ear protection.
- Do not attempt to ignite the gas.
- Evacuate the area as conditions warrant (see above) and banner tape off the "hot zone."
- Request police assistance for evacuation if necessary.
- Eliminate all sources of ignition.
  - Do not move vehicles into or out of the secured area.
  - Secure electrical power where appropriate.
- Make hydrant connections upwind and far enough away from the leak to protect against radiated heat.
- Continuously monitor the area using a multi-gas detector for migration of gas vapors into surrounding buildings, basements, and other enclosed spaces. The pressurized gas will often escape from the pipe vertically, similar to a knocked off fire hydrant. Taking air samples directly next to the gas leak will often yield little to no flammable gas reading as the invisible gas is shooting straight in to the air. Similar to a knocked off hydrant, once airborne, the gas will drift with the wind. Therefore, readings must be taken in the surrounding areas and in structures with open windows downwind, Figure 22-39.
  - Fog streams can be used to help disperse pockets of gas.
- Assign firefighters to the inside of exposed buildings to:
  - Close windows on the exposed side.
  - Open windows on the unexposed side.
- Do not attempt to shut off the flow of gas in the line. Supply lines may only be shut off by the utility company.
  - Due to the generation of static electricity and the possibility of igni-

tion, SDG&E advises against any attempts to bend poly pipes back on themselves to stop the flow of gas.

- Similarly, redwood plugs should not be driven into steel pipes.

Gas Line on Fire (Before Meter)

If the gas is burning outside, do not attempt to extinguish the fire. There is no danger of explosion but the area should still be contained for safety. If there are exposures threatened by the fire, they should be protected with hose lines. Exercise caution when using water on the burning gas at its point of escape. If this point is an excavation, the hole will fill with mud and water and make repairs slower and more hazardous. If there are no immediate exposures, establish a watch line to contain the area for safety.

Figure 22-40 Thirty Inch Transmission Gas Line Explosion, San Bruno, CA, 2010

Never operate gas main valves; stand by until the utility company arrives and controls the flow. Firefighters will still need to check nearby buildings, homes, basements, meter boxes, etc. for migrating gas. Burning gas may also be escaping underground as well. If polyethylene pipe is burning, a larger area of evacuation may be necessary because the burning plastic is very toxic.

Keep back from the break area. In bright sunlight, with almost complete combustion, flames from natural gas will be almost invisible. Additionally, burning natural gas escaping from large distribution or transmission lines may create a tremendous amount of noise and seriously interfere with radio and voice communications.

Consumer Side Gas Emergencies (After Meter)

Gas pressure in most homes is about ¼ pound per square inch, while larger complexes, hotels, and small commercial buildings may be as high as five psi. Once the appropriate safety measures have been taken and SIN CIA has been satisfied, the following procedures shall be conducted by firefighters for gas emergencies that are found on the consumer side of the gas meter. The consumer side of the meter will have ½" polyethylene or ¾" steel piping.

Gas Leak (After Meter)

Figure 22-41 Gas Meter

- Always wear full protective clothing and SCBA.
- Evacuate the area as conditions warrant.
- Eliminate all sources of ignition.
  - Do not move vehicles into or out of the secured area.
  - Secure electrical power where appropriate.
- Secure a source of extinguishment.
- Continuously monitor the area using a multi-gas detector for migration of gas vapors into surrounding areas and other enclosed spaces.
- Secure the gas leak:
  - At localized appliance (stove top knob, on/off switch, etc.)
  - At localized appliance gas valve
  - At gas meter
- Naturally ventilate the area with the highest concentration of gas. (I.e. start high for natural gas and low for LPG). Never use a gas-powered blower due to the spark created at start-up.

Gas on Fire (After Meter)

If gas is burning inside a building, attempt to shut off the appliance valve first. Remember, isolate locally if possible. When this is not practical, or if the valve cannot be located, shut off the gas at the meter supplying the house or business. If the gas supply cannot be safely shut off, keep surrounding combustibles wet with a fog stream until the utility company can arrive and control the gas flow.

Multiple Gas Meters

In some cases there may not be a localized meter for the section or unit of a large building that needs to have its gas turned off. In this case the fire officer may determine that it is necessary to shut off gas to the entire building at the service meter, which will shut off services to multiple units. The necessity of such an action should be weighed against the possibility of disrupting service to other areas and possibly creating further hazards.

The utility company can give specific information to help evaluate the situation. If a firefighter does turn off a gas valve-LEAVE IT OFF- and be sure the utility company is informed. Only a utility company employee should turn a valve on after it has been shut off. This is due to the fact that pilot lights on stoves and water heaters must be relit on all occupancies that had their gas service interrupted.

Figure 22-42 Multiple Gas Meters Serving a Large Apartment Complex

Atmospheric Monitoring

Atmospheric gas monitoring should be done anytime a fire company responds to an incident involving a possible gas release. The portable atmospheric monitors used by SDFD fire companies measure and detect four gases, oxygen (O2), carbon monoxide (CO), Hydrogen Sulfide (H2S), and the lower explosive limit (LEL) of combustible gases.

Figure 22-43 MSA Gas Monitor

Oxygen (O2) Levels

The oxygen section of the muti-gas monitor is used to detect the percentage of oxygen in the atmosphere. Air is a mixture of gases, mainly oxygen and nitrogen. Normal air contains 20.9% oxygen by volume. Deviations from this level, either high or low, are a major concern. The gas monitor is set to alarm when the oxygen level falls below 19.5% or rises above 22.5%. Any atmosphere that falls out of this range is considered IDLH.

Oxygen Deficient Atmospheres (Below 19.5%)

Breathing oxygen deficient air causes poor judgment, loss of coordination, fatigue, vomiting, unconsciousness, and ultimately death. Asphyxiation from insufficient oxygen frequently occurs when subjects, unaware of the problem, reach the point where they cannot save themselves or call for help.

Oxygen Enriched Atmospheres (Above 23.5%)

When oxygen levels exceed 23.5% by volume, the atmosphere is referred to as oxygen enriched. An oxygen-enriched atmosphere is not an asphyxiation hazard, however, it can be a serious fire hazards. Flammable materials will burn very rapidly in an oxygen-enriched atmosphere. A common cause of oxygen enrichment is leaking O2 lines or cylinders

Carbon Monoxide (CO) Levels

As mentioned earlier, CO is a toxic odorless, colorless and combustible gas. It is slightly lighter than air and has a wide explosive range from 12.5% to 74%. The gas monitor specifically measures the level of carbon monoxide in the atmosphere in parts per million, or PPM. According to Cal/OSHA, the permissible exposure level for CO is 25 PPM. Therefore, the gas monitors used by the SDFD are programmed to alarm whenever CO levels exceed 25 PPM.

To help put this measurement into perspective, Cal/OSHA has determined that any level over 1200 PPM is considered IDLH.

Hydrogen Sulfide (H2S) Levels

Hydrogen Sulfide, or H2S, is a toxic, colorless, combustible gas that has the odor of rotten eggs. It has an explosive range from 4.5% to 45.5% and is slightly heavier than air. H2S is commonly found in oil and gas production, refining, sewers, pulp mills and other organic materials which are decomposing.

Signs and symptoms of exposure to H2S include deadache, dizziness, muscle fatigue and cramps, low blood pressure, loss of consciousness and eventually repiratory paralysis and death. Per Cal/OSHA, the permissible exposure level for H2S is 10 PPM and 100 PPM for an IDLH atmosphere. The gas monitor is programmed to alarm when H2S levels reach 10 PPM.

Lower Explosive Limits (LEL) for Flammable or Explosive Gases

The atmospheric gas monitor can measure the lower explosive limits of a wide range of flammable and explosive gases. It should be noted that the gas monitor is in actuality only measuring the explosive limits of one specific calibrated gas. However, because flammable and explosive gases have similar properties, this calibrated gas gives us a fairly accurate measurement of other flammable and explosive gases present in the atmosphere.

The lower explosive limit reading on the gas monitor is expressed as a percentage. For example, a reading of 50% LEL indicates that there is half the amount of gas present that would be needed to reach the minimum levels for combustion to occur. Similarly, a reading of 100% indicates that there is enough gas present in the atmosphere to ignite. The gas monitor is set to alarm when it detects 10% of the LEL for a flammable or explosive gas.

Refer to Chapter 5, Fire fighting Equipment and Hand Tools, for additional information on the operation and maintenance of the atmospheric gas monitor.

Taking Gas Readings

There are several techniques that should be employed when measuring the atmosphere with a gas detector:

- Ensure you power up the gas detector in a fresh air atmosphere.
- Move slowly and pause frequently to allow enough time for the gas detector to draw in a measure the air sample. This is especially important when using a wand and tube attachment.
- Take samples from both high and low areas, as well as enclosed spaces where pockets of gas may settle or accumulate

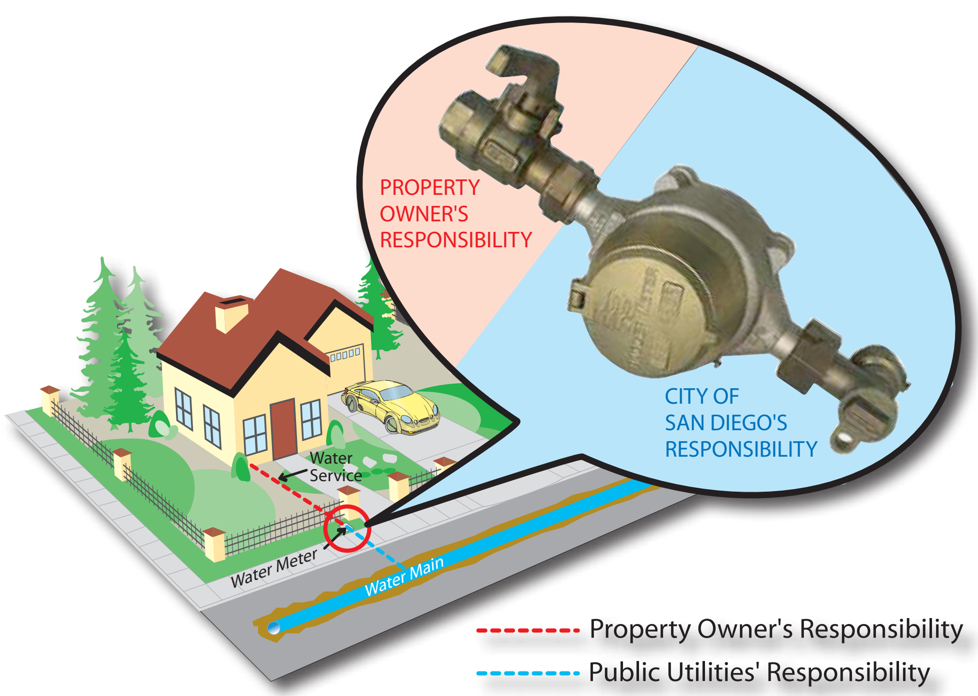
Water

Water is the most used and least recognized public utility. It is supplied to residential, commercial and industrial consumers. For firefighters, water is the most often used extinguishing agent for combating fires. However, when uncontrolled or used improperly, water can be a very destructive element. As firefighters, we will be called upon to use, control, and secure the water systems of many different structures and emergency incidents. With some basic knowledge of water utilities, these hazards can be mitigated without extensive property damage.

Municipal System

The responsibility to provide water to the City of San Diego falls under the Public Utilities Department, Water Division. The Water Division supplies water to its 1.3 million residents on a daily basis through a combination of supply and distribution systems. Water is supplied by large diameter piping in a gravity system. The San Diego public water system is a high to low gravity fed grid loop system. This grid allows the water to be supplied from more than one direction and therefore little or no interruption of service can be attained. A map of these grids, called the Platt Map, can be found in all Battalion Chief apparatus or at the Fire Prevention Bureau.

Water being supplied through the gravity fed grid is systematically distributed throughout the city through a series of pipes.



- Trunk Line - A trunk line distributes water from the supply to the water mains. Trunk line diameters range from 3 feet to 10 feet and are made of iron or concrete.
- Water Main - Water mains run beneath the street, parallel to the curb and range from 2 to 72 inches.
- Service Line - A service line runs from the water mains to the water meter. They range from ½ inch to 12 inches and can be constructed of iron, copper, or galvanized pipe.
- Customer Line - A customer line runs from the water meter to the structure.

Figure 22-44 Localized Water Valve

Typically, utility companies are responsible for maintaining and repairing distribution systems up to the water meter. The customer or consumer is responsible for issues with plumbing in from the meter and into the structure.

Controlling Water Service

Water damage is not only associated with the application of water as an extinguishing agent (hose lines and sprinkler systems), but also with domestic, non-emergency water system problems as well. Water lines can rupture or malfunction during fire and other conditions, creating a water flow that can cause serious property damage. For example, under fire conditions, service pipes can melt, burn, or rupture and damage dry wall, carpets, dropped ceilings, etc. This can present hazards on the fireground. By properly operating fire streams, shutting off local fixtures, and turning off water mains, firefighters are able to control water to avoid unnecessary damage to property.

Figure 22-45 Water Meter with Globe Valves

The preferred method for shutting down water to a structure is to close off the valve as close to the leak as possible. This would include plumbing fixture valves, section or floor valves in large buildings, and master control valves at the point of water entry into the building. Most fixtures (i.e., sinks, toilets, etc.) have localized shut-off valves that can be easily controlled, Figure 22-44.

In larger buildings or commercial structures, each floor or floor section may have separate control valves. Often times, these valves are not labeled and are difficult to find. Firefighters should identify the location of such valves during pre-fire planning and reference those plans when en-route to a water control incident.

Most structures are equipped with master control water valves, which are usually located where the domestic water supply enters the building. These valves may be installed in the basement of the building or above ground, Figure 22-45. Most master valves for residential structures are located at the curbside meter box, Figure 22-46. Once the meter boxes have been located, use the service shut off key to turn the valve a ¼ turn (perpendicular to the pipe) to shut down the water. Valves can also be installed at intervals in the street mains.

Figure 22-46 Meter Valve

Firefighters should notify the Incident Commander and request that FCC notify Public Works if a street main needs to be shut off. The Public Works crews can isolate the water lines to be shut off without unnecessarily disrupting water service elsewhere.

Residential Procedures

- Attempt to turn off water at fixture by turning off localized valve.
- Check other appliances as well as other side of wall for common walls; making sure the leak is not coming from another area.
- If unable or impractical to turn off at fixture, locate and turn off at service entry shut off.
- Lastly, turn off meter that is usually located at the curb in a vault (secure both valves- street side = water department, house side = home owners responsibility).

Figure 22-47 Commercial OS&Y Water Valve

○ Turn bar valve from parallel on incoming pipe to perpendicular on incoming pipe.

○ Turn stem valve in clockwise direction until it stops.

○ Turn "J" valve from parallel to perpendicular position.

Commercial Procedures

- Attempt to turn off water at fixture by turning off localized valve.
- Check other appliances as well as other side of wall for common walls and units above, making sure the leak is not coming from another area.
- If unable or impractical to turn off at fixture, locate and turn off valve serving the individual unit if available.
- If in a multi-story building, locate the floor shut-off valve and close.
- Lastly, shut off the OS&Y valve outside of the structure, Figure 22-47.
- Be aware that some buildings may use one water line to supply their domestic water and fire protection system, while others use two separate supply lines. Ensure that you are closing the correct valve and it is safe to do so.

Figure 22-48 Water Main Cap & Hydrant Shut-Off Key

Knocked Off Fire Hydrant Procedures

The first arriving company officer should contact FCC with the location of the hydrant being shut down and a request the Water Department to respond.

To shut off the water to a sheared hydrant, find the shut off valve located in the street. They can be 5 to 10 feet away from the hydrant and normally have labeled cover plates. Sometimes the cover plate for the valve has been asphalted in, so a tool (pick-headed axe, pry bar, sledgehammer, etc) may be necessary to loosen it. Once you have exposed the actual valve, shut it down using the hydrant shut off key and turning it clockwise until you have controlled the flow of water, Figure 22-48.

Figure 22-49 Knocked Off Fire Hydrant

Be aware of knocked off hydrants flowing water onto roofs of structures. There have been several incidents where the water from hydrants has blown on to adjacent rooftops, over coming the scupper holes and designed drainage system. The increasing amount of weight from the water caused the roofs to unexpectedly collapse. Consider evacuating nearby structures when presented with a similar situation.

Water Main Breaks & Sinkhole Procedures

Sinkholes can occur without warning for various reasons. Most commonly, sinkholes are caused by broken underground water mains that may go undetected for an extended period of time. The leaking water washes away the soil that supports roadways, foundations, and structures located above.

When responding to a sinkhole emergency, the following procedures should be considered:

- Perform Rescue and Evacuations.
- Keep apparatus and other traffic a safe distance from sinkhole, use PD for traffic control, Figure 22-50.
- Notify City of San Diego Public Utilities – Water Division.
- Attempt to locate water main shut-off valve and turn off flowing water.
- Perform salvage operations for properties affected by water run-off.

Figure 22-50 Sink Holes - Do not drive through water when responding to a water main break

Sewer & Storm Drain System

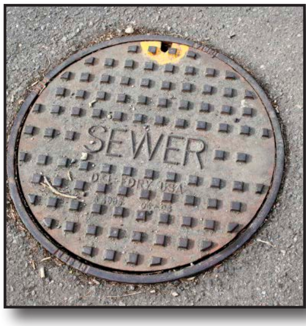


Figure 22-51 Sewer System Manhole Cover

Often confused as being the same, sewer (wastewater) and storm drain systems are two entirely different systems maintained by two separate city divisions.

Sewer (Wastewater) System

The sewer system, also referred to as wastewater system, is responsible for safely removing, treating, and disposing of all solids and liquids which flow down a sink, toilet, shower/bath, and any other drain installed within a structure.

The sewer system in San Diego is primarily a gravity fed system. As wastewater leaves a home or business, it flows down hill to a sewage line, which is typically found in the street or alley. These sewer lines can be identified by the steel manhole covers labeled "Sewer." Because wastewater may not always be able to flow down hill, several pumping stations are necessary to help move the wastewater along to one of three wastewater facilities found in San Diego. These wastewater plants filter and treat the sewage to a level where they can be either released into the ocean or reclaimed for use.

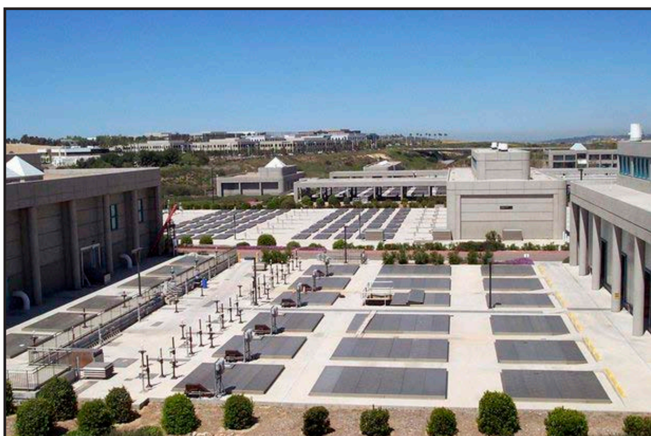


Figure 22-52 North City Water Reclamation Plant

- Point Loma Wastewater Treatment Plant
- South Bay Water Reclamation Plant (San Ysidro)
- North City Water Reclamation Plant (Miramar), Figure 22-52

The responsibility to treat and dispose of all sewage in the City of San Diego falls under the Public Utilities Department, Wastewater Division.

Storm Drain System

Figure 22-53 Storm Drain Grate

The storm drain system is responsible for removing and releasing water run-off that occurs out in the environment with the intent to help minimize the possibility of flooding and improve water quality. Like the sewer system, the storm drain system is also primarily a gravity fed system. It consists of drains and channels designed to funnel the water run-off to the bays and ocean. However, unlike the sewer system, the storm drain system does not treat the water prior to it being released.

The responsibility to maintain and operate all storm water related systems in the City of San Diego falls under the Public Works Department, Storm Water Division.

Sewer & Storm Drain System Emergencies

Both sewer and storm drain systems present similar challenges and hazards to firefighters. These systems are susceptible to leaks, clogs or blockages of raw sewage and other hazardous materials. Flammable or toxic gases may also collect in the system creating an IDLH atmosphere. Additionally, both systems have elements that are considered to be a confined space hazard should entry into the system be necessary.

Confined Space Rescue

A confined space is defined as any space that has limited access for entry or exit and is not designed for continuous human use. For an incident involving a rescue or requiring entry into a confined space, such as the sewer or storm drain system special rules must be followed. Only properly trained personnel may enter a confined space. For the SDFD, those personnel are members of Rescue 4, USAR 41, and the Hazardous Incident Response Team, Figure 22-54. Also required prior to entry is a properly completed confined space permit.

Figure 22-54 Most Sewer and Storm Drain Emergencies Require a Confined Space Entry

Refer to the Confined Space Chapter of this Drill Manual for additional information on Confined Space Rescue.

Sewer Gas / Explosion

For incidents involving an explosion or high levels of sewer gas in the system, the following procedures should be considered:

- Perform rescue and evacuations (with the exception of entering a confined space).
- Keep apparatus and resources uphill and upwind of the sewer/storm drain.
- Eliminate possible sources of ignition.
- Notify Water Division/Storm Water Division.
- Notify Hazardous Incident Response Team (HIRT).
- Continuously monitor areas with a multi-gas detector, checking for pockets of gas.
- Ventilate where appropriate.

Fuel Spill or Hazardous Materials In System

For incidents involving a fuel spill or hazardous material flowing into a sewer or storm drain system, the following procedures should be considered:

- Perform rescue and evacuations (with the exception of entering a confined space).
- Keep apparatus and resources uphill and upwind of the sewer/storm drain.
- Eliminate possible sources of ignition.
- Notify Water Division/Storm Water Division.
- Notify Hazardous Incident Response Team (HIRT).
- Perform damming or diking measures to prevent flow of material into system.
- Continuously monitor areas with a multi-gas detector, checking for pockets of gas.
- Ventilate where appropriate.
- Assist HIRT with clean up.

Steam Systems

Although less common, large-scale steam power and heat generating facilities do exist in San Diego. In locations such as Naval Base San Diego, Naval Training Center/MCRD, Figure 22-55, and North Island Naval Air Station, steam is produced using two auxiliary boilers to provide heat and electricity to the facility, as well as to sell back to SDGE. The steam is transported through a system of above and below ground pipes, Figure 22-56. One pipe delivers the high-pressure steam, while a second smaller pipe returns the condensate.

Figure 22-55 Steam Power Plant at NTC San Diego

Hazards to Firefighters

The greatest hazard to firefighters when working around a steam system is the high-pressured steam contained within the pipes. The steam is extremely hot and will cause immediate and severe scalding burns. Additionally, any sudden release or failure of the piping can cause explosive like results, damaging buildings and streets. Because steam is only highly pressurized water vapor, fire is not typically associated with these types of incidents.

Figure 22-56 High Pressure Steam Pipe

Emergency Procedures

For incidents involving an explosion or failure of any component of a steam generation system, the following procedures should be considered:

- Perform rescue and evacuations.
- Keep apparatus and resources safe distance from leak or failure point.
- Notify SDGE and Steam Facility Representative.
- Notify Hazardous Incident Response Team (HIRT).
- Attempt to locate steam line/pipe shut-off valve (OS&Y) and close if safe to do so.
- Continuously monitor areas with a multi-gas detector, checking for pockets of gas.

New York City Steam Explosion

The July 18, 2007 New York City steam explosion sent a geyser of hot steam up from beneath a busy intersection, with a 40-story-high shower of mud and flying debris raining down on the crowded streets of Midtown Manhattan in New York City, New York, United States. It was caused by the failure of a Consolidated Edison 24-inch underground steam pipe installed in 1924, at 41st Street and Lexington Avenue, near Grand Central Terminal, just before 6 p.m. local time, near the peak of the evening rush hour.

The towering cloud of billowing steam, higher than the nearby 1,047-foot (319 m)-tall Chrysler Building, persisted for at least two hours, leaving a crater about 35 feet (10 m) wide and 15 feet (4 m) deep.

The escaping steam shook nearby office buildings, causing many occupants to immediately evacuate. A 51-year-old New Jersey woman, who worked a block from the site, died of a heart attack suffered while fleeing the disaster area. 45 people were injured, with two injured critically.

The most seriously injured victims were a 23-year-old tow truck driver from Brooklyn, who was scalded over 80 percent of his body by the 400 °F (204 °C) steam and had to be put in a medically-induced coma, and his passenger, a 30-year-old mother of two, who was being driven back to Brooklyn after her car broke down. A witness reported that the tow truck was lifted 12 feet (4 m) by the escaping steam, higher than a nearby city bus.

HVAC Systems

HVAC stands for Heating Ventilation and Air Conditioning. Once considered a luxury, HVAC systems have now become a basic utility found in almost all aspects of everyday life. There is no simple explanation of an HVAC system as they vary widely depending on their intended use. HVAC systems range from massive, hi-tech machines in commercial buildings, Figure 22-57, and residential high-rises to simple inexpensive units in single-family residences, Figure 22-58.

Figure 22-57 Commercial Roof Mounted HVAC

HVAC Emergencies

Firefighters respond to incidents involving HVAC systems quite frequently. Smoke or fire generated from overheated components or motors, burned out belts, electrical shorts, or steam and gas leaks are all fairly common calls for aid.

Figure 22-58 Residential AC Units

Hazards to Firefighters

HVAC systems pose several unique hazards to firefighters. HVAC systems often require high voltage electrical power to operate, caution should be taken to not come in contact or cut any electrical components in the system.

Air conditioning systems typically use chlorofluorocarbons, also known as CFC's or Freon gas in their compressor. CFC's are colorless, volatile, relatively non-toxic liquids and gases with a faintly sweet ethereal odor. Overexposure may cause dizziness, loss of concentration, central nervous system depression and/or cardiac arrhythmia. CFC vapors displace air and can cause asphyxiation in confined spaces. Full PPE and SCBA should be utilized when dealing with HVAC emergencies.

Emergency Procedures

The following procedures should be considered when responding to any incident involving an HVAC system:

- Perform rescue and evacuations.
- Secure power to HVAC system.
- Shut down gas valves.
- Extinguish fire / (ABC extinguisher or hoseline).
- Notify SDGE and Facility Representative.
- Notify Hazardous Incident Response Team (HIRT) for Freon gas leaks.
- Continuously monitor areas with a multi-gas detector, checking for pockets of gas.
- Do not turn unit back on until a certified repair technician has serviced it.

Phone /Cable/Communication Sites

Like power lines, phone and cable lines have been transitioning from above ground installation to below ground with all new construction. Phone and cable lines mounted to power poles are typically strung at the lowest levels of the pole. Existing overhead telephone lines are strung at the lowest height on telephone poles. Phone and cable companies have been transitioning to fiber optic lines because of their ability to transmit information at much higher speeds, over long distances. These lines use light as opposed to electricity to transmit data and pose little risk to firefighters. Existing phone lines used to conduct basic telephone service to a house or business are made of copper. These lines are strung from poles into the service loop for homes and are being progressively transitioned to fiber optic cable as demand for increases data transfer increases.

Cellular phone towers have been installed all over the country and are used as repeaters to provide wireless phone and data service to customers. These towers can be placed in various locations from the side of a freeway to someone's own backyard. These towers are often disguised to make them more aesthetically pleasing. They can be painted and shaped to resemble palm trees, Figure 22-59, disguised as parts of a building, or simply covered with artificial décor in an attempt to mask their presence.

Figure 22-59 Cell Phone Towers

Hazards to Firefighters

While existing copper phone lines transmit very small amounts of electricity, copper is an excellent conductor. With their position strung low on power poles, when they fall they can potentially conduct the electricity from the high voltage lines above them on a damaged poles.

Research has shown that cellular towers can be highly dangerous when on fire. The use of hydrogen cells as back up batteries to eliminate lost service during power outages has created a tremendous hazard for fire suppression crews. Hydrogen used in the fuel cells is a very flammable gas and can cause fires and explosions if it is not handled properly. Hydrogen is a colorless, odorless, and tasteless gas. At present, it is hard to tell if there is a hydrogen leak because it has no odor to it. Hydrogen is a very light gas. There are no known odorants that can be added to hydrogen that are light enough to diffuse at the same rate as hydrogen. In other words, by the time a worker smells an odorant, the hydrogen concentrations might have already exceeded its lower flammability limit.

Emergency Procedures

With the potential for downed copper phone lines to transmit electricity from adjacent power lines, treat them as high voltage. Secure the scene, perform any necessary evacuations, notify the proper utility company and protect exposures if necessary.

Figure 22-60 Pad Mounted Communication Equipment

Treat cellular tower fires the same as a pole mounted transmitter fire. Avoid direct contact with water, maintain an evacuation zone of one and a half pole lengths and cool exposures as needed until the proper utility company arrives. Be aware of any NFPA HAZMAT placards advising the presence of hydrogen. Since the gas burns almost transparently, the use of a thermal imaging camera can help detect the heat of invisible flames and should be used. Stay upwind and listen for sounds of venting gas that could indicate a leak.

Summary

In summary, public utilities are complicated and provide numerous hazards to firefighters. These basic utilities help make everyday life more comfortable for us, but they can also take lives if not treated with proper care. The San Diego Gas and Electric Company are the experts and should be utilized as such. When dealing with utility emergencies the best approach is a cautious one. Take care to understand the basic components of these services and learn how to properly manage them under emergent conditions. The one thing that all of these utilities have in common is that they can ALL be life threatening. The SDFD responds to utility related emergencies daily, and only through continuing education and proper discretion are they managed safely.

Media & Link Index

None At This Time

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2. 72nd SDFD Fire Academy, Utilities PPT
3. 72nd SDFD Fire Academy Truck SOG - Utilities
4. IFSTA Essentials, 5th Edition
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Credits

Writers:

Jared Cheselske, Dickens Tai, Kevin Pendleton

Layout & Editing:

John Brubaker, Kevin Pendleton

Media:

John Brubaker

Grammatical Editing:

Kevin Pendleton

NOTE: If you have any additional information or content that you feel would be appropriate to contribute to this Chapter or would like to report any errors or misrepresentations, please contact the SDFD Training Division or email the Drill Manual Revision Staff at

SDFDDrillManualTeam@SanDiego.gov

Revisions/Updates

Date	*Revision/Update Description*
12/15/2019	Page 22-23 - Removed "SCBA's required during overhaul operations when CO is above 25 ppm / Added "SCBA's are required throughout overhaul at all fires"