GUIDE 115 GASES - FLAMMABLE (INCLUDING REFRIGERATED LIQUIDS)

POTENTIAL HAZARDS

FIRE OR EXPLOSION

- **EXTREMELY FLAMMABLE.**
- Will be easily ignited by heat, sparks or flames.
- Will form explosive mixtures with air.
- Vapors from liquefied gas are initially heavier than air and spread along ground.

CAUTION: Hydrogen (UN1049), Deuterium (UN1957), Hydrogen, refrigerated liquid (UN1966), Methane (UN1971) and Hydrogen and Methane mixture, compressed (UN2034) are lighter than air and will rise. Hydrogen and Deuterium fires are difficult to detect since they burn with an invisible flame. Use an alternate method of detection (thermal camera, broom handle, etc.)

- Vapors may travel to source of ignition and flash back.
- Cylinders exposed to fire may vent and release flammable gas through pressure relief devices.
- Containers may explode when heated.
- Ruptured cylinders may rocket.

CAUTION: When **LNG – Liquefied natural gas (UN1972)** is released on or near water, product may vaporize explosively.

HEALTH

- Vapors may cause dizziness or asphyxiation without warning, especially when in closed or confined areas.
- Some may be irritating if inhaled at high concentrations.
- Contact with gas, liquefied gas or cryogenic liquids may cause burns, severe injury and/or frostbite.
- Fire may produce irritating and/or toxic gases.

PUBLIC SAFETY

- **CALL 911. Then call emergency response telephone number on shipping paper.** If shipping paper not available or no answer, refer to appropriate telephone number listed on the inside back cover.
- Keep unauthorized personnel away.
- Stay upwind, uphill and/or upstream.
- Many gases are heavier than air and will spread along the ground and collect in low or confined areas (sewers, basements, tanks, etc.).

PROTECTIVE CLOTHING

- Wear positive pressure self-contained breathing apparatus (SCBA).
- Structural firefighters' protective clothing provides thermal protection **but only limited chemical protection**.
- Always wear thermal protective clothing when handling refrigerated/cryogenic liquids.

EVACUATION

Immediate precautionary measure

- Isolate spill or leak area for at least 100 meters (330 feet) in all directions.

Large Spill

- Consider initial downwind evacuation for at least 800 meters (1/2 mile).

Fire

- If tank, rail tank car or highway tank is involved in a fire, ISOLATE for 1600 meters (1 mile) in all directions; also, consider initial evacuation for 1600 meters (1 mile) in all directions.
- In fires involving Liquefied Petroleum Gases (LPG) (UN1075), Butane (UN1011), Butylene (UN1012), Isobutylene (UN1055), Propylene (UN1077), Isobutane (UN1969), and Propane (UN1978), also refer to the "BLEVE – Safety Precautions" section.

EMERGENCY RESPONSE

FIRE

- **DO NOT EXTINGUISH A LEAKING GAS FIRE UNLESS LEAK CAN BE STOPPED.**

CAUTION: Hydrogen (UN1049), Deuterium (UN1957), Hydrogen, refrigerated liquid (UN1966) and Hydrogen and Methane mixture, compressed (UN2034) will burn with an invisible flame. Use an alternate method of detection (thermal camera, broom handle, etc.)

Small Fire

- Dry chemical or CO_2.

Large Fire

- Water spray or fog.
- If it can be done safely, move undamaged containers away from the area around the fire.

CAUTION: For **LNG - Liquefied natural gas (UN1972)** pool fires, DO NOT USE water. Use dry chemical or high-expansion foam.

Fire Involving Tanks

- Fight fire from maximum distance or use unmanned master stream devices or monitor nozzles.
- Cool containers with flooding quantities of water until well after fire is out.
- Do not direct water at source of leak or safety devices; icing may occur.
- Withdraw immediately in case of rising sound from venting safety devices or discoloration of tank.
- ALWAYS stay away from tanks in direct contact with flames.
- For massive fire, use unmanned master stream devices or monitor nozzles; if this is impossible, withdraw from area and let fire burn.

SPILL OR LEAK

- ELIMINATE all ignition sources (no smoking, flares, sparks or flames) from immediate area.
- All equipment used when handling the product must be grounded.
- Do not touch or walk through spilled material.
- Stop leak if you can do it without risk.
- If possible, turn leaking containers so that gas escapes rather than liquid.
- Use water spray to reduce vapors or divert vapor cloud drift. Avoid allowing water runoff to contact spilled material.
- Do not direct water at spill or source of leak.

CAUTION: For **LNG - Liquefied natural gas (UN1972)**, DO NOT apply water, regular or alcohol-resistant foam directly on spill. Use a high-expansion foam if available to reduce vapors.

- Prevent spreading of vapors through sewers, ventilation systems and confined areas.
- Isolate area until gas has dispersed.

CAUTION: When in contact with refrigerated/cryogenic liquids, many materials become brittle and are likely to break without warning.

FIRST AID

Refer to the "General First Aid" section.

Specific First Aid:

- Clothing frozen to the skin should be thawed before being removed.
- In case of contact with liquefied gas, only medical personnel should attempt thawing frosted parts.
- In case of burns, immediately cool affected skin for as long as possible with cold water. Do not remove clothing if adhering to skin.

In Canada, an Emergency Response Assistance Plan (ERAP) may be required for this product. Please consult the shipping paper and/or the "ERAP" section.

BLEVE AND HEAT INDUCED TEAR

BLEVE (BOILING LIQUID EXPANDING VAPOR EXPLOSION)

The following section presents important safety-related information on BLEVEs, including a table, to consider in a situation involving Liquefied Petroleum Gases (LPG), UN1075.

LPGs include the following flammable gases:

- UN1011 - Butane
- UN1012 - Butylene
- UN1055 - Isobutylene
- UN1077 - Propylene
- UN1969 - Isobutane
- UN1978 - Propane

A BLEVE occurs when a fire impinged or damaged tank car fails to contain its internal pressure and explodes with a sudden product release. This catastrophic failure is more likely to occur with damaged pressure tank cars, even in the absence of an active fire.

The **main hazards** from a LPG BLEVE are:

- Fire: If the released substance is ignited, there is an immediate fireball.
- Thermal radiation: At a distance of about 4 times the radius of a fireball, the heat radiated from a fireball is enough to burn exposed skin in 2 seconds. Wearing protective clothing limits the thermal radiation dose.
- Blast: A concussive force caused by the sudden release of the pressurized substance. For a BLEVE occurring out in the open, the blast strength at a distance of 4 times the radius of a fireball can break window glass and may cause minor damage to buildings.
- Projectiles: Tank failure can throw metal fragments over large distances. These fragments can and have been deadly.

The danger decreases as you move away from the BLEVE centre. The furthest-reaching hazard is projectiles.

For a video with information on critical safety issues concerning BLEVEs, please visit *https://www.tc.gc.ca/eng/tdg/publications-menu-1238.html*.

HEAT INDUCED TEAR (HIT)

A heat induced tear (HIT) is a rupture of a NON-PRESSURE tank car containing flammable liquids when exposed to the intense heat of a fire. The metal will soften and the pressure in the tank car will increase which can lead to containment failure. The tear generally occurs at the vapor space (upper side) of the container, venting large quantities of flammable liquid and vapors at high speed. A fireball and an intense heat wave will occur.

Compared to BLEVEs, HITs rarely result in the projection of tank car fragments. Heat induced tearing has occurred within 20 minutes of the derailment and as long as 10+ hours following the initial fire.

Responding to these types of incidents (BLEVE and HIT) requires specialized training, equipment and a tactical approach.

BLEVE – SAFETY PRECAUTIONS

Use with caution. The following table gives a summary of tank properties, critical times, critical distances and cooling water flow rates for various tank sizes. This table is provided to give responders some guidance but it should be used with caution.

Tank dimensions are approximate and can vary depending on the tank design and application.

Minimum time to failure is based on ***severe torch fire impingement*** on the vapor space of a tank in good condition, and is approximate. Tanks may fail earlier if they are damaged or corroded. Tanks may fail minutes or hours later than these minimum times depending on the conditions. It has been assumed here that the tanks are not equipped with thermal barriers or water spray cooling.

Minimum time to empty is based on an engulfing fire with a properly sized pressure relief valve. If the tank is only partially engulfed, then time to empty will increase (i.e., if tank is 50% engulfed, then the tanks will take twice as long to empty). Once again, it has been assumed that the tank is not equipped with a thermal barrier or water spray.

Tanks equipped with thermal barriers or water spray cooling significantly increase the times to failure and the times to empty. A thermal barrier can reduce the heat input to a tank by a factor of ten or more. This means it could take ten times as long to empty the tank through the Pressure Relief Valve (PRV).

Fireball radius and emergency response distance is based on mathematical equations and is approximate. They assume spherical fireballs and this is not always the case.

Two safety distances for public evacuation. The minimum distance is based on tanks that are launched with a small elevation angle (i.e., a few degrees above horizontal). This is most common for horizontal cylinders. The preferred evacuation distance has more margin of safety since it assumes the tanks are launched at a 45 degree angle to the horizontal. This might be more appropriate if a vertical cylinder is involved.

It is understood that these distances are very large and may not be practical in a highly populated area. However, it should be understood that the risks increase rapidly the closer you are to a BLEVE. Keep in mind that the furthest reaching projectiles tend to come off in the zones 45 degrees on each side of the tank ends.

Water flow rate is based on 5 ($\sqrt{\text{capacity (USgal)}}$) = USgal/min needed to cool tank metal.

Warning: the data given are approximate and should only be used with extreme caution. For example, where times are given for tank failure or tank emptying through the pressure relief valve – these times are typical but they can vary from situation to situation. Therefore, never risk life based on these times.

WARNING: The data given are approximate and should only be used with extreme caution. These times can vary from situation to situation. LPG tanks have been known to BLEVE within minutes. Therefore, never risk life based on these times.

BLEVE
(USE WITH CAUTION)

Capacity		Diameter		Length		Propane Mass		Minimum time to failure for severe torch	Approximate time to empty for engulfing fire	Fireball radius		Emergency response distance		Minimum evacuation distance		Preferred evacuation distance		Cooling water flow rate	
Litres	(Gallons)	Meters	(Feet)	Meters	(Feet)	Kilograms	(Pounds)	Minutes	Minutes	Meters	(Feet)	Meters	(Feet)	Meters	(Feet)	Meters	(Feet)	Litres/min	USgal/min
100	(26.4)	0.3	(1)	1.5	(4.9)	40	(88)	4	8	10	(33)	90	(295)	154	(505)	307	(1007)	97	26
400	(106)	0.61	(2)	1.5	(4.9)	160	(353)	4	12	16	(52)	90	(295)	244	(801)	488	(1601)	195	52
2000	(528)	0.96	(3.1)	3	(9.8)	800	(1764)	5	18	28	(92)	111	(364)	417	(1368)	834	(2736)	435	115
4000	(1057)	1	(3.3)	4.9	(16.1)	1600	(3527)	5	20	35	(115)	140	(459)	525	(1722)	1050	(3445)	615	163
8000	(2113)	1.25	(4.1)	6.5	(21.3)	3200	(7055)	6	22	44	(144)	176	(577)	661	(2169)	1323	(4341)	870	230
22000	(5812)	2.1	(6.9)	6.7	(22)	8800	(19401)	7	28	62	(203)	247	(810)	926	(3038)	1852	(6076)	1443	381
42000	(11095)	2.1	(6.9)	11.8	(38.7)	16800	(37038)	7	32	77	(253)	306	(1004)	1149	(3770)	2200	(7218)	1994	527
82000	(21662)	2.75	(9)	13.7	(45)	32800	(72312)	8	40	96	(315)	383	(1257)	1435	(4708)	2200	(7218)	2786	736
140000	(36984)	3.3	(10.8)	17.2	(56.4)	56000	(123459)	9	45	114	(374)	457	(1499)	1715	(5627)	2200	(7218)	3640	962