Fresno Fire Department

Utility Emergencies Guide

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INTRODUCTION

This Guide covers Utility Emergencies including Water, Gas, and Electricity. The Fire Department is called to help solve problems such as flooding, gas leaks, and power lines down or electrical emergencies. These often result in the need to quickly contain or isolate the problem or hazard. The following guidelines present an approach which will apply in many situations, but do not replace good judgment and experience in dealing with any incident. The guidelines should be used whenever situations are encountered that do not clearly indicate that a different approach is required to safely resolve the hazard.

WATER TRANSMISSION

Supply Systems

When water is pumped from the underground aquifer and from the Surface Water Treatment Facility, it is distributed through a transmission grid main system to individual customers.

- 1,780 miles of distribution pipeline
- 140,992 service connections
- 12,952 fire hydrants
- 18,942 main line valves
- 260 active pump stations

Pump Systems

When a source of water is below or at the same elevation as a municipality, or cannot naturally provide sufficient pressure through adequate elevation, pumps are used to supply water at the proper pressure into a distribution system.

Distribution Systems

Water is delivered throughout Fresno City by a distribution system of pipes, valves, check valves, and water meters, and is normally cross connected at specific intervals to supply water to areas that can be affected by repairs, breakage, and other similar problems. Pipelines within a distribution system can be classified as trunk lines, mains, service, and customer lines.

Trunk Lines

Trunk lines carry water from a primary source (reservoirs, pumps, etc.) to mains within a distribution system. Trunk lines can vary from 36-inches to 10-feet in size and are constructed from iron or concrete.

Mains

Mains normally run beneath a street and parallel to a curb, can vary from 2 to 72-inches in size, and are constructed from iron pipe. Mains can be cross connected to form loops that allow shutting down a specific main within a distribution system for repairs, etc.

Service and Customer Lines

Water is delivered to individual structures by a combination of service and customer lines. Service lines run between a main and a water meter, can vary from ½-inch to 12-inches, and are constructed from iron, copper, or galvanized pipe. Customer lines run between a water meter and a structure, can vary from ½-inch to 12-inches, and are constructed from iron, copper, galvanized, or plastic pipe.

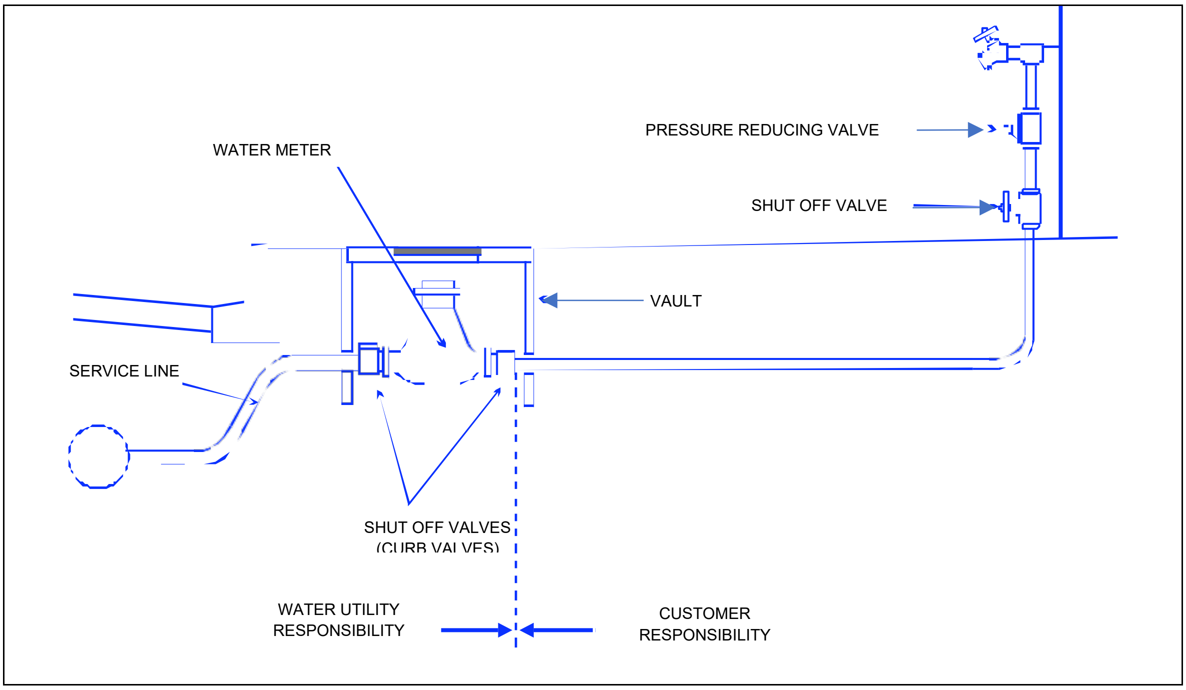


Figure 1 - Customer and Service Line

Water utility companies are normally responsible for maintenance and repair of a water distribution system, including:

- Water metering device.
- Shut-off valves on either side of a water metering device.

Building owners are normally responsible for maintenance and repair of:

- Plumbing from the shut-off valve (on the output side of a water metering device), and into a structure.
- All plumbing inside a structure.

Service

The type and size of water service to a structure is determined by a combination of applicable plumbing code requirements and water consumption needs that result in the following types of water service configurations:

- Domestic water only.

- Domestic water and water for fire protection through a single service.

- Domestic water and water for fire protection through separate services.

Components

Water service systems are comprised of shut-off valves, water meters and detector check valves, and pressure reducing valves.

Access

A meter box, vault, or manhole often has a centerpiece or lid with a hole that can be utilized to remove the cover. The centerpiece or lid normally identifies the type of utility with the word(s) "WATER," or "CITY WATER METER."

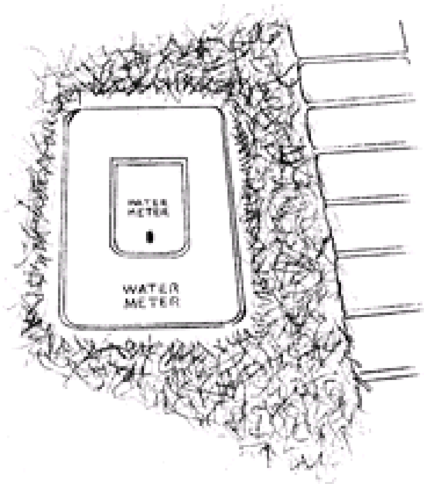


Figure 2 - Meter Box, Vault, Manhole

Shut-off Valves

Shut-off valves (or service valves, curb valves, etc.) provide a means for controlling the flow of water through service and customer lines. Two types of shut-off valves are commonly utilized:

Non-Indicating Valves

- These valves do not indicate an open or closed position and are characterized by ball or cone valves and gate valves.

- A ball or cone valve has a rectangular valve-nut attachment on the top of the valve. When the valve is closed, the valve-nut is perpendicular to the valve.

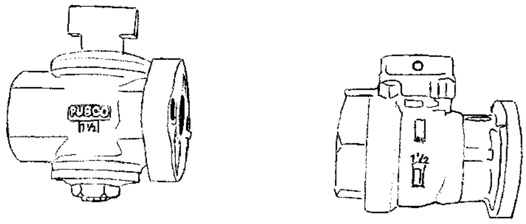


Figure 3 - Ball or Cone Valve

- A gate valve is a non-rising stem valve that has a square valve-nut attachment at the top of the valve stem.

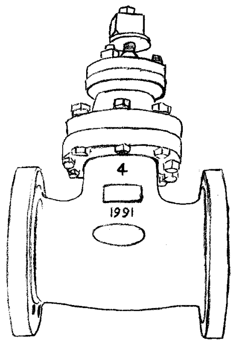


Figure 4 - Gate Valve

<u>Indicating Type Valve</u>

These valves indicate an open or closed position and are characterized by Outside Stem and Yoke (OS&Y) valves and post indicator valves (PIV).

An OS&Y valve has a rising stem type valve.

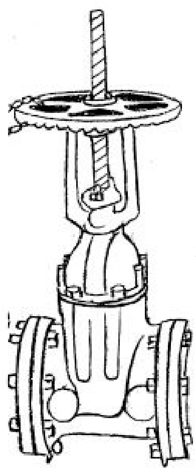


Figure 5 - OS&Y Valve

A Post Indicator Valve (PIV) is connected to an underground gate valve.

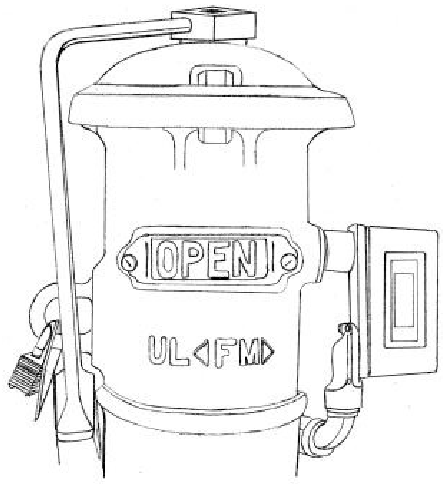


Figure 6 - Post Indicator Valve

Water Meters and Detector Check Valves

Water meters are used to calculate water usage and check valves are utilized to allow the flow of water in one direction only. The type of meter and/or check valve is dependent on the type of water service as follows:

- Water Meter is used to calculate water usage for a domestic water service. Water meters are normally directly adjacent to shut-off valves and vary in size from ½ to 10-inches (inlet-outlet size).

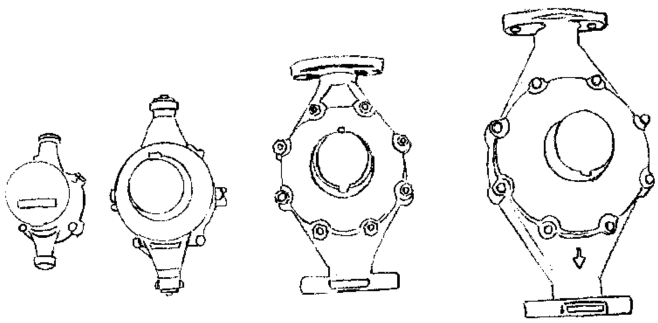


Figure 7 - Water Meter

- Compound Meter is used to calculate water usage for domestic water services that can use low and high-water flows. During low water flows, a compound meter operates as a standard water meter. However, if high flows are necessary, a check valve opens and allows the passage of large flows that are metered separately. Compound meters are 4-inches or larger and are normally found directly adjacent to shut-off valves.

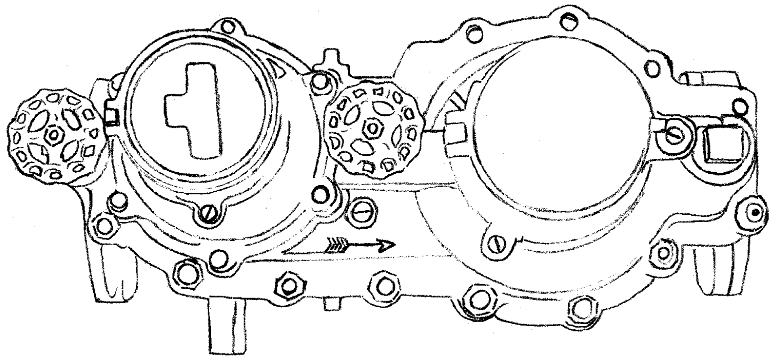


Figure 8 - Compound Meter

- Detector Check Valve with By-Pass Meter. Used to supply water for a closed fire protection system. When necessary, a check valve opens and allows water to flow straight through unmetered. In the closed position, the check valve prevents water from flowing back into a water distribution system (i.e., from Fire Department apparatus pumping into a standpipe inlet). Most detector check valves will use a small water meter in parallel with the check valve(s) to detect leaks and the unauthorized use of water. Detector check valves can vary in size from 2 to 10-inches.

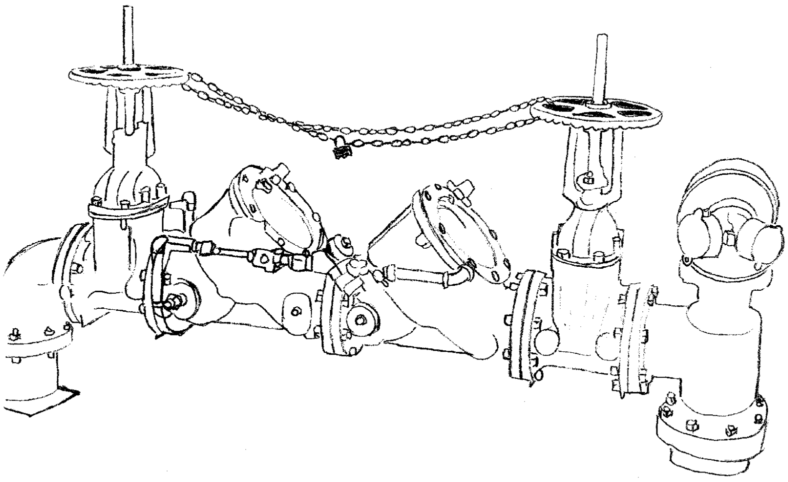


Figure 9 - Detector Check Valve with By-Pass Meter

- Combination Water Service - A domestic water meter and detector check valve providing separate water services. Water meter and check valve may be in the same vault or separated in adjacent vaults.

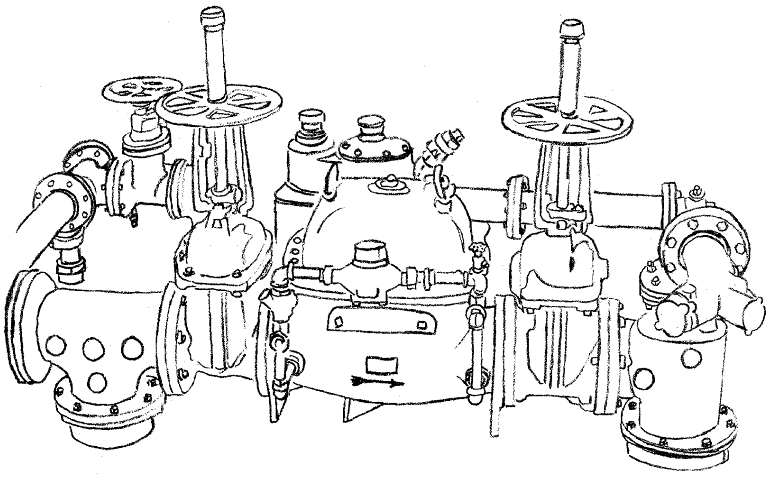


Figure 10 - Domestic Water Meter and Detector Check Valve

Pressure Reducing Valves

Pressure Reducing Valves are normally used in domestic services to reduce high water pressures to an acceptable level inside a structure (i.e., dwellings commonly use 40 to 80 psi). Pressure reducing valves are not normally utilized in fire protection services.

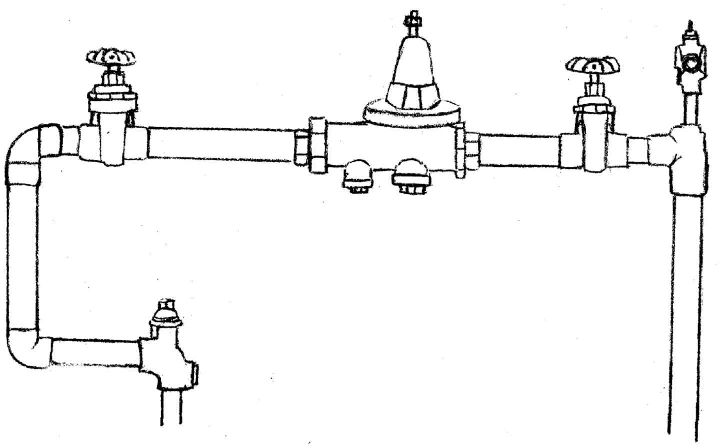


Figure 11 - Pressure Reducing Valves

Location

The order of placement for water system components between a main and structure can vary. A typical domestic water service normally consists of piping, a water meter, shut-off valve(s), a pressure reducing valve, and a typical fire protection service normally consists of piping, detector check valves, and shut-off valves.

In warm climates, water meters can be placed just below grade level, and pressure reducing valves, shut-off valves, and detector check valves can be located above or below grade level.

The following are general considerations for single family dwellings, apartments, hotels, commercials, and high rises:

Single Family Dwelling

Domestic water services will normally consist of a ½ to 2-inch single water meter with shut-off valve on one or both sides of a meter. A customer line runs underground from the meter to a vertical riser that enters a structure on the exterior or in a basement. A pressure reducing valve can be located near the meter or structure. Water service for a domestic sprinkler system will normally be a 2-inch detector check valve that is in a separate vault.

Hotels

Domestic water and fire protection services are provided by a combination water service that provides domestic water with a 4-to-6-inch water meter and water for fire protection with a 4-to-8-inch detector check valve. Shut-off valves are normally adjacent to the water meter and detector check valves, and a post-indicator valve is normally present between the detector check valves and structure. The water meter and detector check valves can be in the same vault, separate vaults, or above ground.

Apartments

Domestic water service will normally consist of 1-to-3-inch customer lines and a single 1-to-3-inch water meter with a shut-off valve on one or both sides of a meter. Like single family dwellings, and depending on water requirements, a customer line runs underground from a water meter to a vertical riser that enters a structure on the exterior or interior. A pressure reducing valve can be located near the water meter or structure. Water service for fire protection will vary between 2-to-4-inches.

The water services for domestic water and fire protection are in separate below ground vaults or located above ground. A common alternative to a single 1-to-3-inch water meter is a 3-inch equivalent water service. This system consists of two 2-inch water meters in adjacent vaults that are connected to a single 3-inch customer line that enters a structure on the exterior or basement. In this configuration, the pressure reducing valve is located near the structure.

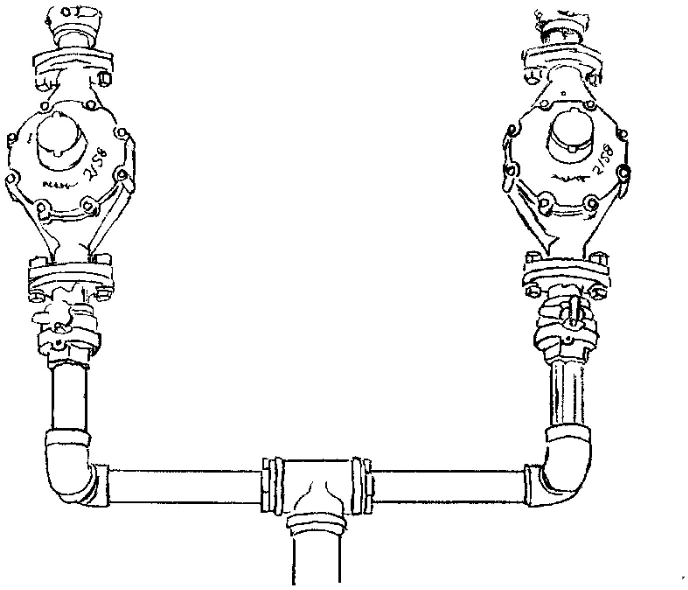


Figure 12 - Domestic Water Service Configured for Apartment

Note: If a structure has Dorothy Mae Sprinklers, a separate 2-inch fire service vault is used.

Commercial

Water services to these types of structures are not primarily based on the size of a structure but will depend on the water requirements of a structure. As an example, a large warehouse with a small office area and large storage area can have a large (4 to 10-inch) water service for fire protection and a small (1 to 2-inch) water service for a domestic water system. Conversely, a moderate size commercial occupancy can have a 2-to-4-inch service for fire protection and a large (4 to 8-inch) domestic water service for specific requirements. Common applications are as follows:

- A commercial occupancy with multiple occupancies (such as mini-malls), can be serviced with water for a domestic water service by a single water meter for an entire building or, by multiple, 1-to-2-inch water meters in separate vaults, which can supply each individual occupancy (referred to as a battery).

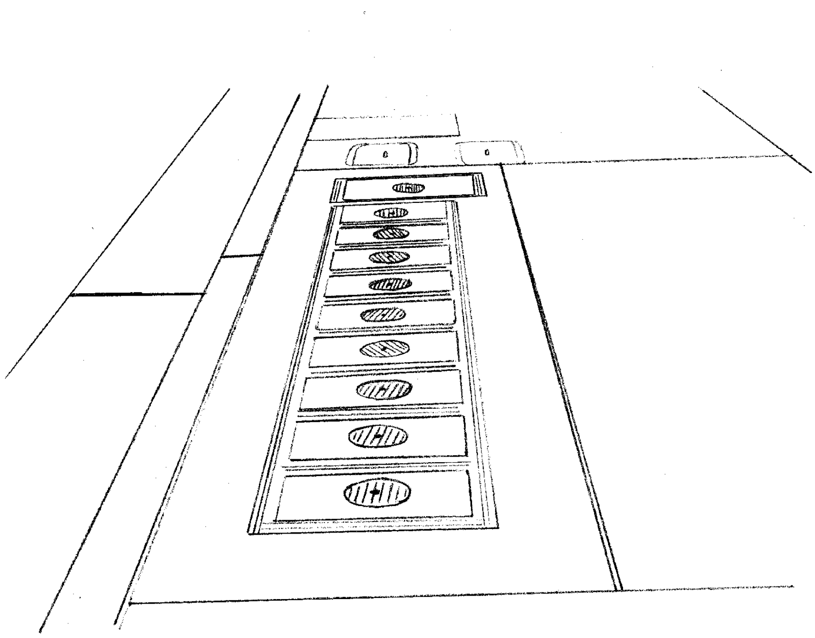


Figure 13 - Multiple 1 to 2-inch Water Meters in Separate Vaults

- 1-to-2-inch water meter for domestic water service and 2-to-4-inch detector check valves for fire protection in separate vaults. Shut-off valves are normally adjacent to a water meter. Detector check valves and a post indicator valve should be present between the detector check valves and structure.

- Combination water service with a 4-to-8-inch water meter for domestic water service, and 4-to-10-inch detector check valves for fire protection in the same vault. This configuration is used for large water volumes. Shut-off valves are normally adjacent to a water meter and detector check valves and a post- indicator valve should be present between the detector check valves and structure.

- Shut-off valves are normally adjacent to water meters in separate vaults or a single meter that serves an entire building. Water for fire protection can be provided by detector check valves in a separate vault, or in a common vault with a water meter that serves an entire building. Shut-off valves are normally adjacent to detector check valves and a post indicator valve may be present between the detector check valves and structure.

High Rise

Domestic water and fire protection service is provided by a combination water service that consists of a 4-to-10-inch water meter for domestic water and 4-to-12-inch detector check valves for fire protection in the same vault. Above ground risers may be present for domestic and fire protection services. Shut-off valves are normally adjacent to water meters and detector check valves in this type of configuration. Post-indicator valves are normally present between the detector check valves and structure.

Fire Protection Systems

Fire protection is provided by sprinkler systems and standpipe systems.

Sprinkler Systems

- Automatic Wet Pipe System. The pipes in this system are always filled with water. When a head is activated, water immediately flows from activated heads. Water is supplied to this system by gravity tank, pressure tank, automatic fire pump, or a water service system.

- Automatic Dry Pipe System. The pipes are filled with compressed air. When a head is activated, air is immediately released from activated heads. This causes a drop in air pressure, which allows water to enter the system and flow from activated heads. Water is supplied to this system by a gravity tank, pressure tank, automatic fire pump, or a water service system.

- Non-Automatic System. Pipes are maintained dry. To charge this system with water, it is necessary for fire department apparatus to pump into the fire department connection to supply water to activated heads.

- Deluge System. Sprinklers may be open or closed and are supplied with water by a heat actuated valve. Water is supplied to this system by a gravity tank, pressure tank, automatic fire pump, or a water service system.

Standpipe Systems

- Dry Standpipe. Dry standpipes consist of a Siamese connection, piping, and 2½-inch outlets on each floor (stairway and/or fire escape balcony) and roof. Water is supplied to this system by fire department apparatus.

- Wet Standpipe. Designed for occupant use and consists of 100' of 1½" unlined single jacketed hose with a ½" straight tip with no shut-off.

OPERATIONAL GUIDELINES

DOMESTIC SERVICES

- For leaks outside a structure, use multiple personnel to locate the appropriate shut-off location (one person may not find the correct location in the least amount of time).

- For leaks inside a structure, use multiple personnel to simultaneously investigate the interior and exterior of a structure to locate the most appropriate shut-off location. This approach will enhance the ability of personnel to locate the appropriate shut-off location in a timely manner.

- Occasionally a shut-off valve may be encountered with a sign as follows: "LIFE SUPPORT MACHINE IN AREA" or "SHUT GATE SYSTEM DIVIDE. " DO NOT turn these valves off unless appropriate approval is obtained.

- When closing a ball, cone, or gate valves that are 3-inches or larger, it may be necessary to exercise a valve to eliminate the flow of water as valves can become encrusted with rust and scale. When a stubborn cone valve is encountered, slightly loosen the nut on the bottom of the valve (if accessible) and strike the threaded shaft with a hammer. This will drive the shaft into the valve and free the valve. The valve may now be shut off. Ball and cone valves can be identified by the lack or presence of a nut on the bottom of a valve. Ball valves do not have a nut on the bottom of a valve, and cone valves do.

- All shut-off valves should be slowly closed and opened to avoid water hammer.

<u>Outside</u>

Shutting off water leaks that are located outside of structures are normally limited to leaks in mains, service lines, or customer lines and are normally handled by utility company personnel. Leaks in customer lines (between a water meter, detector check valve, and structure) are normally handled by fire service personnel as follows:

- 3/4-to-1-inch service:

  A shut-off valve (ball or cone valve) is normally located adjacent to a water meter and may be located above ground or underground. If the valve is underground and not in a meter box it may be necessary to dig down outside a meter box to access the valve. Turning these valves 90 degrees will eliminate the flow of water.

- 1-to-3-inch equivalent service:

A shut-off valve (ball or cone valve) is normally located on both sides of a water meter. Remove each vault cover to access the meter valves. It is necessary to shut off a valve in **both** vaults to eliminate the flow of water past this service configuration.

- 4-inch and larger:

  Gate valves are located on both sides of a water meter. When closing these valves, remember it may be necessary to exercise a valve to eliminate the flow of water. Large above ground or underground installations may consist of back flow valves that are in line with the water meter and multiple OS&Y or gate valves. Due to the size of these water services and the possibility of damage to building heating, cooling, and other similar systems, personnel should not close these valves unless necessary. Normally, the DWP should be requested to handle these systems.

Inside

Shutting off water leaks that are located inside of structures can be accomplished as follows:

- Depending on the type of leak, closing accessible shut-off valves near a water meter or the globe valve that can normally be found on the vertical riser that enters a structure will quickly eliminate the water service to the interior of a structure until an interior leak is located and repaired.

- Broken Pipes. Broken pipes in walls normally require shutting off the flow of water to a structure using exterior shut-off valves near a water meter, etc.

- Toilets. Toilets are found in two configurations, residential and commercial. Leaks from residential toilets can be easily eliminated by shutting off the angle valve at the wall near the toilet. In these applications, plastic tubing has replaced metal tubing and is more susceptible to splitting due to hardening. Leaks from commercial toilets can be eliminated by removing a cap over the relief valve and using a slot-head screwdriver to turn the relief valve screw outward. This will let the valve seat and stop the flow of water to the toilet.

- Urinals. Leaks from commercial urinals can be eliminated by removing a cap over the relief valve and using a slot-head screwdriver to turn the relief valve screw outward.

- Sinks and Residential Appliances. Leaks from sinks and other types of residential appliances can normally be eliminated by shutting off the angle valve(s) at the wall near the sink or appliance.

- Manufacturing Process. Leaks from a manufacturing process that utilizes water will often have readily available shut-off valves near the process. If these types of valves are not readily found, using exterior shut-off valves may be necessary to eliminate the flow of water.

- Hot water leaks can normally be eliminated by shutting off the appropriate valve at a water heater or boiler. However, remember to shut off the gas or electricity to the heater to prevent a possible rupture due to expanding water in the heater.

Fire Protection Services

Depending upon the buildings system a partial system shut down or full system shut down will control the water.

- Sectional shut-off or Zone valves. Sprinklers can be controlled by using the appropriate sprinkler shut-off tool, then look for sectional shut-off or zone valves instead of shutting off the whole system. This will cause less disruption of the system and speed up the draining process.

- 2-inch service:

  A shut-off valve (ball or cone valve) is normally located adjacent to a detector check valve. Turning this valve 90 degrees will eliminate the flow of water past this service.

- 4-inch and larger service:

  Indicating valves (post-indicator valve) can be used to eliminate the flow of water past these valves. Post-indicator valves are located outside of structures, are connected to an underground gate valve, and have a handle or wrench to operate the valve. To operate a post-indicator valve, remove any padlocks or chains securing the control valve. Turn valve in clockwise direction to close the valve. The valve will visually indicate the position of the valve by an arrow or display which states “OPEN” OR “SHUT.”

- OS&Y valves that are normally located directly adjacent to detector check valves on 4-inch and larger fire services are not normally used to eliminate the flow of water past these valves. However, a gate valve should be turned clockwise to stop the flow of water past this service. OS&Y valves are turned clockwise (so the stem is not visible) to stop the flow of water.

Sheared Hydrant

Placement of apparatus for the protection of members is paramount. To insure protection against injuries caused by debris being thrown into the air, the use of protective clothing is recommended (helmet, goggles, turnouts, or rain gear).

Location

The fire hydrant gate valve is normally found in direct line with the fire hydrant and perpendicular to the curb. A six-inch diameter cap (usually painted blue) covers access to the gate valve. Some gate valve locations are indicated by arrows etched on the adjacent curb.

Operation

Remove gate valve cap. Place hydrant shut-off tool on gate valve stem. Turn in a clockwise direction to close valve (your initial attempt should begin with a clockwise rotation). Close the gate valve slowly to reduce the possibility of water hammer.

Two members applying moderate pressure to the gate key should be adequate when closing the valve (fire hydrant gate valves may require 18 to 26 full turns to complete a shutdown). If the gate valve will not turn in a clockwise direction, attempt to close the valve in a counterclockwise direction. Caution must be taken, as excessive force will cause damage or break the gate valve stem.

Note: Although approximately 98% of all fire hydrant gate valves close in a clockwise direction, a member must recognize those instances when a counterclockwise rotation is necessary to close the valve.

As the gate valve is operated, you will hear and feel the vibration of the valve as it closes. If there is no decrease in the amount of water flow, you may be operating the wrong valve, or the valve may be broken. If it has been determined the wrong gate valve has been closed, return the valve to its original position. Always count the number of full turns when closing fire hydrant gate valves.

Note: Fire hydrant gate valves should only be operated to shutdown sheared hydrants. For leaking fire hydrants, follow procedures described in the Manual of Operation, Volume 2, 4/2-34. 59 (J).

The sheared off hydrant should be secured in a safe location.

Communication

When notifying OCD of a sheared off fire hydrant, include the following:

- Fire hydrant location.
- State if fire hydrant has been shut-off.
- The number of valves operated.

OCD will notify the DWP Water Operating Trouble Board and advise them of your actions. The DWP will then dispatch necessary resources to the location.

GAS UTILITIES

INTRODUCTION

Natural gas is the product of nature's action on organic material over millions of years. It is a common source of heat in buildings due to its convenience, abundance, and relatively low cost. Almost every structure in the City of Los Angeles has natural gas delivered to the property, via underground service pipes. Firefighters respond to natural gas incidents every day. This product is considered safe, due to its relatively small window of flammability. However, if we refuse to give it the proper attention, it will take advantage of our complacency. We must train ourselves to be vigilant, and on the alert, for situations that can injure or kill firefighters and/or the public that we serve.

Properties Of Natural Gas

Pure natural gas is completely odorless. For leak detection, odorant is added so that as little as one-percent of natural gas in the air can be detected. The common odorant is a Mercapitan/Thiophane mix, which is used in solution of one pint per million cubic feet of gas. Natural gas is non-toxic and is not considered hazardous when inhaled in limited concentrations. However, in quantities large enough to displace oxygen, asphyxiation can occur.

Natural gas is lighter than air, which results in escaping natural gas rising and rapidly dissipating. This is a distinct safety advantage over heavier fuels such as butane and propane, which are heavier than air; and when escaping, it will collect in low areas. Escaping natural gas can be hazardous when trapped by confined spaces such as structures, hollow walls, etc. Natural gas also has an ignition temperature of 1100 degrees and has a flammable range between 4 and 14 percent.

Transmission And Storage

Most natural gas is initially distributed through over 30,000 miles of transmission lines from Texas, Kansas, New Mexico, Oklahoma, Arizona, and the Rocky Mountain area. Transmission lines maintain pressures up to 1000 psi and use pressure booster compressor stations, at specific intervals, to maintain appropriate flow and pressures. To compensate for fluctuating demands, gas companies can maintain underground or above ground storage facilities. Natural gas is generally distributed by a combination of transmission lines and distribution mains. Transmission lines bring natural gas into the Southern California area and vary in diameter from 12 to 36-inches. Natural gas is then distributed to Gas Company customers by distribution mains. The gas is carried by service lines at medium pressure, which normally does not exceed 60 psi. At the service meter (Meter Set Assembly), the pressure is reduced to a low pressure (approximately 1/3 psi.). Distribution mains are generally polyethylene and account for a high percentage of the mains in use today. Older existing distribution mains are made of steel or copper but are rare to find. Polyethylene mains are color coded to identify the pipe as transporting natural gas. These pipes are yellow, which is the national color code for newer installations. Older installations of plastic pipe can be pink (salmon beige), or orange in color.

Polyethylene will have a wire running the length of the pipe, for locating plastic gas lines, below ground. Above ground gas lines must be made of steel and cannot be plastic. Distribution mains are normally located underneath city streets, parallel to curbs, under grassy parkways, between the curb and sidewalk, and occasionally in alleys.

Gas Equipment And Meters

Meter Set Assemblies

Natural gas is distributed from a distribution main to the customer by a service line. Service lines run from distribution mains to structures, via an outside riser, where pressure regulators and meters are located. The pressure inside a customer line (inside the structure) is low pressure (approximately 1/3 psi) and is regulated and measured by a regulator and gas meter. Gas companies refer to gas meters as Meter Set Assemblies (MSA's). MSA's can be found in the following three locations:

- Outside Sets - MSA's are located outside the structures.
- Underneath Sets - MSA's are located underneath structures, stairs, etc.
- Curb Meter Box - MSA's are in a vault underneath a sidewalk.
- Cabinet Set - MSA’s are in an enclosure on the exterior of the structure.

Additionally, MSA's can be categorized as follows:

- Residential
- Industrial
- Multiple Gas Meter

Residential Meter Set Assemblies

The basic MSA consists of piping, a shut-off valve, regulator, and gas meter. The pipe rising vertically from the ground, close to the exterior wall of a structure is called a riser. Tracing the riser up from the ground, the first fitting is the shut- off valve called a stopcock or service cock. This valve is usually of primary concern to the personnel responsible for shutting off the gas to a structure. Of particular interest is the following:

- A ring on the stopcock valve indicates a branch service.

- A flat washer on the stopcock valve indicates that the service line is a plastic pipe inserted inside an older metal pipe.
- A band on the stopcock valve indicates the service line is plastic.
- Next, up the riser, is a flat circular device called a "regulator" that reduces medium gas pressure (up to 60 psi) to a relatively low level of approximately 1/3 psi.
- Next are pipes and fittings, leading to the gas meter. The meter measures the amount of gas that is used. After the meter, gas flows through pipes and fittings into the structure.

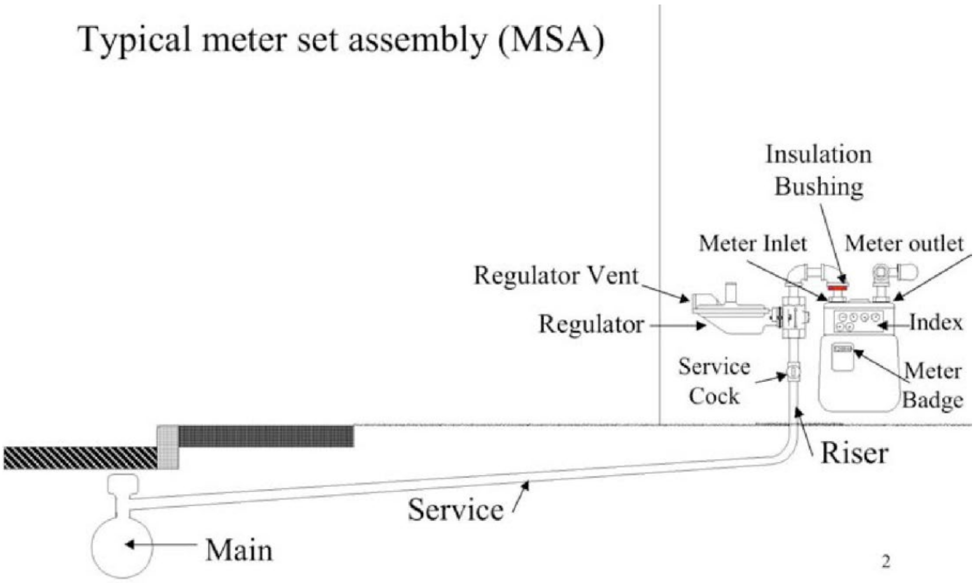


Figure 14 - Meter Set Assembly

Shutoff valves can be located by finding the MSA since they are always adjacent to each other. Initially, look for a "G" that is either chiseled or painted on the curb. A "G", required by Cal-OSHA, marks the location where the service line passes beneath the curb and indicates which side of the building the MSA is located. If a "G" cannot be quickly found, do not waste time looking for one.

Next, look along the foundation of the structure. MSA's and shut-off valves are normally located on an outside wall of a structure, in a location that is easily accessible to gas company personnel who read the meters for billing purposes.

If an MSA is not visible along an outside wall, it is usually found in the following location:

- In a crawl space, under the building.
- Beneath an outside staircase.

- In an outdoor cabinet, particularly new condos.
- In an underground garage.
- In a sidewalk or parkway vault, at the side of a building.
- In a basement, with the shut-off valve usually accessible from the outside of the building.
- Subsurface, in the parkway or sidewalk.

Some MSA's may be equipped with an emergency vibration-sensitive shut off device known as an earthquake valve. These valves are marketed by private industry and are normally mounted on the discharge side, right side as you face the meter, of an MSA. Earthquake valves take on various shapes and sizes and can easily be mistaken for any number of gas appliances. Personnel should recognize and understand that a swift-kick may possibly shut off the flow of gas, but only in the event of a damaged or frozen stopcock; never done in lieu of a normal shut-off procedure. Turning a reset button, one-quarter turn, completes reset of this device.

Industrial Meter Set Assemblies

Industrial MSA's are similar to, and larger than, residential MSA's due to the increased flow of gas (volume) that is necessary for commercial/industrial applications. Industrial MSA's can be characterized by any of the following features:

- A curb valve and curb valve extension handle can be utilized to control the flow of gas in the service main.
- Industrial shut-off valves, known as Nordstrom valves, are used for high pressure applications. They are larger than standard shut-off valves and may require more effort and larger tools to shut off the flow of gas. Some industrial installations have gate valves with wheel handles that may be turned clockwise to close.
- Industrial applications that are high pressure can use two regulators in series to regulate the gas pressure. A rotary meter is used, instead of a conventional MSA, to regulate the high pressure and handle quick surges.
- Meters under the sidewalk, called curb meters, are common in commercial areas. The lid over the curb meter space is made of lightweight concrete, or fiberglass set in a metal frame, and is easily identified by its gas company markings.
- Industrial MSA's are physically larger than MSA's used for residential applications.

Multiple Meter Set Assemblies

Multiple habitational or commercial occupancies are often equipped with multiple MSA's, which provide a master stopcock and a separate meter and stopcock for each unit. Past the riser, and master stopcock, is a horizontal header that feeds multiple stopcocks and MSAs. Master stopcocks shut off the entire building and individual meters/stopcocks can control the flow of gas to individual occupancies in one structure. The Gas Company is required to identify the individual MSA's, as to which unit or building they serve. If the identification has worn away, notify The Gas Company to have the meters properly marked.

Branch Service

In some commercial areas, multiple structures may be commonly serviced by a single service pipe called a standard service main. A metal ring identifies this branch service. The occupancy that is further from the supply main is a standard service, and the other occupancies are branch services. All MSA's that are served from the branch main will be identified by a ring at the stopcock.

Shutoff Valves

Stopcocks

- To turn off the flow of gas, turn the tang, crosswise, to the flow of gas, crosswise to the pipe. The tang on some stopcocks can be square. Turn the tang, so the line on the tang is crosswise to the pipe. Tangs can be easily turned with a crescent wrench.

- If a tang appears to be stuck, do not apply too much pressure. If the tang breaks off, it will be difficult to stop the flow of gas. It is recommended that The Gas Company service a stuck tang. However, stuck tangs can be approached in EMERGENCY CONDITIONS as follows:

    1. Use two wrenches, one on the tang and the other on the backing nut. Holding the tang steady, loosen the backing nut one-quarter turn only! If the backing nut is loosened too far, the core can fly out, leaking medium pressure gas, 40 to 60 psi. It is nearly impossible to replace the core while gas is leaking. NOTE: Newer stopcocks have a pin driven into the backing nut, and bolt, and cannot be loosened.

    2. Give the backing nut a tap with a non-metallic hammer, freeing the core.

    3. Turn the tang, one-quarter turn, to stop the flow of gas; a half-turn will continue to let the gas flow.

    4. Tighten the backing nut to lock the core in the "OFF" position.

Nordstrum Valve

- The Nordstrum Valve is a larger version of a residential stopcock. It is used on high-pressure risers and piping, at industrial/ commercial sites, and comes in various sizes to fit different diameter pipes. The tang on a Nordstrum valve can only be turned one-quarter turn, in either direction, ensuring the "ON" and "OFF" positions are easy to locate. Depending on the size of the valve, large wrenches may be necessary to turn this valve.

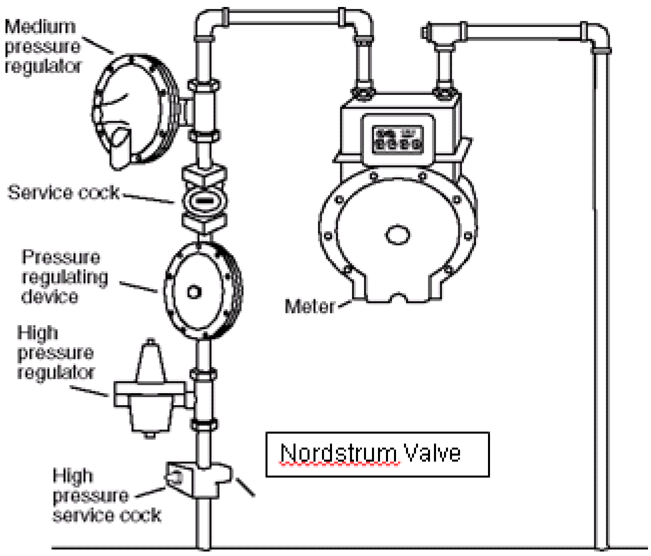


Figure 15 - Nordstrum Valve

Gate Valves

- Some industrial meters are equipped with a gate valve that has a wheel handle (like an OS&Y). Turning the handle clockwise several revolutions will shut off the gas.

Curb Valves

- Also referred to as an Emergency Shutoff Valve, these valves can be installed in addition to stopcocks at public assembly occupancies such as schools, hospitals, churches, etc. They are normally located near the property line, by a sidewalk. They are two to three feet underground and under a small metal, concrete, or fiberglass lid; with "Gas Company" markings in raised letters. To gain access to this valve, lift the lid with a common utility tool, screwdriver, in the hole. If the lid is stuck, and additional leverage is necessary, insert the point of a pick head axe in the hole and apply the proper leverage. This valve is an ordinary gate valve with a "faucet" type handle. Turn the handle CLOCKWISE to stop the flow of gas. If the valve is too deep to reach with the hand, a sprinkler key can be used for extra reach.

- Remember that if this valve is present, either turning the gas off at the curb valve or meter stopcock can eliminate the flow of gas.

Leaks Inside Structures

Natural gas emergencies can be divided into the three following categories:

- Inside leaks
- Outside leaks
- Leaks resulting in fires

While each leak has its own dangers and concerns, the greatest danger results from gas leaks inside structures, due to the potential for ignition and explosion.

The first priority upon arrival on the scene of a reported leaking natural gas incident is safety. If a heavy odor of "gas" occurs, expect the worst. Expose as few people as possible, meaning prompt evacuation where necessary. A faint whiff of "gas" or a leak, which has “come and gone” for the past few days, may allow more leeway to perform a leak examination.

For faint odors, always check the condition of pilot lights as a first action. If a leak is suspected, pouring soapy water over the suspected area can confirm its presence. When a leak is found, always try to isolate the area as close to the leak as possible. Sometimes, turning the appliance valve near the problem one-quarter turn, the leak can be stopped leaving the rest of the premises unaffected. If it is not possible move back along the supply piping to the next point of control: generally, another stopcock at the MSA.

Multi-meter service is often present in multiple-tenant occupancies, such as apartment houses, or shopping centers. Each tenant has a meter and stopcock. Additionally, where the service pipe comes through the slab, prior to the MSA’s, there will be a "master" valve called the isolation valve stopcock, which stops the flow to all tenants in the building on the service pipe. This valve should be used with discretion, a minor leak at an appliance does not warrant shutting off 20 or 30 apartments. Conversely, if there is a major leak and difficulty is experienced in determining which meter controls the appropriate apartment, the main service stopcock provides the fastest means of control.

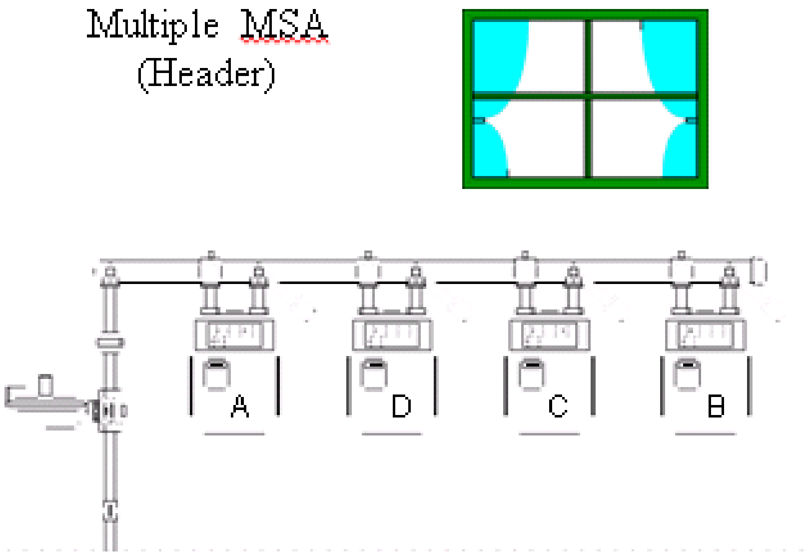


Figure 16 - Multiple MSA (Header)

Tactical considerations at an inside leak should include the following considerations:

- Determining necessity and extent of evacuation.
- Remove all sources of ignition. Avoid operating electrical switches. Turning a switch "ON" or "OFF", can cause sparking. Also, avoid walking on carpets in dry weather to prevent sparks from static electricity.
- Turn off appliance valve located at the connection from the appliance to the customer house line.
- Open windows after all sources of ignition have been eliminated. This ventilation can bring the gas into the proper explosive mixture with air.
- Searching for occupants who may be overcome by gas.
- If it is determined to be unsafe to enter the structure, consider the following:
    - Turn off gas at the meter.
    - Spot apparatus in safe zones.
    - Establish a water supply and prepare for fire suppression operations.

Leaks Outside Structures

Outside leaks can be just as dangerous as inside leaks because gas can take the path of least resistance, as it tries to escape to the atmosphere. Quite often, that path is along the gas service pipe or other underground lines into buildings or manholes. This migration may not be apparent because, as the gas travels through the ground, it tends to deodorize as the soil filters out the odorant. The best immediate procedure for responding to an outside leak should include the following considerations:

- Call the Gas Company. Allow the Gas Company representative the opportunity to assess the situation and call for equipment. In large emergencies, The Gas Company will send a management representative as a liaison and spokesperson for the company. Only the Gas Company can shut down a transmission or distribution line.

- The Fire Department's role at the site is to maintain public safety. This usually means eliminating potential sources of ignition until the leak is stopped. Place apparatus upwind of the leak and away from manhole covers, storm drains, or structures that can contain trapped gas. Evacuate when appropriate and maintain site security. It can take several hours for The Gas Company to shut off gas in a large, high-pressure, pipeline.

- The only sure way to safely check suspected areas are to use a combustible gas indicator. Currently, hazardous material squads carry equipment that can be used to detect the presence of natural gas and its lower explosive limit (LEL).

- If the leak is adjacent to structure(s), close doors, and windows to prevent gas from entering.

- If gas ignites, protect exposures close enough to be damaged.

    - Previously, The Gas Company used to teach its members a technique, known as the bend-back method, for controlling the flow of gas in small diameter pipes. This method is now against The Gas Company’s policy, due to a recognized danger to their employees. There is an extremely high potential for creating a static charge that usually accompanies the increased pressure of gas flowing from the restricted opening as the pipe is bent over.

- Crimping plastic pipe is acceptable if all tools used to work on plastic pipe are grounded.

- Redwood plugs can be driven into various diameter steel pipes with a rubber mallet. This method, redwood plugs, does not work with polyethylene pipe.

- Be aware that, on rare occasions, pipelines may contain hazardous contaminants such as Polychlorinated Biphenyls. The Gas Company states that its product is 97 percent free from impurities. However, if any liquid flows from a natural gas pipe, do not let it touch your body. Treat the liquid as a hazardous material and notify the hazardous material squad.

- Whenever a gas travels through piping, it can create a static electric charge on the pipe. On steel pipe, the current is drawn off and safely dissipated to the ground by the conductive pipe itself. Plastic pipe is an insulator, and it is probable that the pipe will have a static charge. A person grabbing the pipe to apply a plug will likely discharge this current, creating spark. Fog down the plastic pipe with a wetting agent such as wet water to prevent ignition from static electricity. Water alone tends to bead up and run off polyethylene pipe, thus reducing the effectiveness of water. A wetting agent such as wet water will add an adhesive quality to water that helps ensure that a static charge cannot form. (Use water judiciously and avoid flooding as mud hampers utility crews working at the break). Some plastic pipes are equipped with a wire that is used to help work crews locate the pipe from above ground. This wire provides no electrical charge. Additionally, it should not be relied upon to provide an adequate ground to eliminate the potential for a static spark.

- Newer installations of pipeline have fiber optics installed inside the pipe. The rupture of pipe and damage to fiber optic wires can disrupt business over a wide area.

Leaks With Fire

Considerations at a natural gas fire should include:

- Protect exposures.

- Generally, let the gas burn until the supply is shut off.

- If necessary, control evacuation and maintain site security.

- Notify the Gas Company.

Small fires may be extinguished with dry chemical, or CO^2 if necessary, to approach a shut off valve. For larger fires, fog streams can be used to approach any valves. Use care when placing hose streams where excavations have ruptured a gas line. Try to keep unnecessary water out of the pit. Utility crews may have to work in that area to stop the leak, and water could compound their problem.

ELECTRICAL EMERGENCIES

Power lines can come in contact with the ground as a result of storm related activity, fire, or vehicles striking power poles. In all cases, the potential for electrical shock/electrocution and secondary fire must be considered.

Electric Safety Awareness

Electricity will travel any conductive path it can as it seeks a ground. A direct path to ground can occur when contact is made between something energized and a portion of your body such as your hand, arm, head, or other body part. An indirect path to ground will occur when you are holding something or touching an object that is in contact with something energized. This could include tools or other equipment you may be holding or when touching a fence, vehicle, or other object that may be in contact with something energized. Gradient Voltage (Step and Touch Potential) is when power lines are down, and they will energize the ground around them. For Example: a point of ground contact could be over 7000 volts; this voltage will lessen as it radiates out from this point. Several feet from the initial point of contact the voltage could drop to 6000 volts. If your feet are in areas where there is a voltage difference, you could complete the circuit and be the source to ground. This is called “step potential.” This danger could be indicated by a tingling sensation in your feet and serve as a warning to back away from the area. Step potential is greater when the ground is wet. You should remain at least 35 feet from electrical lines on the ground.

Key Points

- Downed lines must always be considered energized with potentially lethal current.

- Lines can reset and become “hot” or “energized” again by manual operation of a switch, by automatic re-closing methods (either method from short or long distances away), by induction where a de-energized line can become hot if it is near an energized line, or through back feed conditions.

- Power line tends to have “Reel Memory” and may curl back or roll on itself when down.

- Use caution when spraying water on or around energized electrical equipment. Hose streams conduct current! Do not spray directly into the power lines, unless PG&E personnel have confirmed the lines are dead and have authorized use of water on the lines. Use a fog spray at the base of the pole. Your primary responsibility is to protect the surrounding area. Short bursts of water are preferred methods to avoid being grounded. Never spray water onto electrical equipment until a PG&E representative has confirmed that the equipment is dead and has authorized the use of water on the equipment.

- Electrical equipment is classified as:
    - Energized
    - De-energized (cannot be 100% guaranteed)
    - Dead (confirmed by utility representatives after grounding the lines(s).
- PCB hazards: Smoke potentially fatal; avoid and contain pools of oil around transformers.
- Poor soil resistance on dry earth may not provide enough of a ground to trip a circuit even when a conductor is laying on it.
- You cannot tell the voltage of a power line by the size of the conductor. Most overhead conductors are not insulated.
- Voltage can travel through both dry and especially wet ground for considerable distances.
- Pad-mounted, overhead transformers, and vaults can explode.
- Until grounded, equipment can contain electric potential, which can cause severe injury or death.
- Electricity can flow through the ground or other conductive objects, like metal fences to point far from the scene.

Operating Around Energized Electrical Hazards

- Request utility company to respond.
- Consider all down wires as energized.
- Place apparatus away from down lines and power poles and out from under involved overhead lines that could fail and fall onto equipment or personnel.
- Secure the area/deny entry.
- In the event of multiple lines/poles down over a large area, call additional resources.

<u>Down Power Lines and Vehicles</u>

- Request utility company to respond.

- Do not touch vehicle
- Have occupants remain inside the vehicle
- Place apparatus a safe distance away from down lines.
- Fire personnel should remain at least 35 feet from power lines in contact with the ground.
- If occupants must leave the vehicle (fire or other threat to life) instruct them to open the door, not step-out! They should jump free of the vehicle without touching vehicle and ground at the same time; they should move away from the vehicle shuffling their feet or hopping to avoid a voltage difference (step potential) between their feet as they move away from the source.

<u>Sub-Station, Transformer, Electrical Vault and Manhole Fire</u>

- Request utility company to respond.
- Clear the area.
- Be aware of explosion potential.
- Place apparatus in a safe location away from overhead power lines.
- Protect exposures.
- Do not make entry until the utility representative has verified that the electrical equipment has been de-energized. The utility representative may have to make entry to uninvolved sections to safely de-energize the equipment.

<u>Power Pole Fires</u>

- Request utility company to respond.
- Consider all wires and poles as “energized.”
- Place apparatus away from down lines and power poles and out from under involved overhead lines that could fail and fall onto equipment or personnel.
- Secure the area/deny entry.
- Do not make any fire attack until the utility representative has verified that the electrical equipment has been de-energized.

- Protect exposures without applying water to the powerlines/transformers.

SOLAR PHOTOVOLTAIC SYSTEM SAFETY AND THE FIRE GROUND

Daytime, Daylight = Danger Shock Hazard!!

Nighttime, Darkness = Potential Shock Hazard!!

- During daylight hours the Solar PV modules (panels) are energized and present a potential electrical shock hazard. This is also true during overcast days. Use extreme caution when working around a PV system to minimize any potential of electrical shock.

- During the nighttime/darkness, the Solar PV modules are generally not energized and present minimal hazard from electrical shock. However, scene lighting, low ambient light, or other artificial light sources can generate enough voltage-current to pose a shock hazard at night. The same safety precautions taken during the day should be taken at night.

- Never walk or climb on Solar PV modules. Although the modules will likely withstand some weight load, they still present a significant safety hazard from breaking glass, tripping and slipping. Exposure to the cells inside of the PV modules presents a potential electrical shock hazard.

- Do not place ladders on or against the Solar PV modules/arrays.

- Do not break a Solar PV module (panel) with an axe or other forcible entry tool.

- Do not attempt to remove a Solar PV module/array to perform firefighting duties. Leave the Solar modules/arrays in place and work around the system. If unable to work around the Solar PV array, notify the IC immediately. Alternative ventilation tactics should be considered.

- Do not cut metal conduit or wires strung between Solar PV modules or wires coming from a series of Solar PV modules to a combiner box. This could result in serious or fatal injury from electrical shock!

- Do not attempt to remove fuses from Solar PV fuse boxes. (Not all PV systems have fuse boxes.) Doing so will likely start a fire and presents a significant electrical shock hazard!

- Stay clear of the Solar PV modules and conduit. Utilize walkways and PV system clearances.

- Secure the Main Electric Service Panel (Main Circuit Breaker Box) for the building.

Securing the main electric power coming into the building from PG&E will only shut down power inside the building and does not stop the PV modules from producing DC power when sunlight or a light source is present. An electric shock hazard still exists from the array to the DC side of the solar inverter.

Firefighter Safety Around Solar Photovoltaic Systems

<u>Background</u>

This section will help Firefighter awareness and safety when working around Solar Photovoltaic systems (PV) at an emergency or fire scene. It will provide firefighters with a fundamental understanding of Solar Photovoltaic systems and identifying PV installations.

A fundamental understanding of PV systems includes, basic knowledge of PV components, how PV systems operate, how to safely secure a PV system, and how to safely perform firefighting operations, such as fire attack and ventilation at an emergency or fire scene with a PV system.

Solar Systems: "Knowing The Difference"

While some people might think that all solar technology is the same, there are very distinct differences between the three common types of solar system technology on the market today. This section will identify the differences between Solar Photovoltaic, *(referred to as PV or Solar Electric)*, Solar Thermal *(Water-Heating)* and Solar PVT *(also known as cogeneration or combined systems)*. Firefighters will learn common terminology, general function, solar components, and potential hazards for each system.

Solar Photovoltaic

Solar Photovoltaic (PV) systems are used in both residential and commercial (Figure 2 & 3) applications and produce DC electricity that is converted, using an inverter, to AC electric power for use by the consumer. Roof mounted PV systems are the most common and are generally visible from the street. PV systems can also be integrated into building materials, such as roofing tiles, awnings or overhead covers for parking lots and other structures.

PV system components include cells, modules (aka panels), electrical conduit, and DC to AC inverter(s). The number of PV modules per system will vary according to the total kilowatt size design of the system. Potential hazards for PV systems include electric shock, limited or difficult roof access/egress, tripping, slipping, falling, increased roof loads, hazardous materials, and battery hazards. Any of these hazards emphasize the need for constant awareness and adherence to safety procedures to prevent serious firefighter injury or death.

Solar PV Modules wired in series are referred to as Solar Arrays. The presence of a Solar PV system on this peaked roof may not be immediately noticeable from the street. Be prepared to change tactics if roof operations are hindered by the presence of a PV system. Access and egress become immediate concerns. Do not place ladders on, or break, PV modules!

Metal electrical conduit leaving Solar Modules and penetrating the roof can help identify Solar Electric versus Solar Thermal

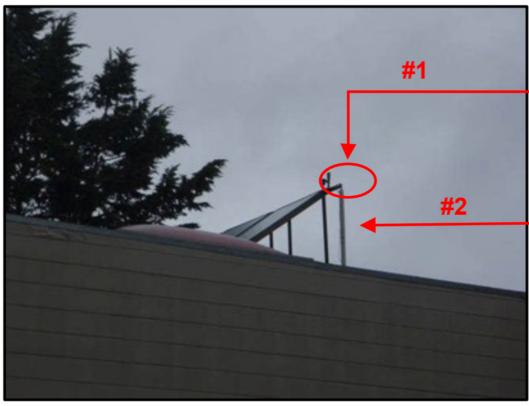
Figure 17 - Solar PV System

Solar Thermal

Solar Thermal systems (Figure 4, 5) are used to harness the solar thermal properties of the sun to heat water and **DO NOT** produce electricity. Solar Thermal systems are generally roof mounted and, range between 4-6 collectors (panels), and cover a much smaller rooftop area than Solar PV.

Thermal system components consist of collectors with pipe to heat water, heat exchangers water pipes, usually copper, pressure relief vents, and storage tanks. The potential hazards related to thermal systems are increased dead load weight on the roof and thermal burns from hot water that can be as hot as 180 F if the panels or pipes are breeched.

A Solar Thermal system can be identified by noticeable air vents, and/or the copper pipes (Figure 4 & 5) running between the panels and down through the roof to the hot water storage tanks. Newer solar Thermal systems (Figure 4) can be difficult to identify from the street.



This Solar Thermal system can be identified from the street by the pressure relief vent (#1 arrow at left) sticking up above the array and the copper pipe wrapped with insulation (#2 arrow at left) leaving the array. Solar Thermal systems do not present an immediate risk to firefighters.

Figure 18 - Solar Thermal Heating System

This Solar Thermal system may be difficult to identify from street level. The copper pipe wrapped in insulation (highlighted by the red circle at left) leaving the bottom of the Thermal panel is the main indicator to identify the system as solar Thermal versus Photovoltaic. Solar Thermal systems do not present an immediate risk to firefighters as there is no hazard of electrical shock.

Figure 19 - Large Solar Thermal System

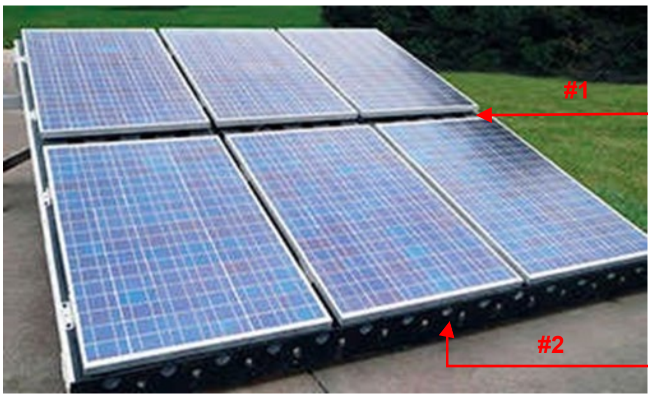
Solar Co-Generation

Solar PVT modules are designed to incorporate both Solar PV and Solar Thermal into the same system. This type of system is referred to as co-generation. Solar Photovoltaic/Thermal Co-generation (PVT) systems can generate DC electricity, solar thermal for heating water, or thermal heating of air used to heat a building.

A PVT system covers about the same amount of roof top area as a single PV system. The number of PV modules is dependent on the total kilowatt size of the system and are generally mounted on roof tops.

The potential hazards with Solar PVT are the same as thermal and single PV systems. The main hazard is electrical shock. These systems should be treated with the same caution as Solar PV.

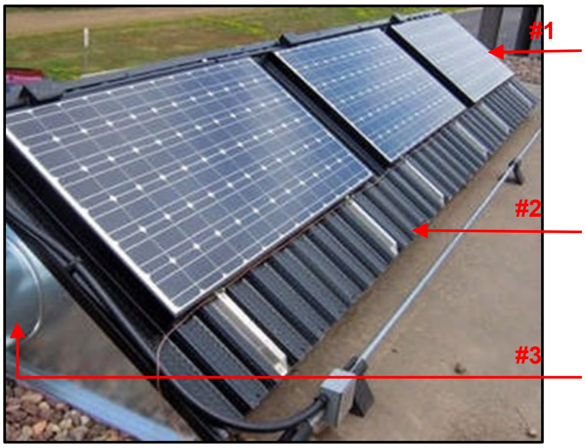
Identifying PVT systems should not be difficult. At first glance the system will have the same appearance as PV. The only discernable difference will be the Solar Thermal panels or heat "tubes" for heating air incorporated into the system, which are generally positioned at the top of the array; however, other design configurations exist (Figure 6 & 7).



This Solar PVT Co-generation system may look like a Solar PV system from street level. A tip for identifying Solar PVT systems from the ground will be to look for electrical conduit and PVC piping leaving the same array. The immediate risk to firefighters from Solar PVT systems is electrical shock. Do not walk on, ladder, or break solar modules! Arrow #1 to the left is the PV module.

Arrow #2 to the left is the Thermal component for heating water.

Figure 20 - Solar Co-Generation PVT System; Solar Module Combined with Thermal Components



The Solar PVT Co-generation system at left has Solar PV (#1), Solar Thermal for heating water (#2) and harnesses heated air to heat the building (#3). This type of co- generation system will be easier to identify because of the apparent air duct (#3) used to carry the heat into the building. The PVC for water heating component is hidden by the sheet metal for the duct work. The PV electrical conduit is also obvious when looking at the system. Again, the immediate danger to firefighters for this Solar PVT system is electrical shock.

Figure 21 - Solar Co-Generation System. Solar PV and Thermal Combined. This system will generate DC electricity and harness thermal energy to heat water and the building.

The integrated Solar PVT Co-generation system at left has a row of Solar Thermal, to heat water, on the top (#1) and three rows of Solar PV (#2) on the bottom. From street level, this Solar PVT installation may appear to be a Photovoltaic system only. There are no pipes or metal conduit visible from the street since the system is integrated into the roof system. Firefighters should notify the IC immediately and take the appropriate steps to make the system safe to work around. Do not ladder, walk on, or break solar PV modules.

Figure 22 - Residential Solar PVT Co-Generation Installation

SOLAR PV SYSTEM COMPONENTS

This section will briefly identify and discuss PV components such as a PV cell, PV module/array, inverters, AC and DC disconnects electrical conduit, system labeling, and solar battery storage. Firefighters with this basic knowledge will be able to identify PV components and learn the appropriate steps to safely secure and work around a PV system quickly and confidently.

Photovoltaic Cell

A Photovoltaic cell is the smallest part of a PV system. However, the PV cell is the most important part in terms of gathering solar energy produced by the sun (photons). There are two basic types of Photovoltaic semi-conductor cells: silicon and amorphous silicon. In most cases, the semi-conductor silicon is approximately 1/100th of an-inch in thickness.

The basic function of a PV cell is to collect photons from the sun to energize and force electrons from a negative layer to a positive layer in the PV cell. The process of harnessing photons and forcing electrons from the negative to positive layers generates around. 5 volts of solar energy per PV cell. Generally, semi-conductor cells are cut and cast together into a thin multi-crystalline construction, then fused and sandwiched inside a PV module. A PV module has many cells that work together to generate solar energy.

Module/Array

Solar PV modules (also known as panels) are designed to harness DC electricity from sunlight. A module has no moving parts and is weatherproof. Photovoltaic modules consist of numerous PV cells wired together, enclosed in an aluminum frame, and covered with tempered glass. Although the modules can range in size, typically each module is 30” wide X 50” long, weighs between 30 to 50 pounds, and consists of 50 to 72 semi-conductor cells. Solar PV modules are generally rated between 125 to 300 watts and can produce 20 to 50 volts of DC power. Solar PV modules are normally grouped and wired in series and parallel to increase voltage and amperage. When PV modules are grouped and wired together, the group of modules is referred to as a PV array.

Residential PV arrays can have a total number of modules ranging from 15 to 40, depending on the electrical needs and design of the home. A typical residential PV system is 3 to 4 kilowatts and can produce between 120 to 600 volts DC at currents from 5 to 9 amps during daylight hours depending on the intensity of sunlight. With optimal sun exposure, a PV array can generate between 2,000 to 5,000 watts, or 2 to 5 kilowatt hours of DC power daily. Commercial PV systems vary widely.

From a safety perspective, what does all this discussion of voltage and amperage mean? Simply stated, the current (amperage) is what causes damage/injury to a person’s body; the voltage is what drives the current through the body. The voltage and amperage identified above is more than enough, if contact or exposure to the DC electrical source is made, to cause serious injury or death from electrical shock.

Figure 23 - Solar Photovoltaic Module

Figure 24 - Back of PV Module Showing the Connection

Photovoltaic Inverters And Disconnects

Solar PV system inverters and disconnects are critical PV components. Understanding the function of these components will assist Firefighters to know where the potential dangers exist and how to isolate and shut down power to the inverter as well as to the building. Shutting down and securing electrical utilities for a building with a PV system is a top priority at an emergency or fire scene to maintain a safe working environment for Firefighters.

Inverters

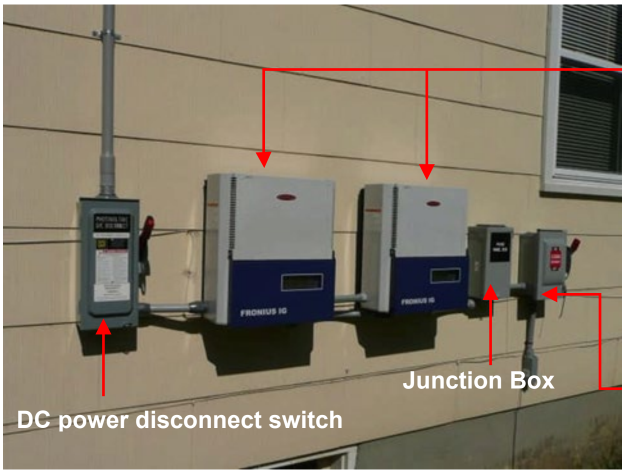
Typical household fixtures and appliances utilize AC power to operate. Since PV arrays generate DC power, it must be converted to AC power before it can be used by the consumer. An inverter converts the DC electricity from the PV array to AC electricity which is fed into the Main Electrical Service Panel (Circuit Breakers) for the building.

There are a variety of inverter styles and sizes. The two types of inverters used for PV installations are system inverters and micro-inverters.

System inverters (also referred to as String inverters) are the traditional and most common type of inverter used for solar PV systems to date. PV system inverters are rated and designed to receive a specific amount of DC voltage from multiple PV modules in the array and convert that power to AC electricity. A Solar PV system may require one or more inverters depending on the total kilowatt per hour design of the system, which determines the potential amount of DC voltage generated by the array.

System inverters are generally large and can be located inside and/or outside of a building depending on available space. To operate and convert DC power to AC power, system inverters require a dedicated AC electrical circuit wired from the Main Electrical Service Panel. The dedicated AC circuit for the inverter(s) is a built-in safety design to prevent the potential of electrical power being back fed into the PG&E utility grid in the event of a power outage.

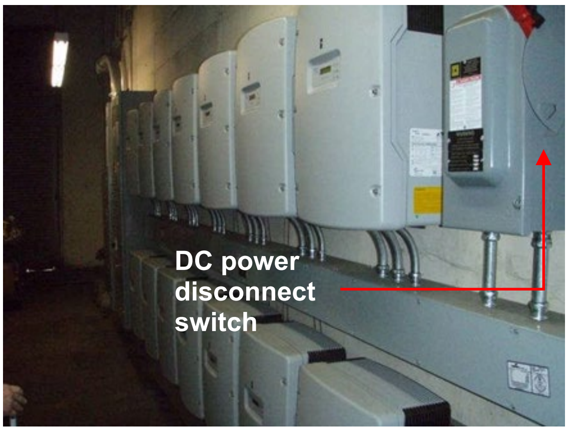
The dedicated circuit for the inverter(s) also provides Firefighters with the ability to quickly isolate converted AC electricity coming into the building from the inverter(s) by shutting down and securing all the circuit breakers located at the Main Electrical Service Panel. However, this means that DC electricity is still present in the electrical lines and conduit from the PV modules/array down to the DC line side of the inverter(s).



Residentially installed system inverters. The inverters can be located inside or outside of the building. Inverters require a dedicated AC circuit to convert the DC electricity into usable AC power. Securing electrical power at the Main Electrical Service Panel will shut down the inverters. During daylight hours, DC power is still being generated from the Solar PV array to the DC disconnect or the DC side of the inverter

AC power disconnect switch.

Figure 25 - Residential System Inverters Along with AC and DC Disconnects



Securing the Main Circuit Breaker at the Main Electrical Service Panel will shut down the inverters for residential and commercial PV systems.

To prevent equipment used during firefighting operations in commercial buildings with PV systems from being accidentally shut down, such as HVAC, consult with the IC or building engineers before securing the circuit breakers in the off position at the Main Electrical Service Panel.

Figure 26 - Multiple System Inverters for a Large Commercial PV System

Micro-inverters are single inverters built into and/or secured on, or adjacent to, each individual PV module. This type of inverter provides what is referred to as “Module Level Control”, which optimizes the DC voltage levels by converting DC electricity to AC electricity at each individual module in the array. After the individual Micro-inverters have converted DC voltage at each module, the converted AC electricity is fed through ordinary AC electrical circuit wiring to the Main Electrical Service Panel for use by the consumer. Micro-inverters can be used on residential and/or commercial solar PV installations.

PV systems that use micro-inverters significantly improve system efficiency and provide a higher level of PV safety for Firefighters. Like string inverters, micro-inverters require a dedicated AC circuit wired from the Main Electrical Service Panel to operate. When power to the building is shut down at the Main Electrical Service Panel, AC power wired to each micro-inverter is also shut down. This isolates and contains DC power within each individual PV module in the array and prevent the micro-inverters from converting DC power to AC power. Firefighters must still use extreme caution when working around the PV modules/arrays as they may still be energized and could pose an electrical shock hazard. Avoid breaking and/or always exposing the internal construction of PV modules to prevent serious injury or death. The micro-inverter will be built into and/or mounted on or adjacent to PV modules.

Figure 27 - Micro-Inverter

Disconnects

Disconnects are switchblade-type electrical components required for safety. Usually, disconnects are mounted and wired in-line on the DC line side (upstream) and the AC load side (downstream) of the system inverter(s).

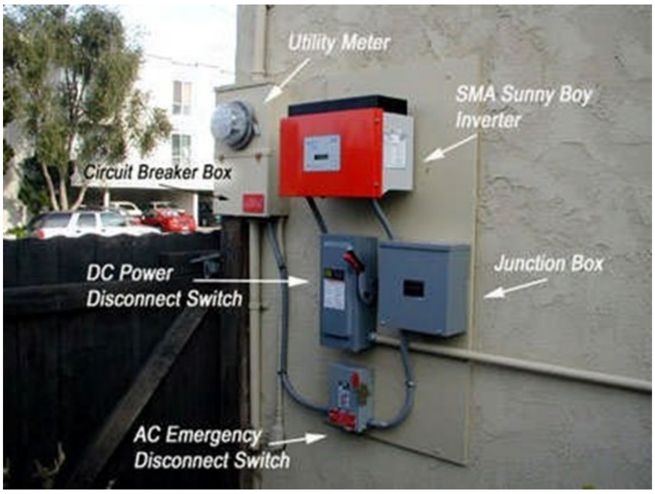
When an electrical disconnect is located on the DC line side (upstream) of the inverter it is called the DC power disconnect. When an electrical disconnect is located on the AC load side (downstream) of the inverter it is called the AC power disconnect.

The primary function of the DC and AC disconnects is to allow solar technicians to perform routine maintenance on the inverters by isolating electrical power coming into and out of the inverters. Shutting down the DC disconnect only secures and prevents DC electricity produced by PV array from entering the inverter. The DC disconnect does not shut off DC electricity supplied from the PV array. The DC electricity coming from the array down to the DC disconnect is still energized during daylight.

Shutting down the AC disconnect only secures and stops converted AC electricity coming from the inverter(s). It does not shut off AC electricity supplied from the PG&E power grid, or any AC electrical circuits coming from the Main Electrical Service Panel for the building.

As a general safety rule for securing PV systems at an emergency or fire scene, firefighters should shutoff and secure all switches/disconnects that are visible and accessible and all circuit breakers at the Main Electrical Service Panel.

Communication with the IC is critically important before and after shutting off and securing electrical utilities.



When securing a Solar PV system, shutoff and secure all switches / disconnects that are visible and accessible. If the DC and/or AC disconnect switches are not found, securing ALL circuit breakers at the Main Electrical Service Panel will shut down the inverter and stop AC power from going into the building.

During daylight hours, DC power is still being generated and is present from the Solar PV array to the DC disconnect.

Figure 28 - Residential Solar PV inverter, DC and AC disconnect junction box and Main Electrical circuit breaker panel.

Solar PV System Labeling

Labeling of Solar PV systems, residential and commercial, can be a critical clue for overall Firefighter safety. This critical component can easily be overlooked if firefighters are not performing thorough size-up of an emergency or fire scene. The danger that exists with solar PV systems is having two electrical power sources for one building: the traditional AC electrical service provided by the Pacific, Gas and Electric (PG&E) power grid and the secondary electrical power source from the solar PV system.

Since solar PV systems are categorized as **"Customer Side Power Generation Equipment with Back Feed Potential,"** PG&E requires that labeling on the Main Electrical Service Panel identify the presence of a secondary power source (Figure 29). Unfortunately, labeling for solar PV installations is not uniform or regulated. The type and amount of warning labels throughout the PV system will vary depending on who installed the system, where (what city or county) the system is installed, and how long ago the system was installed.

Various labels can be found on PV components, such as Main Electrical Service Panels, PG&E utility meters, PV modules, electrical conduit, DC, and AC disconnects, and other random locations. The purpose of PV labeling is to indicate the presence of a Solar PV system on or supplying the building with solar power.

Figure 29 - Warning label on the front of a Main Electrical Service Panel (circuit breaker). The label in this instance clearly identifies the secondary power source is solar PV.

A bi-directional PG&E meter (Figure 30), used only for grid-tied PV systems, will be identified with a label that states, **"Meter Runs in Both Directions."** This type of labeling is to prevent accidental back feed of electricity into the grid. Bi-directional meters will be present on all "grid-tied" solar PV systems.

Figure 30 - Bi-directional meter labeled to indicate the presence of an alternative power source (PV).

Key Point: **This should be a Top Priority!**

Securing both AC and DC electrical power sources to the building is critical to rendering the building as safe as possible for Firefighters. The electrical power to the building will not be completely shut down until the Main Circuit Breaker, located in or on the Main Electrical Service Panel for the building is secured (shut down). If any of system disconnects are visible, they should also be placed in the "OFF" position. Notify the IC when both AC and DC electrical power sources to the building have been properly secured. This should be a Top Priority!

Remember, during daylight, DC power is being generated from the PV modules down to the DC disconnect. DC power cannot be completely shut down unless all the PV modules are completely covered with an opaque tarp or cover during daylight hours. During darkness, ambient light from fire or scene lighting may generate enough power to present an electrical shock hazard. Always use extreme caution.

Figure 31 - Label on the side of a solar PV mobile installed on the roof, provides firefighters with a reminder of potential hazards as well as the name of the electrical contractor who installed the system.

The warning: "Line" and "Load" sides of any disconnect switch box could still be energized and present a shock hazard, even after the disconnect switch has been placed into the "OFF" position. This is generally the result of having dual power sources and the potential for back feed of electrical power throughout the system.

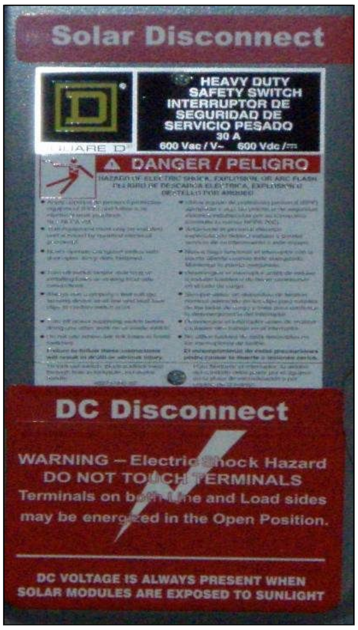


Photo 2. Label on ac PV disconnect

Figure 32 - DC and AC power disconnect labels.

THE PHOTOVOLTAIC SYSTEM: HOW IT WORKS!

While every building is different, PV systems are functionally the same. The technology utilizes a basic process to produce and convert solar power for use by both residential and commercial consumers. Each of the PV components has a specific job; when combined with each other the PV system will harness the highest amount of solar power possible.

This section will bring all the components together in one unit to provide a better understanding of the technology and operation of “grid-tied” and “off-grid” PV systems, battery back-up and storage, how daytime and nighttime light affects PV systems, and to improve recognition of different PV designs and installations. The differences in PV design and installation are based on individual consumer electrical needs, how the solar electricity will be used or stored, and whether the system will be residentially or commercially installed.

Knowing the difference between the system types determines what optional PV components might be installed and is an important safety factor for Firefighters. A basic knowledge of how solar PV systems work will help Firefighters understand where the potential hazards exist and how to reduce close-call injuries or Line of Duty Death (LODD).

Basic PV System Overview—“Grid-Tied” and Off-Grid”

The amount of DC electricity generated by a solar PV system is variable. Solar PV systems are dependent on the atmospheric conditions and the condition of interconnected PV components to operate correctly and at optimal efficiency. The time of day, the amount of direct and indirect sunlight on the array, cloud cover, shade, shadows, and the mechanical condition, location, and proper installation of PV components are examples of factors that directly affect the overall operation and performance of a solar PV system.

The basic function and operation of how Solar PV systems harness energy from sunlight to produce electricity is the same; Sunlight is converted to DC electricity by solar cells and DC electricity is converted to AC electricity using an inverter. The only difference from one PV system to the next is design. PV system design is divided into two categories, grid-tied and off-grid. To determine the most suitable PV system for a specific consumer, the design is based, in part, on individual consumer electrical needs and objectives and overall cost.

“Grid-Tied” PV Systems

The term “grid-tied” refers to alternative solar photovoltaic electrical power being used in combination with traditional electrical power supplied by the PG&E utility power grid. For most consumers, a grid-tied PV system is the ideal configuration. Consumers get all the benefits of using their own solar electricity as well as the benefits of being connected to the PG&E power grid. There are two design styles for grid-tied PV systems, direct and battery back-up.

A direct grid-tied system is the basic style design for grid-tied PV. Consumers do have the option to upgrade the system with battery back-up to mitigate power outages. The basic operation and design difference between direct grid-tied PV and a grid-tied battery back-up system is discussed below.

Direct Grid-Tied PV Systems

The most common PV system is a direct grid-tied system. A grid-tied PV system is connected directly to the PG&E utility power grid. This allows AC power to flow both into and out of the building through a bi- directional meter on the Main Electrical Service Panel. The amount of AC power being supplied into or out the building depends on the electrical needs of building occupants and the amount of electrical power produced by the PV system at that exact time.

When the PV system is producing adequate solar electricity, the building only utilizes solar power. This is the PV system’s first priority. During times when the PV system cannot produce enough solar electricity or is not producing solar electricity at all, such as at night, the building electrical service will utilize power from the PG&E grid.

When the PV system is producing more solar electricity than the building occupants can use, the excess is fed back through the bi-directional meter into the PG&E power grid.

This is known as net-metering. With net-metering, when a consumer uses electricity from the PG&E grid, the bi-directional meter spins forward. When the consumer-based PV system is producing excess solar electricity and feeding power into the PG&E power grid, the bi-directional meter spins backwards. The offset means that consumers with PV systems are receiving market rates for the amount of electricity fed into the PG&E grid.

The downfall of direct grid-tied PV systems occurs during power outages. As discussed earlier, PV inverters require a dedicated AC circuit to convert DC voltage into usable AC voltage. When the PG&E grid has a power outage, the inverter also loses power and cannot convert DC electricity into AC electricity for the duration of the outage. This is a built-in safety design to prevent back feeding of DC electricity through the system and into the power grid. AC electrical power to the building will be restored after the PG&E grid power is restored. This will occur regardless of the time of day.

****Safety Point: If the power outage occurs during daylight, the solar PV array is still producing DC voltage. Therefore, DC electricity will be present at the arrays and in the electrical conduit from the array to the DC voltage side (input) of the system inverter(s). There will be no power beyond the inverter until grid power is restored. Light from fire or scene lighting during darkness may produce enough electricity to present a significant shock hazard. Use caution when working around the array and electrical conduit**

always coming from the array to the inverter, whether there is a power outage or not!

In the typical Direct "Grid-Tied" Solar Photovoltaic System, the DC electricity is converted into AC electricity by the Inverter and then fed into the Main Electrical Service Panel. The Main Electrical Service Panel supplies residential or commercial buildings with AC electricity. Excess AC power not being used in the building is fed into the PG&E power grid.

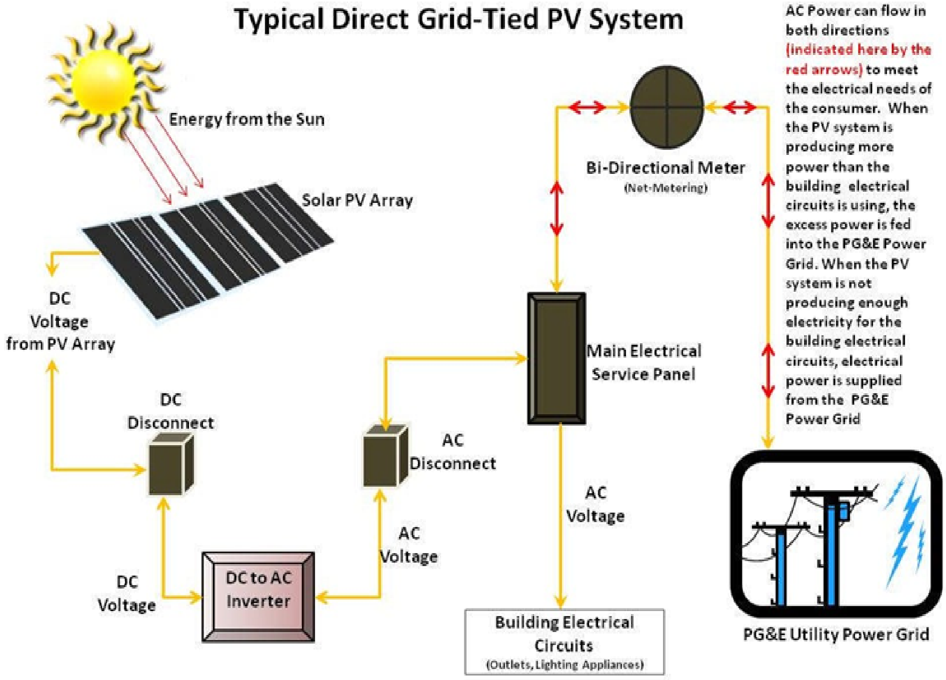


Figure 33 - Typical Direct Grid-Tied PV System

Grid-Tied PV with Battery Back-up Storage System

Grid-tied PV systems with battery backup storage offers the convenience of being connected to the grid with the security of having uninterrupted backup power during a PG&E grid power outage. This system design is commonly used for buildings that have critical electrical needs. Grid-tied PV systems with battery back-up storage operate in the same basic manner as direct grid-tied PV systems and utilize Net Metering. The difference between the two systems is the bank of batteries to store DC electricity for use during power outages. The DC electrical storage is accomplished by adding components into the PV system designed to use excess DC electricity to charge the battery bank.

Identification of battery back-up storage systems must be reported immediately to IC to prevent accidental electrical shock. To isolate a battery back-up system, Firefighters should be familiar with the basic functions of the additional components, which include the following:

- Charge Controller - To prevent the batteries from overcharging.

- Bank of batteries - To store accumulated DC voltage for use when there is a power outage or no electricity is being produced, such as at night.

- Stand-Alone Inverter - Inverters of this type use both AC power on a dedicated circuit when the PG&E grid is operating, and DC power supplied from the battery bank during a power outage, to convert DC electricity into AC electricity. The inverter utilizes DC voltage from the batteries and capacitors that store energy to operate during an outage. Energy in the capacitors will discharge soon after the power to the inverters has been isolated. A significant electrical shock hazard could always exist.

- Backup Electrical Sub-Panel and Electrical Circuits – During a power outage the AC voltage being converted by the stand-alone inverter is fed into a backup AC electrical circuit that energizes and feeds into a backup sub-panel before distributing power from the backup sub-panel into the building electrical circuits. The sub-panel is a safety feature designed to isolate electrical power during a power outage and any potential for electricity back feeding into the PG&E grid. Backup electrical circuits are tied into the normal electrical circuits for the building such as outlets, lighting, and appliance circuits.

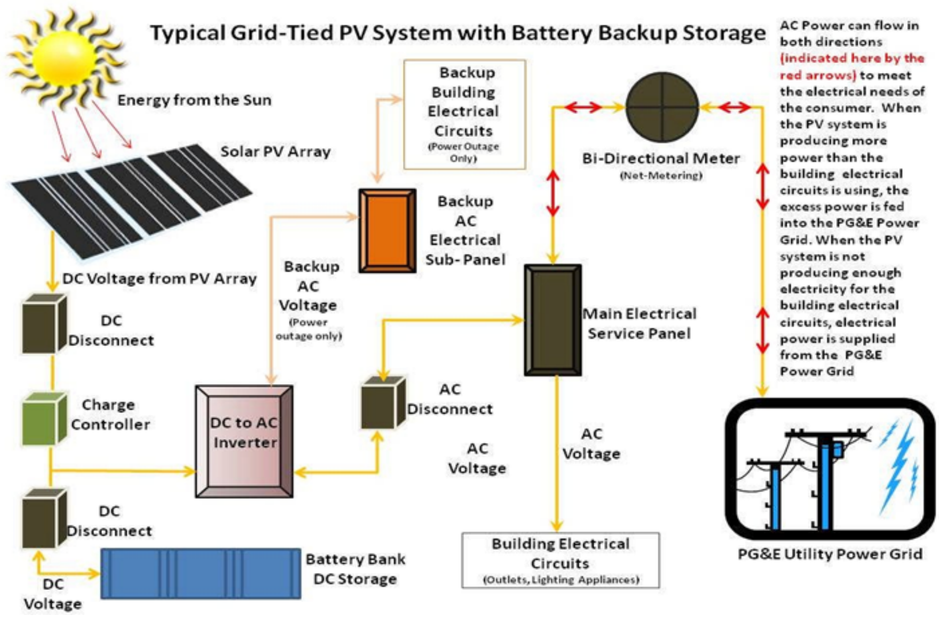


Figure 34 - Typical Grid-Tied PV System with Battery Backup Storage

<u>“Off-Grid” PV System</u>

A PV system that is “off-grid” or a true stand-alone PV system produces solar electric power independent of the PG&E utility power grid. This type of system is more commonly found in rural areas, in environmentally sensitive areas, or in illegal activity. Most off-grid PV systems rely on DC electricity produced during daylight to charge and store DC voltage using a large bank of batteries. The system components for an "off- grid" system is basically the same as a grid-tied system with battery backup storage.

Stand-alone inverters commonly utilize power from batteries and capacitors that store energy to convert the DC power into AC power. The capacitors hold an electrical charge capable of producing a significant electrical shock hazard for several minutes after power to the inverters has been disconnected. The basic operation of off-grid PV systems is essentially the same as a grid-tied PV system.

The most distinguishable difference is the use of a backup generator as a secondary source of electrical power when the battery bank is discharged or depleted of DC voltage. The backup generator produces DC voltage and is tied directly into the inverter. Backup power can be used during the night or when there is a problem with the bank of batteries. Off-grid PV systems reaffirm the need for Firefighters to have a standardized approach to working around solar PV for optimal safety.

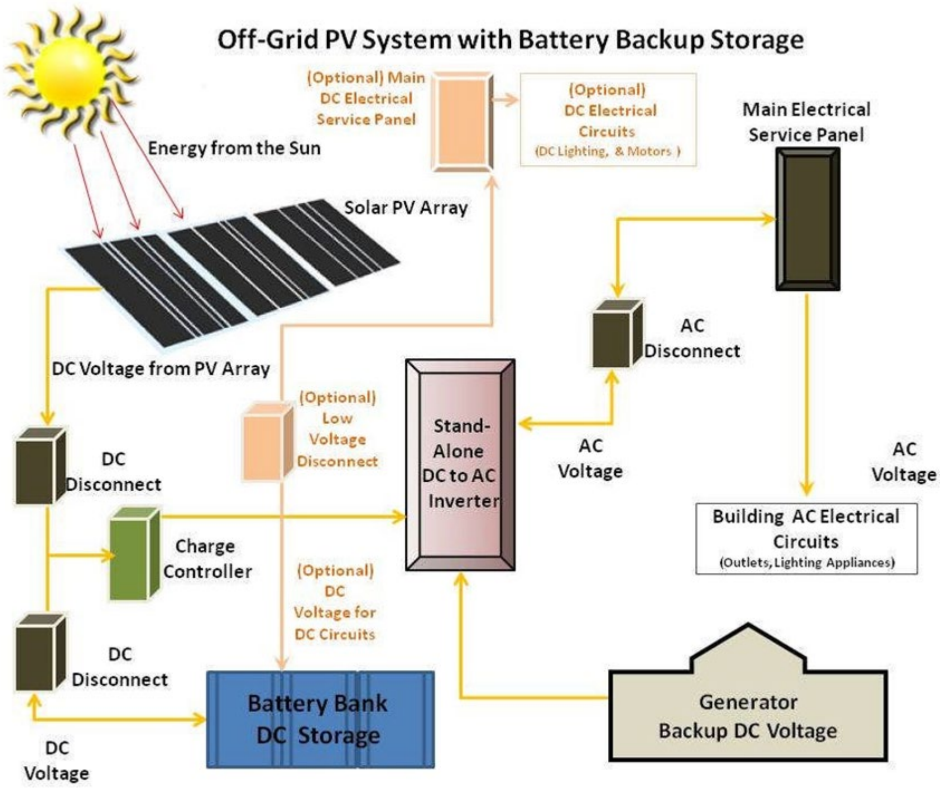


Figure 35 - Off-Grid PV System with Battery Back-up Storage and Backup Generator as a Backup Secondary Source

Solar PV System Recognition

Roof-Mounted PV Systems

Roof mounted systems are the most common installation design for residential and commercial solar PV Systems throughout the industry. Roof-mounted PV systems are a popular design because of the utilization of unused space on the roof and optimal southern exposure to the sun. Roof-mounted systems generally use metal racks or single anchors, specifically designed for PV modules, to secure the array over existing roof surfaces to the sub-structure (rafters) below the roof. Racks for PV modules can be elevated for flat roof installations or may sit just a few-inches over the existing roofing material on a peaked roof. Identification from the ground at street level can be difficult. Firefighters should be able to recognize PV components to assist in recognition of a PV system. Recognizable components from the street level include modules mounted on the roof, PV labels on electrical components, visible electrical conduit coming from the roof or entering the attic space, inverters, multiple disconnect switches, or a bi-directional meter at the Main Electrical Service Panel.

Street level recognition of roof-mounted systems is not always possible due to weather conditions, building height, flat roofs, parapet walls, and time of day. Firefighters working on a roof should immediately communicate the presence of a roof-mounted PV system and any hazards preventing normal operations to the IC.

Figure 36 - Roof Top Residential PV System

Ground Mounted PV Systems

Ground-mounted PV systems are not often found in urban areas. Ground-mounted PV systems generally allow the PV array to be installed in a proper location and angle for optimal exposure to the sun.

Ground-mounted PV systems are generally not difficult to recognize. The difficulties for Firefighters are the ability to identify the location of system disconnects, location of electrical conduit, and the ability to isolate and shutdown electrical power coming from the PV array.

Street level recognition can be difficult, and Firefighters must have a higher level of awareness for identifying alternate PV system installations and designs located in their geographical response area.

EFFECTS OF LIGHT ON PV SYSTEMS

Daylight

During daylight, a Solar PV system will provide some, or all, of the building's electrical needs, residential or commercial, depending on the amount of electricity that appliances or machinery inside the building require at the time. If the Solar PV system is not providing all the power needs, the balance of power needed is automatically provided directly from the PG&E power grid. On days when sunlight is intense, the PV system will generally produce more power than needed. The excess power is automatically fed into the PG&E power grid and a credit is recorded on the bi-directional meter (Net Metering).

The amount of power being generated at any time during the day will still present a significant electrical shock hazard that could result in permanent injury and/or death, regardless of the intensity of the light on the array. Firefighters should never assume that low levels of daylight or less intense sunlight due to clouds or shade will stop a PV system from producing electricity.

Nighttime

Generally, at night, solar PV systems will not produce electricity. However, low ambient lighting, artificial light from scene lighting, light from fire, or street lighting may be able to generate enough light for solar cells to produce DC electric power that could present an electrical shock hazard during hours of darkness.

This has been documented by Underwriter Laboratories (UL) during experiments with solar PV and the effects of light from sources other than the sun.

The potential to create solar electricity from light sources other than the sun depends on several conditions: intensity, location, and distance of the light source from the PV modules.

In the recent past, the fire service considered a solar PV system safe to work around at night or during darkness because it was assumed that the systems do not generate enough DC electricity to be harmful. However, the potential for a PV system to generate enough DC electricity to present an electrical shock hazard, indicated by UL studies, has prompted a change for overall Firefighter safety related to solar PV during periods of darkness at a working fire or an emergency scene.

Even though it is nearly impossible to know if the PV system is producing enough DC electricity to present a hazard, Firefighters should consider the potential for electrical shock and take steps during hours of darkness to render the PV system as safe as possible. Remember, during the night, a "grid-tied" PV system is not producing enough DC power and electricity from the PG&E power grid is provided. Firefighters should also be aware of the potential for “grid-tied” systems to have battery back-up.

****Safety Point: For overall safety, ALL PV systems should be isolated at any time of day or night, before working around the system.**

PV SYSTEM HAZARDS

The general hazards that exist for solar PV on residential or commercial structures are not strictly specific to PV technology. The same hazards exist with traditional electrical systems. However, when the integrity of a PV system component or protective covering is compromised or damaged due to fire or other destructive causes, the system always presents significant hazards and unique safety concerns for Firefighters.

Hazardous Materials Inhalation Hazard

Hazardous materials such as silicon, boron, phosphorus, cadmium, tellurium, arsenic, and gallium, are used in the construction of PV modules and components. In PV modules these materials are sealed between the top layer of glass and the plastic backing of the module, and then are encased in an aluminum frame.

When the PV system is operating under normal conditions, these chemicals do not constitute a hazard. However, a fire may expose the hazardous chemicals to direct flame and/or significant heat.

Wear all PPE during fire attack and overhaul operations. All chemicals listed above are considered toxic under fire conditions; some have a significant increased cancer risk with exposure.

PV System Battery Hazard

Banks of batteries storing electricity are generally arranged in a line and are connected to each other. There are two types of batteries used as electrical storage for PV systems, lead acid and lithium ion.

Both battery types are stable under normal circumstances. Firefighters working around battery banks during fire attack and overhaul operations must utilize proper PPE, including breathing apparatus.

Firefighters should isolate the bank of batteries from the PV system, if needed. If the PV system is disconnected from the batteries, the bank of batteries themselves still has potential for electrical shock. Firefighter should never attempt to cut into or attempt to damage the batteries under any circumstance. If the batteries are punctured by a conductive object, such as halligan tool, the object may become energized. Firefighters working around or adjacent to the battery storage areas should only use flashlights and equipment approved for CLASS 1 atmospheres.

When Firefighters determine that a PV system is using a battery bank to store electricity, the IC should be notified about the hazard and the location of the batteries in the building.

INCIDENT PRIORITIES AND TACTICAL CONSIDERATIONS

Fire and emergency incidents for residential and commercial buildings have a basic and standardized approach. However, fire and/or emergency incidents involving solar PV systems require special considerations. The special considerations are a result of the inherent and associated hazards of PV systems and are necessary to ensure Firefighter health and safety and to accomplish fire control in a safe and efficient manner. Incident Priorities and Tactical Considerations for solar PV systems during fire and/or emergency operations are outlined below.

Communications

- All findings during the initial and on-going size-up and any actions taken need to be communicated to the Incident Commander (IC).
- Incident size-up and identification of PV system and components
    - Solar PV array visible from the street upon approach and/or arrival.
    - System inverter(s) visible or evident anywhere on the building.
    - PV labeling identifying the presence of a PV system.
    - DC or AC disconnects visible and/or accessible.
    - Visible electrical conduit penetrating the attic space or near the main panel.

Securing Utilities

- Securing Utilities is a top priority for incidents involving a PV system to maintain a safe work environment for Firefighters.
- Locate Main Electrical Service Panel.
    - Shut off Main Breaker inside the Main Electrical Service Panel.
        - This will shut down the AC power at the Main Electrical Service Panel and AC power going into the building.
        - Shutting off the Main Breaker will also de-energize the AC power used by the inverter to convert DC into AC power.
    - If in doubt which is the Main Breaker, shut-off all circuit breakers inside the Main Electrical Service Panel.

            - Use caution for large commercial and high-rise buildings.
                - Electrical power might still be needed to power HVAC systems and elevators.
                - Consult with building engineers (if applicable) to isolate the PV system ONLY!

- Consider using Lock-out/Tag-out system to secure PV system.
- Locate and isolate the PV system and battery bank (if applicable).
    - Locate PV Inverter(s) and disconnects.
        - Shut disconnects into the "OFF" position.
    - Locate PV system batteries (if applicable).
        - Shut disconnects for battery bank into the "OFF" position.
    - Locate and shut off all visible disconnects or switches for the PV system.
        - Near Bi-directional Electric Meter.
        - Near the inverters.
        - Switch-gear on the roof.
        - Roof top disconnects.
    - Notify the IC when the utilities and PV system have been secured.

Fire Attack Considerations

- Coordination of fire attack and ventilation
    - Fire attack could be delayed or hindered due to difficulties with completing ventilation.
    - Advancing hose lines could be delayed due to securing PV and building utilities.
- Be aware of energized PV system components inside the building.
- Notify the IC if wires and conduit inside the building is located.
    - Avoid contact with conduit or wires if possible.

- Attempt to avoid directing hose streams directly onto energized PV system components.

- If possible and indicated, use Dry Chemical Extinguishers or CO2 Extinguishers around PV components.

- If water is used PG&E recommends Fog Nozzle at a 30-degree pattern at 100 psi minimum at the tip and at least 33 feet from the energized source.

- UL experiments indicate that using a solid stream, smooth bore nozzle at 50 psi at the tip and at least 20 feet from the energized source is considered safe up to 1000 volts. PV systems have a maximum allowable voltage of 600 volts.

- Difficulties with fire attack must be communicated to the IC.

Ventilation Considerations

- Early recognition of the PV modules and identification of difficulties with completing ventilation objective is key for Firefighter safety.

- Identify safe access and egress to the roof if possible.

- PV modules/array on the roof may affect ground or aerial ladder placement.

- Do not cut through any conduit or wires to complete ventilation due to the potential for electrical shock.

- Do not break PV modules with an axe or attempt to remove PV modules to ventilate due to electrical shock hazard.

- If vertical ventilation cannot be accomplished because the PV system does not provide firefighters with clearance, consider changing ventilation tactics, and notify the IC immediately.

- If a PV module is involved in fire, it does not present a hazard to utilize a hose line to extinguish the fire if all recommendations for PPE, SCBA, and use of water streams are followed.

DEFINITIONS

AC Disconnect - The AC disconnect is the AC power shutoff. The AC disconnect is in line between the inverter and the Main Electrical Distribution Panel for the building.

AC Voltage - AC stands for "Alternating Current." This means that the voltage is not constant and changes polarity (reversing positive and negative) or direction over time. AC is the type of electricity that is found in your home and delivered by PG&E. AC voltage in the home is commonly 110 volts for most ordinary electronics. Larger appliances, such as a clothes dryer, are usually 220 volts.

Appliance Valve - A hand-operated valve on the pipe connecting a gas appliance to a customer house line. Turning this valve will shut off gas to the appliance.

Array - A group of modules wired together in series to generate a greater amount of DC voltage. Arrays can be mounted in various locations on a building or adjacent to a building. Arrays will vary total size.

Backing Nut - The nut on a stopcock, located opposite the tang. This nut should never be loosened except in an emergency.

Combiner Box - The combiner box is used as a collection point for the many wires from the modules that are wired together (combined). The wires coming into the combiner box will vary in number depending on the number of PV modules in the array. Wires leaving the combiner box will generally be encased in electrical conduit on the way to the DC disconnect before the inverter(s).

Core - The cylinder inside a stopcock that allows or blocks the flow of gas. It is connected to the tang and rotated by turning the tang. It is held in place by the backing nut.

Curb Marker - The letter "G" painted or chiseled on a curb. It marks where a service line passes under the curb. It, also, indicates on which side of a structure a meter is located.

Curb Vault - A small concrete compartment containing an emergency gas shutoff valve that is usually located under a sidewalk or parkway. It is accessible through a removable lid.

Customer House Line - Gas pipe within a structure that is usually running inside walls and floors. It is the line from the meter to which appliances are connected.

DC Disconnect - The DC disconnect is the DC power shutoff. The DC disconnect is in line between the solar arrays and the inverter

DC Voltage - DC stands for "Direct Current." This means that the voltage or current maintains constant polarity or direction over time. DC is the kind of electricity made by a battery (with definite positive and negative terminals), or the kind of charge generated by rubbing certain types of materials against each other. DC electricity must be converted to AC electricity to be used for household appliances and electrical circuits.

Distribution Pipeline System - Part of the system that carries gas from large transmission pipelines to individual customers, which is sometimes referred to as a gas main. Normally, the pressure in these mains is between 40 and 60 psi.

Emergency Shutoff Valve - A gate valve with a wheel type handle located in a curb vault at a sidewalk or parkway. Turning the handle clockwise will shut off the gas to the structure. These valves are usually located at public assembly buildings, schools, churches, hospitals, and theaters.

Flash Point - The temperature at which ignition or explosion will occur. For natural gas it is 1100 degrees Fahrenheit. However, natural gas will only ignite when its concentration in air is between four and 14 percent.

Grid Tied - A solar PV system that can feed electrical power into the PG&E utility power grid.

High Pressure Leak - A leak in either a transmission line or distribution main. Only the Gas Company has the capability of shutting down these leaks.

Hydrogen Sulfide - A toxic gas that, on rare occasions, is present in leaks at natural gas compressor stations or at underground storage fields.

Inverter - The inverter converts incoming solar DC voltage from the modules to AC voltage before going to the building circuit breaker panel.

Line - In relation to a given switch or device, line refers to wires or voltage being "supplied" to it from "upstream" or from the direction of the Main Electrical Service Panel or power source.

Load - In relation to a given switch or device, load refers to wires (or terminals) that are "downstream" from or controlled by the switch or device. Another use of the term "load" is to refer to the energy "user(s)" along the circuit's path, such as a light or appliance. By providing resistance, these items limit current and, in the process, do useful things with that current.

Low Pressure Leak - A leak in a customer house line, on the outlet side of the meter, approximately 1/3 psi. Using a redwood plug, or even by pressing a finger against the leak, can temporarily stop such leaks.

Main - Gas pipe running under a street or parkway; part of the distribution system.

Management Representative - The Gas Company sends a liaison to the scene of a major gas emergency that remains until the hazard is eliminated. This person will maintain communication with The Gas Company, the Fire Department, the Police Department, and the public.

Master Meter - A meter that serves more than one unit, e. g., an apartment complex or mobile home park.

Migrating Gas - Gas from an underground leak. It may travel along pipes and rise through ground openings, or it may become concentrated in sewers and spaces under structures.

Meter Set Assembly (MSA) - This is the term The Gas Company uses to describe the meter and all the surrounding fittings, including the pressure regulator, the riser pipe, and the stopcock.

Module - A single aluminum-framed solar panel covered with tempered glass. Modules are sometimes referred to as panels.

Module Level Control - Solar PV components designed to improve overall PV system efficiency and safety. Increased safety is achieved by improving the ability to isolate a PV system to prevent accidental electrical shock.

Multiple Meters (Headers) - A row of meters connected to a common riser. Each meter is connected to a separate customer house line. These meters can be turned off together or individually.

Natural Gas Emergency - An incident involving a natural gas leak from a damaged pipeline or appliance.

Net Metering - Agreement between the utility company and the PV system owner to "bank" excess power produced by the PV system and to feed it into the utility power grid. The excess power used by the utility company is offset when the PV system owner needs to use power from the utility power grid when the PV system is not producing power.

Non-Sparking Mallet - The type of mallet that should be used to drive a plug into the end of a broken pipe. Wooden, rubber, plastic or brass mallets will not cause an igniting spark if they strike the pipe.

Odorant - Substances known as Mercapitan and Thiophene. They have a distinct odor that is added to natural gas. Since natural gas is odorless, this substance makes it possible to identify the presence of a leak.

Off Grid - A PV system not connected to the utility power grid. This type of system is otherwise known as a "stand-alone" system.

Photovoltaic Cell - A semi-conductor device designed to convert solar energy, produce by the sun, into DC electric power.

Plastic Pipe - An increasing number of gas distribution pipelines are made of plastic. Gas escaping from a break in these pipes can create a static electric charge. Fogging the pipe with wet water reduces this hazard.

PV - PV stands for Photovoltaic. Solar Photovoltaic Systems generate DC electricity from sunlight (photons).

PVT - Solar Photovoltaic and Thermal Systems generate DC electricity and solar thermal heating for water co-generated from sunlight.

Redwood Plug - Wooden plug that is driven into a broken, low-pressure, pipe to stop the flow of gas.

Regulator - A fixture shaped like a disc installed in the gas line, above the riser and before the meter. It reduces gas pressure to approximately 1/3 psi.

Rerouting - When there is a leak in a high-pressure pipeline, The Gas Company will shift the flow of gas into an alternate line. Because of the large amount of gas involved, it can take several hours for the gas to be purged from the damaged line.

Riser - A vertical pipe that carries natural gas from an underground service main to the MSA. It is the pipe on which the stopcock is located.

Service Line - The gas line that runs under a customer's property from the main, to the riser.

Stopcock - A gas shutoff valve located on the riser; occasionally referred to as a "service shutoff valve".

Tang - The grip on the stopcock. When its long side is turned crosswise to the riser, the flow of gas is stopped; if square, a raised line on the tang is turned crosswise when the flow of gas is stopped.

Transmission Pipeline System - Large size pipeline, up to 36-inches in diameter, used to move gas over long distances to local distribution areas. Pressure in such a pipeline can be as high as 1,000 psi

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