

## Recommendations for Emergency Action In Controlling & Prevention of Fire Involving LPG

The difficulties of controlling a fire involving LPG cannot be overstated. It is therefore of key importance to minimise the possibility of outbreak of fire by providing good plant design and layout, ensuring sound engineering and good operating practice, and providing proper instruction and training of personnel in routine operations and actions to be taken in an emergency. These emergency actions include those to deal with damaged plant and vessels, and unignited releases of LPG. However, such are the potential consequences of any outbreak of fire, that emergency actions also need to be developed and appropriate precautions provided to contain and mitigate the effects of an outbreak of fire.

These precautions include :

- Consideration of fire protection of plant;
- Water supplies;
- Fire fighting;
- Means of access for fire brigade appliances and alternatives where appropriate;
- Protection of fire brigade personnel;
- Arrangements to ensure an early call out to the fire brigade in the event of fire.

The local authority fire brigade will assume responsibility for tackling a fire upon their arrival. At larger installations it is important that there is prior discussion and liaison with them to ensure that they are familiar with the site and the site fire precautions arrangements.

The fire brigade can also assist in dealing with other emergencies, such as the setting up of water sprays, fog screens or water curtains to cool and safeguard approach to the plant, aid dispersal of LPG vapours and prevent their reaching vulnerable plant and ignition sources.

**NOTE: In the event of any incident involving an LPG vessel, please notify the Calor Emergency Number 0845 7 444999.**

### Personal Protective Equipment PPE.

Personal engaged in the emergency actions should be provided with the appropriate PPE. That recommended as good industrial practice for typical work activities on site will usually be adequate. For example:

- Natural fibre clothing, such as wool. For outer wear material which is fire retardant should be worn in preference to synthetic materials such as nylon which can generate static and increase the severity of burns in a fire;
- Gloves and eye protection should be worn to provide protection against cold burns from LPG escapes. Depending on the size of leak, suitable respiratory protective equipment may also be required;
- Protective footwear should be worn, ideally that is antistatic and which has no exposed steel tips on the soles and heels.

For personal who may be engaged in tackling fires, the clothing, including head-ware, should afford protection against thermal radiation and flames.

### Damaged LPG Plant or Vessels

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Any LPG plant or vessels that have been exposed to fire, or subject to severe mechanical impact; e.g. hit by a vehicle, or dropped, should be checked for damage. It is to be recognised that even though leaks may not be immediately present, they can subsequently occur, including potentially catastrophic failure and BLEVE. It is therefore, important that until the assessment can be carried out, to restrict access to the area and limit the pressure in the vessel by spraying with water. Where vessels are connected to other plant, the supply to the plant should be shut off.

### Unignited LPG Leaks.

- Leaks are normally identified by smell, noise or refrigeration (hoarfrost) at the source. Suspected leaks may also be detected by soapy water or a gas detector. A gas detector is especially useful for testing leaks in enclosed spaces such as inside a building. Where a gas detector is used, it is important that it is calibrated for LPG, that it is properly maintained and the person using it is competent in its use. **NEVER SEARCH FOR LEAKS WITH A NAKED FLAME.**
- Where leaks are known to exist, an urgent assessment should be made of volume of gas released by evaluating time and rate of discharge. Prevailing winds, total areas involved, the personnel or public at risk, and possible ignition hazards and effects should be studied, and an 'exclusion zone' specified. At the same time, every attempt should be made wherever possible to isolate or close the leak by non-flammable means. Because of the danger of incendiary sparking, cold working of ferrous or aluminium should not be attempted.
- All persons should be evacuated from within the exclusion zone, and entry prohibited. Every precaution should be taken to prevent ignition of escaping gas. If safe to do so, ignition hazards should be removed by shutting down boilers, extinguishing fires and naked lights (including pilot lights), switching off (at a point remote from the source of leakage) electrical equipment and switching-off vehicle engines. Motor vehicles in the designated exclusion zone should be abandoned and no attempt made to drive these away. Telephones in the exclusion zone, unless suitable for use in a potentially flammable atmosphere, should not be used.
- An immediate exclusion zone of at least that indicated in Table 1 should be established around any uncontrolled leak of LPG. This should be kept under constant review and the zone reduced or extended as circumstances dictate. Leaks of LPG, especially as a liquid, can remain flammable for considerable distances from the original source. This is significantly influenced by the weather conditions and topography of the site. These aspects should be taken into account in reviewing the exclusion zone.

Suggested Exclusion Zones (Table 1)	
Small vapour leak characterised by a 'smell of gas'	30m
Large vapour leak characterised by a loud 'hissing of gas'	100m
Liquid leak characterised by a 'roar of gas'	200m

- Wherever possible, escaping LPG should be shut off as soon as possible. In the case of a leak of gas, even if it cannot be stopped, much good can sometimes be done by directing water hose streams at the leak, to reduce the hazard of any ignition. If suitable water monitors are available, dispersal of gas may be assisted by water spray or heavy water fog screens, continuing until all liquid LPG has been evaporated and the vapour concentration reduced below the lower explosion limit. However, where the liquid spillage is large (for example at LPG terminals), application of

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water to the liquid pool is inappropriate, as the rapid vapourisation of the LPG this would cause, may result in the formation of a large cloud of flammable gas.

**NOTE:** Unless pools of liquid LPG are formed the operation of any liquid water deluge system on tanks should be initiated. Whilst this may not aid dispersal of unignited leaks, it prevents delay should the situation deteriorate and a fire develop.

- Dense water sprays and water curtains can be used to control the movement of vapour clouds and prevent their reaching vulnerable locations and ignition sources, which cannot be isolated.
- It is important that every endeavour should be made to cut off the LPG escape at the earliest possible moment, either by normal or emergency means. Where personnel could potentially enter a gas cloud for this or any other purpose, they should be wearing suitable personal protective equipment and breathing equipment and their approach under a heavy water fog screen or water curtain.
- Where the LPG leak occurs within, or enters a building, in addition to the precautions stated above the risk of ignition can be further reduced by purging with an inert gas or water spray.

Alternatively, the building should be thoroughly ventilated for several hours or longer, depending on size and construction. This may be assisted by the use of large air movement fans, such as those used by the Fire Brigade for 'positive pressure ventilation'. Wherever, an LPG leak has affected a building and especially any underground rooms, a suitable gas detector should be used to check that the atmosphere is safe. The responsibility should be with a nominated person, to declare the building is safe to re-enter.

**Ignited LPG leaks**

- With LPG fires the first concern should be to examine the possibility of cutting off the source of leakage, and secondly keeping other exposed equipment as cool as possible by water streams or fog curtains. Whilst small LPG fires can be extinguished with a Dry Powder Extinguishers, there is at present no known method, or extinguishing agent which will extinguish fires involving large volumes of LPG vapours. Such fires are impossible to blanket, and unless of reasonable proportions it is difficult to inert the area sufficiently to starve the fire into extinction. However, the application of water can reduce the thermal radiation from the fire.
- If the leak of LPG cannot be shut off at the source, and it is already alight, it is not necessarily advantageous to attempt to extinguish the flame, because of the risk posed by the potential accumulation of substantial quantities of LPG vapour and its subsequent re-ignition. If the LPG is burning, accumulation of LPG, with the consequential risks this will bring, will not occur. Even where the possibility of fire extinction exists, no attempt should be made to extinguish the flames unless:
  - it is known that the gas supply can then be immediately cut off and such action will be taken;
  - there is the danger that the existing fire may progress rapidly into an uncontrolled conflagration, which is deemed to pose a larger risk than the possible explosion of unburnt gases.

**NOTE:** Where burning off is taking place under controlled conditions, a method should be in place to be able to re-ignite the vapour should it be accidentally extinguished.

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- Exposure of vessels to heat will cause increased amounts of LPG liquid contents to vaporise, increasing the internal pressure within the vessel. As mentioned, the majority of vessels are equipped with a PRV to limit this pressure. This time for this to operate will depend on both the amount of heat falling upon the vessel and the total heat capacity of the vessel and its contents.

However, the temperature that a vessel needs to be warmed to for the PRV to operate is relatively low circa 55°C for butane and propane cylinder and 45 °C for a bulk LPG tank. For example, the PRV on a portable cylinder, exposed to a nearby fire, might operate within a few minutes; whereas, on a bulk tank, it could take many minutes before the tank and contents are sufficiently heated for the PRV to operate.

The purpose of the PRV is to prevent the pressure failure of the vessel. However, if the vessel walls become heated above a critical temperature (typically taken to be in excess of 300°C), then the vessel may fail resulting in a BLEVE. The main consequences of a BLEVE are thermal radiation; failure of the vessel producing missiles; and potentially, explosion over-pressure effects depending on the degree of confinement. The magnitude of these consequences is related to the volume of LPG involved. For example;

- A BLEVE of a 15kg cylinder may result in a fireball of about 14 m diameter, nominally lasting 1 second, with perhaps the cylinder being thrown some 10's of metres. It is to be noted, that the manner in which an LPG cylinder fails can result in the fireball occurring where the cylinder lands;
- A BLEVE of 25 tonnes of LPG in a bulk vessel could result in a fireball of over 170m diameter, lasting about 28 seconds and parts of the vessel being thrown many hundreds of metres. It is difficult to predict their direction, but for cylindrical tanks, the tendency is for missiles to be ejected along the nominal direction of the longitudinal axis of the tank.

A minority of small portable containers and especially cartridges are not equipped with a PRV. Therefore, if rupture of the container occurs, it is likely to be at a very high pressure, with the result that the container can be projected a considerable distance, ranging from tens of metres for cartridges to over several hundred metres for cylinders.

Similarly, where a vessel is upset so that the PRV is submerged in liquid or damaged, the resulting high pressure may cause a more intense force and vessel failure may result.

There is normally no warning when a vessel might fail, though if the PRV is operating, failure may well be imminent, especially if flames are impinging on the vessel. An increase in the pitch (frequency) of the PRV discharge is also an indication that vessel failure is about to occur. There are many factors, which influence when a vessel may fail, including size of vessel and the intensity of the fire. Essentially the smaller vessel and the more intense the fire, the faster it will fail. For example, a flashing liquid LPG jet fire impinging on a 2 tonne tank can easily bring about its failure within five minutes. Flames impinging from a hydrocarbon pool fire could result in vessel failure within perhaps, 10 to 15 minutes. In the case of fires near to a vessel, but without flame impingement, vessel failure, should it occur, is probably unlikely within a substantial period after this.

In the absence, or failure of the PRV, the times to vessel failure are likely to be significantly reduced.

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The purpose of mentioning these periods is NOT to establish a safe period for any Emergency Actions. Rather, it is to indicate the minimal time available to implement any Emergency Actions, where the priority should be given to ensuring that people are not exposed to any unnecessary risk in trying to undertake these.

Cooling the vessel and its contents will reduce the LPG vapour pressure and allow the PRV to shut. Once this is achieved, the likelihood of BLEVE is significantly reduced. Vessel cooling may be achieved by any of following means, or mixture of these;

- Spraying thoroughly and continuously with water over the entire vessel surface area, particularly on the upper areas.
- Extinguishing, or controlling the fire
- Creating a water curtain between the vessel(s) and the fire.

**NOTE:** A vertical curtain of water is effective in reducing the heat in a jet flame and tests have shown that a jet flame does not penetrate two water curtains placed in its path. Water curtains can be generated by using a plate on the end of a slotted branch. This produced a fan shaped curtain of water.

It is also necessary to ensure that the structural supports, or vehicle on which the vessel(s) are located are kept sufficiently cool to guard against their failure and consequent displacement of the vessel(s).

Consideration should also be given as to whether any other plant and equipment in the vicinity of a fire needs to be kept cool by spraying with water.

## Recommendations for Emergency Action In Controlling & Prevention of Fire Involving LPG SUMMARY OF EMERGENCY ACTIONS

### General

- In the event of FIRE call the Fire Brigade  
The Fire Brigade can also help in dealing with other emergencies, including cooling vessels and the dispersal of LPG.
- Establish an Exclusion Zone around the incident. Evacuate people from this to a safe location under cover, or shielded from incident plant.

### Damaged LPG Plant or Vessels

- Restrict access to the area, close available valves to isolate the plant and limit the pressure by spraying with water until the damage can be assessed.

### Unignited LPG Leaks

- Leaks may be identified by smell, noise or frost at the source
- Suspected leaks may also be detected by soapy water or a gas detector.
- **NEVER SEARCH FOR LEAKS WITH A NAKED FLAME**
- Isolate the leak (in the case of portable or moveable plant, move to a safe area if possible).
- Ventilate the building/area.
- For large leaks, assist dispersal of LPG gas and protect vulnerable plant and areas with water sprays.

### Ignited LPG Leaks.

- Cut off or reduce the supply of fuel, wherever possible.
- If safe to do so, deflect or move any flame from impinging on vulnerable plant.
- Before attempting to extinguish the flame, assess if the LPG will cause an explosion risk.

### LPG vessels threatened by Fire.

- Keep exposed surfaces of the vessels with cool water (monitors and/or fixed deluge system).
- Move the vessels where this is an option and it is safe to do so.
- Tackle fire and establish water curtain between it and vulnerable plant.

### Tackling the Incident.

- Carefully assess before any approach.
- Wear the right equipment, including clothing.
- Ensure safe route of access and egress is available.
- Approach any fire or escaping LPG from upwind.
- Avoid coming into contact with the LPG, it can cause severe cold burns and saturate clothing which may subsequently be ignited.
- Any vessel involved in a fire may suddenly rupture. Change in the size of the fire, or noise from the PRV may be an indication. But there may be no warning.
- **IF IN DOUBT DO NOT APPROACH.**