Massachusetts Department of Fire Services
Massachusetts Firefighting Academy

Liquefied Petroleum Gas (LPG) Awareness

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(LPG) Awareness

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1075 is the United Nations (U. N.) number used to identify Propane.1978, not commonly seen, is also used to identify pure (odorless) Propane. Pure Propane is commonly used as an expellant gas for items such as shaving creams and deodorants.

Where is it?

Some of the traditional things we associate with LPG.

Where is it?

Common LPG containers ranging from 1- pound plumber's torches to large storage tanks holding tens of thousands of gallons.

Where is it going?

Some of the new places we will be dealing with LPG. Many municipal fleets across the country are converting to Propane Auto gas. Not all vehicles will be as clearly marked. Lawnmowers and recreational vehicles may also cause access problems due to their location.

Properties of
LPG

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Composition

LPG is composed of both propane and butane

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Source

- LPG is a by-product of oil refineries
- Can also be found in gas and oil wells

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LPG is a by-product of oil refineries during distillation process of crude oil, but can also be found in oil and gas wells.

LPG Properties

COLOR
- Propane is colorless

ODOR
- Propane is naturally odorless
- Propane is odorized by adding Mercaptan

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Pure Propane (1978) is odorless. 1) Propane placarded 1075 is odorized with Mercaptan, and therefore will be detected by the sense of smell. 2) Pure Propane U.N. 1978 is odorless. As mentioned earlier it is used as an expellant as well as other industrial processes, therefore it is not odorized. The ONLY way to identify where vapors are is with a CGI.

Toxicity

- LPG vapors are non-toxic
- However, they are an asphyxiant

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Specific Gravity

- What is it?
  The weight of a liquid as compared to water
- Why is that important?
  - LPG's specific gravity is .509
  - LPG will float on water

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Like LNG, LPG wants to revert back to a vapor state when release from it's container.

Weight

- Liquid propane weighs approximately 4.4 pounds per gallon
- In comparison, water weighs approximately 8.3 pounds per gallon

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A little heavier than LNG but still roughly half the weight of water.

Vapor Density

- Why is Vapor Density?
  The weight of an airborne concentration of a gas as compared to an equal volume of air.
- Why is that important?
  - LPG's vapor density is 1.6
  - This makes it heavier than air

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Completely the opposite of LNG and NG these vapors will follow the contour of the ground and collect in low spots.

Expansion Rate

- The expansion rate of propane is 270:1
- This makes storing and transporting propane as a liquid is more economically sound

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Example: one 10,000 gallon road transport full of liquid equals 270 transports full of vapor

Temperatures

Boiling Temperature
- - 44° F

Ignition Temperature
- 920° F to 1120° F

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Compared to Butane at 32F, this is why Butane is used more in the south.

LPG Flammable Range

- 2.2% to 9.5%
- Can be rounded off to 2% to 10%
- Which would be potentially more dangerous, a lean or rich atmosphere?

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LPG Flame Spread

- Approximately 900 feet per minute
- Similar to Gasoline

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Compare this to LNG: Approximately 300 to 400 feet per minute. LPG flames spread twice as fast.

Storage Temperature

- Propane is stored at ambient temperature
- Ambient temperature is the temperature of the day
- LPG is kept in liquid form due to pressurization

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Storage Pressure

- At higher temperatures the pressure will be greater
- At lower temperatures the pressure will be less
- 120 PSI at 70°F

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Unlike LNG containers, LP tanks are NOT insulated…the one exception is LP railcars.

Transport Pressure

- Placing LPG in transport does not change the pressure
- Temperature is the factor affecting pressure

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Specific Dangers

- Flammable (2%-10%)
- Asphyxiant – will displace oxygen
- Frostbite (-44 degrees)
- Explosive – in confined spaces

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Combustible Gas Indicators

What do you have for meters? What the meters are calibrated to? Who calibrates the meter and when is it done?

Combustible Gas Indicators

CGIs, also referred to as “explosive meters” or “explosimeters,” are used to test atmospheres that may contain a sufficient concentration of combustible vapors to cause an explosion or support combustion

Combustible Gas Indicators

There are three different scales used on various CGI models:

- Percentage of lower explosive limit (LEL)
- Percentage of gas in air
- Parts Per Million (PPM)

The most common is the percentage of LEL meter

CGI Response

- A properly set low level alarm on a CGI meter is 10% of the LEL for the calibration gas
- The reason this percentage is fairly low is that it serves as a safety factor

CGI's and Oxygen

- Oxygen concentrations will effect meter readings

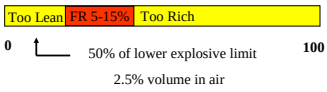
Oxygen is required for proper functioning of any CGI since oxygen is necessary for the combustion of the gas or vapor. Most instruments will not give an accurate reading at less than 10% oxygen.
Oxygen-enriched atmospheres will enhance the catalytic combustion process and may result in false high readings.

Instrument Operation

Combustible gases enter the instrument, diffuse through a coarse metal filter, and come in contact with two hot filaments inside the sensor. Both filaments are heated to the same temperature and, therefore, have the same resistance. One filament is coated with a catalyst. Combustible gases burn on this catalytic filament; no combustion occurs on the uncoated filament. Combustion causes the filament with the catalyst to increase in temperature, causing an increase in resistance. This change in resistance causes an imbalance in the resister circuit. The change in resistance across the circuit is translated into a CGI meter reading.

Combustible Gas Indicators

If a meter reading is 50% LEL, this would be equivalent to 2.5% vapor in air



Carbon Monoxide (CO) and Hydrogen Sulfide (H_2S) Meters

- These instruments utilize a detector that operates by chemical reaction with the gas
- Like the oxygen meter, these meters are subject to interference from other gases or vapors

Note that both these materials are measured in **Parts Per Million**. Remember that CO also has a wide flammable range.

Oxygen Meters

- Oxygen meters are used to detect the percentage of oxygen in atmosphere
- Most oxygen-sensing devices are calibrated to indicate concentrations between 0% and 25%

Note that when oxygen levels become too high, OR too low, that readings may not be accurate.

CGI

All CGI readings are relative to a calibration gas. When measuring another gas or vapor, the instrument still responds to the increased temperature of the filament

In order to know what the exact levels are you must know what your meter is calibrated to, and what the conversion factors are.

Conversion Factors

Combustible Gas/ Vapor	Correction factor when Instrument is calibrated on Propane	Correction factor when Instrument is Calibrated on Methane
Hydrogen	0.61	1.11
Methane	0.55	1.0
Propane	1.0	1.82
N-Butane	1.0	1.82
N-Pentane	1.22	2.22
Methanol	0.65	1.18
Ethanol	0.85	1.54
Ammonia	0.46	0.83
Toluene	1.57	2.86
Gasoline	0.85	1.54

This is an example of a partial conversion chart for a **PhD Ultra** combustible gas sensor. Many gas sensors are calibrated to Pentane. In order to get an accurate reading you must know what you are metering for. It is very important that students know what their gas meters are calibrated for, and where the conversion chart is located. A suggestion might be to make a smaller chart of the materials found in the student's response areas, and tape it too the meter itself.

Metering Considerations

- Confirm meter is reading properly in a non contaminated atmosphere
- Approach with full PPE
- When possible approach from uphill/upwind side

Metering Considerations

- Take readings both high AND low
- Consider the need for metering both inside and outside
- Establish operating zones based meter readings
- Do not rely on a single meter

B.L.E.V.E.

- Boiling
- Liquid
- Expanding
- Vapor
- Explosion

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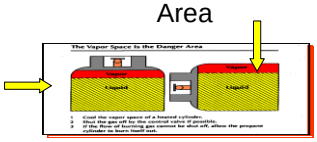
Typically associated with LPG, it does not have to be a flammable gas. Any container holding liquid above it's boiling point can bleve when exposed to fire or excessive heat.

The Vapor Space Is the Danger Area



- Cool the vapor space of a heated cylinder
- Shut the gas off by the control valve if possible
- If the flow of burning gas cannot be shut off, allow the propane cylinder to burn itself out

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The vapor space (regardless of the size of the tank) which is always at the top of a cylinder is the area of most danger. The liquid inside will absorb heat when heat is applied to the cylinder at the liquid area, but the vapor space has no such capabilities. The cylinder should be cooled with water when it is exposed to a heat source.

When to Anticipate a BLEVE

- Activation of PRV
- Sounds from PRV increase
- Pitch from PRV becomes higher or louder
- Space between flame and PRV increases
- Water hitting the tank turns to steam

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Quick decisions must be made.

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Bleve Update Video

Managing LPG Incidents

- The goal of any LPG incident is to control any vapors, prevent ignition and prevent a BLEVE from occurring.

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Extinguishing or Preventing Fire

The purpose of vapor control is to direct the vapor into an area YOU want it to go.

Another goal of vapor control/suppression is to dilute the gas concentration below its flammable range.

If a fire is present the intention is to keep the fire burning unless there is a confirmed life hazard and there is certainty the leak can be shut down.

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Fire hose streams are used to direct, control, and disperse vapors, just as with natural gas or LNG.

Extinguishment

- Extinguishing Agent: Dry Chemical
- Extinguishing Method: Stop the flow of gas

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Extinguishing the Fire

When using the dry chemical extinguisher the fire process is being interrupted simply by stopping the chemical chain reaction.

If the fuel amount is between the flammable range, oxygen is within range and there is an adequate heat source fire will erupt if the interruption of the chemical chain reaction is stopped.

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LPG In Storage

- LPG storage tanks are built to specifications based on their usage.
- LPG storage tanks will be built to specifications of either the Dept. of Transportation (DOT) or the American Society of Mechanical Engineers (ASME).

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LPG In Storage

- DOT storage tanks vary to their sizes.
- DOT tanks will be stored vertically.
- DOT tanks are referred to by "pounds." Example is a 20 lbs. tank on a grill.

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With propane weighing 4.4 pounds per gallon, the reference of the size of the cylinder determines the volume. Example of the 20 pound LPG cylinder on the grill will provide approximately 4.5 gallons of liquid propane. A 100 pound cylinder will provide approximately 20 gallons of liquid propane.

LPG In Storage

- ASME storage tanks vary to their sizes.
- ASME tanks can be horizontal or vertical.
- ASME tanks are referred to by gallons.

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Cylinder Capacities

- LPG cylinders are designed to be filled to approximately 80% capacity.
- The 20% vapor space allows for expansion of the product due to heat.
- Recent changes to the standards now provide for a safety device to prevent overfilling the container.

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Common D.O.T. Cylinders

- One pound
  - Hand torches, small camping appliances
- 20 pound
  - Recreational vehicles, grills, torches

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LPG cylinders can be everywhere. Think about the size of the cylinders and their locations. (For instance it is possible to find up to 200 full one-pound cylinders in a retail outlet.)
These are all D.O.T. cylinders which are normally transportable.
Should be hydrostatically tested every 12 years
Vapor or liquid feed may be determined by cylinder orientation, i.e. vertical / horizontal.

The 20 Lb Cylinder / Gas Grills

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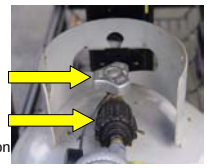
The biggest problem in the Propane industry is the “disrespect” of the 20lb cylinder.. Most people have propane in some form at their home. Almost everybody has one of these at home, in fact most people have more than one! In the off season where are the cylinders kept?

Safety Changes for Residential Use of LPG

- Changes to residential use D.O.T. cylinders:
  - Overfill Protection Device
- Changes to gas grills:
  - thermocouple connection (QRC)



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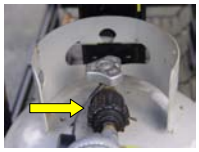
Improper use of LPG has brought about two major changes in regards to safety and LPG. The two changes are the OPD and the thermocouple connection.

20 # Valve Assembly

- Residential/Recreational connections of the 20 lbs. tank will be right hand thread



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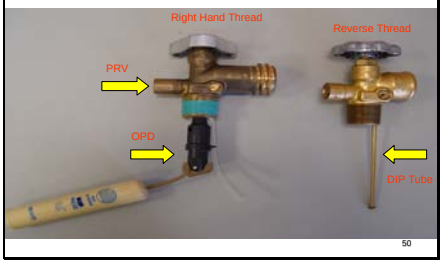
Quick **C**onnect **C**oupling/**Q**uick **R**elease **C**oupling.
Right hand thread, designed to be attached by hand (no wrenches required.) As the connection to the propane cylinder is made, the pin inserts into the valve assembly which pushes back the check valve allowing propane to flow. The plastic connector is designed to melt during a fire (240 to 300 degrees F) allowing the check valve to close which stops the flow of gas.

DOT Tank Valve Assemblies



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NOTE: This is a good example of the old style turn valve and the new style with the OPD. Also note that both valves are equipped with a dip tube which indicates 80% full when “spitter” valve is open. Previous filling techniques allowed the tank to be overfilled by keeping the “spitter” valve closed.

Composite DOT Cylinders

- Composite LPG cylinders should be treated the same as steel LPG cylinders.
- Tank is lighter, liquid level can be seen
- Composite cylinders are not prone to explosions but fail by melting.

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Have not caught on mainly due to higher cost.

Common D.O.T. Cylinders

- 33 - 43 pound
  - Industrial trucks (forklift / zamboni) may run on either liquid OR vapor
  - Connections of industrial use of LPG cylinders will be reverse thread

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Vapor or liquid feed may be determined by cylinder orientation, i.e. vertical / horizontal. Notice the industrial tank has a volume gauge and connectors for the liquid or vapor space.
Liquid will always be in the pick up tube.

Common D.O.T. Cylinders

- 100 pound
  - Residential, usually in pairs, tar kettles
- 200 pound to 400 pound
  - Residential or commercial applications

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Common D.O.T. Containers

1,000 - 14,000 Gallon
- Bobtail delivery and Road transports

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Even though these are referred to as containers because of their size, and are measured in gallons not pounds, they fall under D.O.T. specifications, because the are moveable.

Common D.O.T. Containers

30,000 - 40,000 Gallon
- Rail transports

55

Even though these are referred to as containers because of their size, and are measured in gallons not pounds, they fall under D.O.T. specifications, because the are moveable.

DOT Tank Safety Relief Valve Operating Pressure:

- 375 PSI for fixed use tanks
- 375-450 for tanks used in transportation

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20 lbs. tanks will have a 375 PSI setting. Forklift tanks may have a higher PRV setting.

Common A.S.M.E. Containers

500 - 5,000 Gallon
- Normally found in commercial applications

10,000 Gallon and above
- Storage facilities

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A.S.M.E.- American Society of Mechanical Engineers.
Note the change from pounds to gallons when changing from D.O.T. **cylinders** to A.S.M.E. **Containers.**

Safety Relief Valve Operating Pressure:

- A.S.M.E. Containers - 250 PSI

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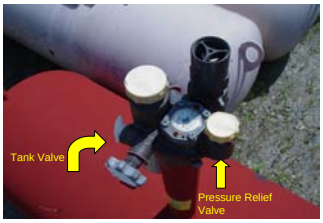
ASME Tank Valve Assembly



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NOTE: Red paint indicates underground tank

LPG in Road Transportation

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Road transportation is performed by a LP transporter/trailer or a Bobtail.

LP Gas Transports

- Over-the-road transporter. May be 10,000 to 14,000 gallons.
- Non insulated, single shell container.

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Landing gear of trailer is not intended to hold the weight of the product and the trailer.

LP Gas Transports

- Product is off loaded by a PTO pump capable of flowing 400 GPM.
- Loading and off-loading ports may be together at one location or may be separated between front and rear of the trailer.

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Controls and valves may be located in one caged area or positioned in tow areas. If they are separated, typically, the loading valves will be at the rear of the trailer and the off loading valves will be up towards the cab.

Emergency Shut Offs

Front

Rear

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Front shut off located on drivers side near the cab of truck. Rear shut off located on passenger side opposite corner by the rear axle. Shut offs may be either pneumatic or cable operated.

The Bobtail Delivery Truck

- Workhorse of the propane industry.
- Vary in sizes from 1,000 to 5,000 gallons.
- PTO pump capable of 60-90 GPM.

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The “Bobtail” is the “work horse” of the propane industry. It can be found anywhere in any community.

The Bobtail Delivery Truck

- Meter box and hose reel are areas for potential leaks.
- Typical hose reel is 1”in diameter and approximately 150’ long.

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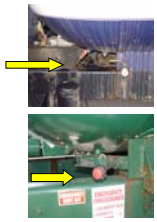
Common leak points are the meter box, flanges at hose reel, and connectors on piping.
Even after a small leak has been shut down, due to the size of hose and amount of hose there may be considerable delay in the releasing of the residual product.

Bobtail Emergency Shutoffs



- Manual shutoff behind cab on drivers side of truck
- In the event of an emergency will close the main liquid discharge valve or PTO

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The shutdown may be manual cable, pneumatic, or vernier throttle.

Bobtail Emergency Shutoffs

- Emergency shutdowns may also be located in the rear of the truck near the controls.

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Whether it is cable or pneumatic the shutdown procedures are the same. The shutdown activates the “slug valve” which stops the liquid from leaving the tank.

Bobtail Emergency Shutoffs

- Bobtails are now equipped with remote control shut offs.
- Device is activated by a garage door type control kept with the driver

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This system allows the driver to stop the flow of product in the event of an emergency from a safe distance. Box indicates antenna located at meter box.

Bobtail Emergency Shutoffs

- When the remote control is activated for emergency shutdown the PTO and the engine shutdown.
- Bobtails above 4,000 gallons requires a "Query" every five minutes to confirm delivery.

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On bobtails greater than 3,999 gallons, every five minutes an alarm sounds requiring the driver to confirm delivery is being made. If there is no reply the emergency shutdown mode is activated.

Bobtail Emergency Shutoffs

- Fusible link in cable can also shut down liquid valve in the event of a fire

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LPG Transporter Emergencies

- Often becomes multi agency incident.
- Each agency comes to the table with their own expertise.
- Safety is the #1 criteria in the mission to mitigate the incident.

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LPG Summary

- Vapors are HEAVIER than air and will collect in low spaces
- Liquid leaks are 270 times worse than Vapor leaks
- LPG is found EVERYWHERE!
- Structures or vehicles and there may be no placards.
- Protect yourself!

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EMS Patient Care

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Always perform EMS care according to appropriate standards

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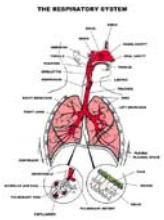
Always follow prescribed protocols

Respiratory Hazards



- Asphyxiation
  - Vapors mix readily with CO2 in the lungs, signaling the body to stop breathing
  - Extremely cold vapors may cause respiratory tract damage

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Respiratory Treatment

- Remove from hazard to minimize exposure
- Place on high flow O2
- Check lung sounds for signs of pulmonary edema

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Respiratory Treatment cont.

- If possible check SPO2 level
- Be prepared to support respirations if necessary
- Arrange for transportation to medical facility

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Frostbite

- LNG boils at minus 260 degrees F
- LPG boils at minus 44 degrees F
- Direct contact with skin will cause immediate loss of tissue

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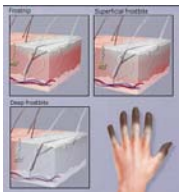
Frostbite Treatment

- Remove to safe area
- If possible elevate affected area to help minimize swelling
- Remove any clothing or jewelry in affected area



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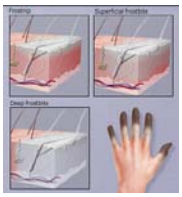
Frostbite Treatment cont.

- Cover area with dry gauze and use cotton to separate toes or fingers if affected
- DO NOT rub area in an attempt to rewarm
- Arrange for immediate transport to closest appropriate medical facility



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Burns

- There are several ways thermal burn injuries can occur when dealing with LNG, NG and LPG fires

  Direct flame contact
  Radiant heat
  Steam burns

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Steam burns often caused by perspiration trapped under firefighting PPE

Burn Classifications

- **First Degree**

  Is superficial and causes local inflammation of the skin. Sunburns often are categorized as first degree burns. Characterized by pain, redness, and a mild amount of swelling. The skin may be very tender to touch

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Burn Classifications

- **Second Degree**

Deeper into the tissue and includes blistering of the skin in addition to the pain, redness and inflammation

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Burn Classifications

- **Third Degree**

The deepest burn involving all layers of the skin, in effect killing that area of skin. Because the nerves and blood vessels are damaged, third degree burns appear white and leathery and tend to be relatively painless

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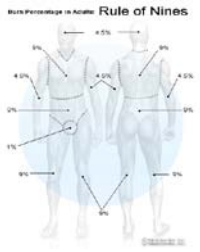
Determining Extent of Injury



Burn Treatment

First or second degree burns involving a small area of the body

- **Always ensure airway has not been compromised**
- **Gently clean the wound with lukewarm water**
- **Rings, bracelets, and other potentially constricting articles should be removed (edema, or swelling from inflammation may occur and the item may cut into the skin)**

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Burn Treatment cont.

First or second degree burns involving a small area of the body

- **The burn may be dressed with a topical antibiotic ointment**
- **Area may be covered with dry gauze.**
- **If there is concern that the burn is deeper and may be second or third degree in nature appropriate medical care should be sought, emergency transport if necessary**

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Burn Treatment cont.

Serious burns (second and third degree)

- Remove the victim from the burning area, remembering not to put the rescuer in danger.
- Remove any burning material from the patient.
- Always ensure airway has not been compromised.

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Burn Treatment cont.

Serious burns (second and third degree)

- Call 911 or activate the emergency response system in your area if needed.
- Once the victim is in a safe place, keep them warm and still. Try to wrap the injured areas in a clean sheet if available. DO NOT use cold water on the victim; this may drop the body temperature and cause hypothermia

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Burn Treatment cont.

Burns of the face, hands, and feet should always be considered a significant injury
(although this may exclude sunburn)

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Blast Injuries

A BLEVE involving an LPG storage container may result in both blunt force trauma and penetrating injuries

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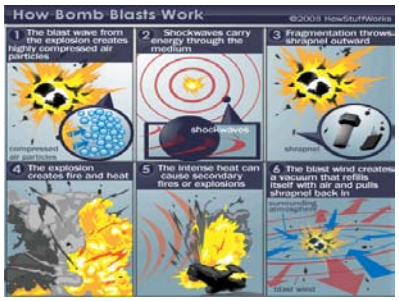

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Blast Injuries

- **Primary**

Injury from over-pressurization impacting the body surface

(blast wave)

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Injuries could include Tympanic Membrane rupture, pulmonary damage and air embolization as well as hollow viscus injury

Blast Injuries

- **Secondary**

Injuries caused by projectiles (shrapnel) which could include container segments and other flying debris

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Injuries may include penetrating trauma, fragmentation injuries and blunt trauma.

Blast Injuries

- **Tertiary**

  Injuries caused when the victim is displaced by the blast wind

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Injuries can include blunt/penetrating trauma, fractures and traumatic amputations.

Blast Injuries

- **Quaternary**

  All other injuries

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May include crush injuries, burns, asphyxia, toxic exposures and exacerbations of chronic illnesses.

Summary

- There are many ways flammable gases can cause injury
- Scene safety is the primary concern for emergency responders
- Proper body substance isolation (BSI) practices MUST be followed
- It is very likely that it will turn into a mass casualty incident (MCI)

Summary cont.

- Not all injuries will be readily apparent
- Rapid triage, treatment and transportation is critical
- EMS responders may be working side by side with other rescuers
- Post incident issues may need to be addressed