

Table 8.7.1 Biogas Facilities Accidents

Biogas Facilities Accidents				
Source	Date	Location	Description	Categories
eMARS	08/03/2019	EU	Release of biogas in a biogas plant caused by a digestate store overflowing. During the operation of the biogas plant, the digestate store in digestion section 1, consisting of solid material collection tanks, mixing containers, digester 1 and digestate store 1, overflowed. This led to the release of fermentation substrate via the gas pipelines of digestion section 1 into condensate duct 1. The biogas produced was discharged by means of an overpressure protection system. There was no release of fermentation substrate onto unsurfaced areas.	Biogas
eMARS	14/01/2019	EU	Release of methane at a biogas facility's digestate store. The event was triggered by a storm or strong gusts of wind. They led the roof foil to rupture and then, as a direct consequence, to tear off around the edge. As a result, the free-standing central support (wood) attached to the dome fell on its side and floated on the digestate. Other areas of the roof foil were then torn off.	Biogas
eMARS	16/03/2018	EU	Release of sewage gas from a sewage treatment plant. The emission was primarily caused by a failure of the programmable logic controller (PLC), following which (i.e. when PLC operation was restored) the gas users (CHP plants) were shut down. The amount of gas could therefore not be reduced, yet gas production was high. The gas holder, which was already almost full, could not therefore be used as a reservoir.	Biogas
eMARS	18/01/2018	EU	Release of biogas at a biogas plant as a result of high winds. Strong gusts of wind tore off the inflatable roof (damage probably originating from the joins on the membrane cover along the service shafts). Subsequently, the weatherproof roof and the gas accumulator membrane tore. There was no damage to the remaining gas holder structure.	Biogas
eMARS	29/10/2017	EU	Release of biogas in a biogas plant as a result of hurricane-strength gusts. Entire roof of a digestate store torn off by hurricane-strength gusts.	Biogas
eMARS	05/10/2017	EU	Release of biogas in a biogas plant. As a result of a storm with hurricane-force gusts, two inflatable roofs and gas membranes ruptured.	Biogas

Biogas Facilities Accidents				
Source	Date	Location	Description	Categories
eMARS	20/06/2017	EU	Release of methane at a biogas facility's digestate store. On 24 February 2017, work was being carried out on the biogas plant's electricity grid. The biogas plant has been provided with a connection for an emergency generator set. The filling level of the digestate in digestate store 3 is said to have been around one-third (approx. 1.80 m). However, this cannot be verified. The gas link between digestate store 3 and digestate store 4 was closed due to the damage that had occurred on 24 February 2017. During the work on the transformer (12:00 - 14:00), the electricity supply to the entire biogas plant frequently failed. The biogas still being produced in the three lines is compressed entirely by means of gas compressors for gas processing. Lines 1 and 2 have a gas interconnection via digestate store 1 and digestate store 2. Digestate store 2 has a storage function thanks to its inflatable roof with a flexible internal membrane. Without power supply, the outlet gas compressor for gas processing and the emergency flares do not work. The overpressure and under pressure protection of digestate store 3 and digester 3 were not able to release sufficiently the quantity of biogas produced during the power failure. According to the digitally documented measurements, the pressure in the system increased from 5% (approx. 0.5 mbar, 10:30) to an initial peak (30%, approx. 11:50) to 65% (approx. 3.9 mbar, approx. 14:00) before then the roof of the digestate store tore and the pressure fell again.	Biogas
eMARS	24/02/2017	EU	Release of biogas at a biogas facility's digestate store. As a result of the lower gas pressure and the prevailing squalls, the old roof tore. The raw biogas that was still present was released into the atmosphere and dissipated very quickly due to the strong wind.	Biogas
eMARS	31/07/2016	EU	Fire in a fertilizer warehouse of a biogas plant. A fire broke out in a fertilizer warehouse of a biogas plant at approximately 18.00 on 31 July 2016. The warehouse includes a storage room for dried digestate and a digestate drying process, including air scrubbing and a sulphuric acid tank required for this process. The fire in the digestate drying process resulted in the release of biogas as a result of the emergency flare being shut down so that the fire could be extinguished. In addition, the fire in the drying hall destroyed the acid tank and sulphuric acid leaked out.	Biogas
eMARS	14/06/2016	EU	Release of biogas at a biogas facility's digestate storage tank. The weather protection cover and holding membrane of the foil roof over the digestate storage tank developed a 10-metre-long tear from the point at which they attach to the container. It is presumed the system was experiencing unintended overpressure at the time.	Biogas

Biogas Facilities Accidents				
Source	Date	Location	Description	Categories
eMARS	10/06/2016	EU	Release of biogas and fermentation substrate in a biogas plant. On 10 June 2016 a foil covering on a digester of the biogas plant tore. About 3,700 m ³ of biogas escaped and about 750 m ³ of fermentation substrate leaked out. As the plant is surrounded by a wall and the containers are somewhat sunken, the fermentation substrate was completely retained within the site. All plant sub-installations are concerned, except for biogas processing and biogas injection. The site was secured. The operator separated all the containers from heating, feeding and gas pipelines. The flare, the biogas processing (BGP) and biogas injection were shut down.	Biogas
eMARS	25/10/2015	EU	Release of sewage gas from a sewage treatment plant. Blackout across the entire operational area. As a result, gas removal stopped while gas production continued, causing the maximum permitted pressure to be reached in the gas container. Therefore, as intended, the container's overpressure relief system (gas release) was triggered, resulting in depressurization.	Biogas
eMARS	19/03/2015	EU	Explosion in a fermenter at a biogas plant. An explosion occurred during repair work on a fermenter. The roof membrane was damaged and had to be replaced.	Biogas
eMARS	16/09/2014	EU	Fire at a biogas facility. Fire broke out at a biogas facility. The facility operator became aware of a fire in the control panel in the technical/pump room as a result of a mobile-phone alert. Initial attempts to extinguish the fire using an available fire extinguisher failed. The fire brigade was notified by the operator. The inflatable membrane cover of fermenter I adjoining the technical/pump room then caught fire. The fire brigade was able to prevent the fire spreading to the adjoining fermenter II. The gas storage membrane was damaged, however, and biogas was able to escape. The fire did not cause any explosion or deflagration. The fire resulted in the release of 500 m ³ of biogas and 10 m ³ of fermentation substrate. The other components of the installation (post-fermenters 1+2, fermentation residue storage containers, the CHP and the emergency flare) were not damaged. An emergency power supply was guaranteed. The closest residential area is situated approximately 400 m to the south-east of the biogas facility. The fire spread from the control panel in the pump room and spread upwards via the walls and ceiling of the room up to the gas storage membrane of fermenter I. An easterly wind helped the flames to spread to the gas storage unit of fermenter II. The gas contained in the gas storage units was combusted. A failure alert was generated on the operator's mobile phone.	Biogas

Biogas Facilities Accidents				
Source	Date	Location	Description	Categories
eMARS	03/10/2013	EU	<p>Biogas leak at an urban wastewater treatment plant. At about 16.30, a biogas detection alarm intermittently sounded in the control room of a large urban wastewater treatment plant, and the operator in charge transmitted the alert to the security station. Thinking that the alarm could be due to a problem with the sensor, a security guard equipped with breathing apparatus went to a manhole leading to the underground pipes that feed into the digesters for producing biogas, and confirmed that there was a pocket of biogas beside the sensor and also in two nearby manholes (100% of the lower explosive limit (LEL)). The site duty officer was alerted at 17.30 and, suspecting a leak in an underground pipe, he decided to shut off the sludge mixing booster and to mechanically ventilate the contaminated manhole shafts. The measure was lifted at 18.30 without the leaking pipe having been located, due to the tight network of underground pipes in the area. The investigation was resumed 72 hours later, and measures were taken to reduce the flow of the leak and secure the area during the investigation. This was successful after 60 hours, when a 4 cm hole was discovered at a depth of 4 m in cast-iron piping (DN 400, PS=18 mbar) connecting two of the plant's digesters to the gas holders. 24 000 m³ of biogas was lost as a result of the leak. Since they could not be shut down, the output of these digesters was reduced by shutting off the mixing, heating and intake of sludge; the biogas zone was sealed off and ventilation was set up near the leak. A sleeve was placed over the leaky section, which was secured until the complete shutdown of the digesters it fed into, and its output (18 500 m³ of biogas) was progressively released into the atmosphere through the release valves. A segment of the pipe collapsed during the work, rendering repair impossible. The section of pipe was then isolated using a reversible joint of the 'panhandle' type. The biogas network and the station's other digesters were then put back into operation. The two digesters in question were cocooned (with mixing once per week) pending the replacement of the broken section of pipe, causing a production loss of 5% or EUR 160 000.</p>	Biogas

Biogas Facilities Accidents				
Source	Date	Location	Description	Categories
eMARS	10/06/2010	EU	Explosion in a wastewater treatment unit at a pharmaceutical factory. The accident took place during hot work on the supply line to Tank TKX which contained spent stripped fermentation broth (SFB) from the production of antibiotics. This work was being carried out by a subcontract firm as part of a temporary modification to the wastewater treatment unit. There was a confined explosion of gas inside the tank which led to the roof of the tank being projected approximately 20 metres; the explosion killed one subcontractor and injured four other workers (three subcontractors and one company employee), all of whom were working on the modification. The SFB supply line had been emptied of wastewater coming from the distillery unit. The air vent of the tank, located on the roof of the tank, had been open as usual. The tank was approximately 50% full. Five workers were carrying out the work, four from the external firm and one from the company itself. The external workers had disconnected the SFB line by removing the shut-off valve on the entry duct on the roof of Tank TKX without closing it with the port's blind flange. One worker was standing on the roof of the tank near the open flange; the others were on the walkway giving access to the roof of the tank. They were beginning to cut the existing tube using a disc saw; sparks most likely produced by contact between the disc and the tubing ignited the explosive atmosphere which, unknown to them, had collected inside the tank. There was a confined vapour explosion (CVE) inside the tank which projected the tank roof approximately 20 metres. The shock wave threw the worker standing on the roof onto that of the adjacent tank, killing him; pieces of the tank roof fell onto the other four workers standing on the walkway; the connected tubing was also thrown a great distance.	Biogas
iChemE	01/07/2000	Lawrence, USA	An explosion occurred at an industrial plant, the second to have happened in a week. The explosion is thought to have occurred in the compressor building involving a pipeline containing hydrogen gas as workers were examining the system. It is thought there was approximately 12,000 pounds of gas in the system.	Hydrogen
iChemE	01/07/2000	Philadelphia, USA	A fire occurred at a refinery that produces cumene, used to manufacture plastics and synthetics. The fire occurred due to a leak of hydrogen from a ruptured pipeline, which ignited. The fire was brought under control within a few hours and fire fighters remained on site to make sure escaping vapours burned out safely. An investigation into the cause of the incident is being carried out.	Hydrogen
iChemE	02/02/2000	Mailiao, China	Three workers were asphyxiated when argon and hydrogen gas leaked from pipes they were installing on an aromatics plant being built on a cracking complex	Hydrogen
iChemE	08/04/1999	Florida, USA	A generator exploded inside a coal-fired power plant killing two workers and injuring fifty others. At least three of the injured suffered serious burns. An investigation into the incident found that a hydrogen gas leak may have caused the explosion. The explosion occurred as the generator was being tested following routine maintenance. The plant was shut down whilst investigations took place to make sure that none of the other generators were affected by the blast.	Hydrogen

Biogas Facilities Accidents				
Source	Date	Location	Description	Categories
iChemE	01/07/1998	UK	During an attempt to make 4-chloro-2-butyn-1-ol a serious explosion occurred. Although actual bodily injury was sustained by the person involved, who required 3 days in hospital, it is fortunate that the injuries were not more severe. The procedure used was a modification of the method to make 4-chloro-2-butyn-1-ol in which a stoichiometric amount of thionyl chloride was used without pyridine or solvent. It was assumed that the product was a mixture of starting diol, the required mono-ol and the dichloro compound. The violent detonation occurred during an attempt to separate the product by fractional distillation under reduced pressure. In the original preparation of this compound, the product is isolated by fractional distillation (50 degrees C, 0.5mmHg). No mention of explosion is made in the original reference. The dichloro compound and the diol are commercially available which reports a boiling point of 238 degrees C for the diol and 165-168 degrees C for the dichloro compound. No hazard of explosion is reported in the MSD compilations for the dichloro compound, however, for the diol it is reported that it decomposes violently when heated above 340 degrees C. The bath temperature certainly did not reach 340 degrees C in our distillation, but it is likely that it reached 180 degrees C.	Acetylene
iChemE	01/06/1997	Turkey	A shift supervisor received severe burns and later died after a flexible hose used to transfer hydrogen to the catalytic reformer was overpressured and caught fire.	Hydrogen
iChemE	01/05/1997	Tyneside, UK	An explosion and fire occurred in an acetylene store at a dockyard.	Acetylene
iChemE	10/07/1996	Yorkshire, UK	An explosion occurred in a hydrogen storage tank followed by fire	Hydrogen
iChemE	01/02/1996	California, USA	Explosion and fire occurred after a hydrogen gas pipe broke.	Hydrogen
iChemE	23/12/1994	Heerlen, Netherlands	A fire on one of two naphtha crackers reduced ethylene production by 40% for two weeks. The fire was brief but intense, following a release of naphtha, hydrogen and catalyst. Damage is estimated at US\$570,000 (1994).	Hydrogen
iChemE	06/04/1994	Oberhausen, Germany	A mixture of carbon dioxide and hydrogen escaping from a synthetic gas plant caused a fire. Fire extinguished in half an hour	Hydrogen

Table 8.7.2 Compressed Gas (Cylinder) Related Accidents

Compressed Gas (Cylinder) Related Accidents			
Source	Date	Location	Description
eMARS (000876)	20/08/2009	EU	A fire broke out at the Polyethylene DINA Petrokemija d.d plant. Polyethylene leaked from a high-pressure compressor during the regular production of low density polyethylene. This was caused by the presence of cracks on two cylinders valves of a second grade compressor. Approximately 80 to 100 kg of ethylene escaped through the cracks at a pressure of 2600 bar. The vapour then dispersed throughout the compressors room before igniting. At the same time, the safety program was automatically activated to stop the high pressure compressor and to vent the gases through pipes so to reduce the pressure. However the presence of fire ignited about 1200 kg of gas which was present in the pipes. The fire in the compressor room was extinguished within two minutes whereas the fire in the venting pipes was extinguished within 17-20 seconds. It took two hours to extinguish the fire on the cylinders until all remaining ethylene gas was released from the compressors and related piping.
eMARS (000389)	31/03/2003	EU	A metal fire broke out at a piston compressor causing material damages amounting to approx. 2 million euro. The incident began inside the cylinder on stage 3 (most heavily used) most likely via the piston in the top compression space. This is clear from the damage: dismantling of the system confirmed the first impression. A metal fire must then have developed inside which spread by exploding outwards having melted the top wall of the cylinder. The fire was then apparently further fed by the oxygen flowing back out of the pipes until the stop valve of the pipe system was closed manually. There was evidence that the piston in stage 3 had jammed (piston rod twisted). It is likely that this seizure was a result of the primary cause, i.e. the piston got stuck and the piston rod was twisted as a result of the continued running (or trail) of the machine. The presumed cause is that parts inside the compressor broke up or off and then gathered on the piston. These broken parts were then beaten against the cover of the compressor compartment and consequently became warped, or alternatively got into the gap between the piston and the cylinder liner (also possible for parts bigger than the width of the gap around the valve opening) and were ground there. Both of these processes produce friction heat which ignited the fire.

Compressed Gas (Cylinder) Related Accidents			
Source	Date	Location	Description
eMARS (000622)	27/12/2002	EU	In the isomerization unit a mechanical rupture in one out of two compressors occurred. The compressors, which were working in parallel and were operating at a pressure of 20 bars, were dedicated to conveying the gas mixture needed for the isomerization process. The rupture caused the release of a gas mixture containing hydrogen, which on coming into contact with air ignited forming a jet fire. The jet fire headed towards the adjacent benzene saturation (BenSat) section hitting the nearest equipment (a pressure vessel) located 14 m from the release point. Weakening of the BenSat structure, consequent release of benzene from these structures and extension of the fire, with substantial destruction of the section. The length of the jet-fire could not be calculated with precision because the flame hit against the nearby BenSat unit; if the jet had not been stopped by the BenSat unit, it could have had an estimated length of approximately 30 m. The accident source is the reciprocating compressor K-2901B operating in a pressure range of 15 to 21 bars, equipped with two cylinders sized to transfer hydrogen mixtures to the isomerization unit and to the BenSat unit.
eMARS (000798)	18/08/1998	EU	Leak on an acetylene cylinder and ignition of the gas.
eMARS (000713)	11/10/1990	EU	The accident occurred during a filling operation of a charge of 100 cylinders from an acetylene gas holder. The filling operation was started in the charging room at 07:00. The filling operation was proceeding smoothly without the operators observing anything unusual (an operator inspected the front of the racks at 09:00 and everything was normal). No particular action by the operators were taken immediately prior to the explosions. The first explosion occurred at 09:10 and the second 10-15 seconds later. Soon after, an operator switched off the electric supply system at the main switch. Part of the roof blew off, windows were blown out and part of the wall between the charging room and the electrical room collapsed. Fires broke out and further explosions occurred. 11 cylinders were either completely ruptured or partially opened. Deflagration or detonation occurred in the piping system and likely in the cylinders. Acetylene was released from the gas holder. This release was either due to continued gas production after the compressors were stopped or acetylene back flow from the high-pressure system where valves were leaking after their seats had melted. The local fire brigade was mobilized (32 firefighters involved) from Holbaek in extinguishing the fire. Cooling by means of water was continued for 24 hours before all the valves could be closed. Cylinders which have been exposed to fire were emptied outdoors.
iChemE (1293619)	01/07/2000	Willoughby, USA	A series of explosions and fires occurred at a plant. The explosion was caused by a spark or static electricity, which ignited gas leaking from overfilled cylinders. One person was injured in the incident. An investigation found that an estimated 900 of 1,1000 cylinders were leaking from safety relief valves. The building was evacuated.

Compressed Gas (Cylinder) Related Accidents			
Source	Date	Location	Description
iChemE (1248425)	01/04/2000	USA	An explosion occurred at a liquid petroleum gas plant killing one worker and injuring two others. The incident occurred in a gas bottle storage building at the plant whilst a gas tanker was being loaded. A cylinder was gassing off at the time of the explosion
iChemE (120801999)	01/10/1999	Unknown	A hyper ethylene compressor on a low-density polyethylene manufacturing unit, suddenly stopped with bang. This was due to the failure of the second stage front feed crosshead pin through-bolt which resulted in the fracture of both plungers of the front feed cylinders. The leaking ethylene was automatically diverted to the reactor enclosure through emergency vent piping. Damage occurred to the compressor. It is thought that the failure was due to problems resulting from replacement of the pin a year earlier.
iChemE (1114810)	01/06/1997	Turkey	A shift supervisor received severe burns and later died after a flexible hose used to transfer hydrogen to the catalytic reformer was overpressured and caught fire. Hydrogen is supplied from three modules each consisting of 12 x 1m ³ cylinders at 150 bar (2205 psig) pressure
iChemE (8217)	01/09/1995	East Rutherford, New Jersey, USA	Gas from an old compressed cylinder leaked and ignited. After the initial blast, several other cylinders containing unidentified gases also exploded.

Table 8.7.3 LPG Storage Accidents

LPG Storage Accidents				
No.	Date	Location	Description	Categories
1	19/09/2001	New South Wales, Australia	LPG bottles led to a series of explosions in an industrial estate. Firecrews responded after LPG bottles caused multiple explosions in an industrial estate.	LPG
2	14/09/1997	Visakhapatnam, India	A pipe carrying LPG from harbour to refinery leaked setting off an explosion that triggered a fire which engulfed 18 storage tanks. Seven tanks containing LPG and crude oil were completely destroyed. 100,000 people were reported to have left the area following the incident. All within a 500 metre radius of explosion were killed	LPG
3	01/07/1995	Yaroslavl, Russia	A fire at an oil refinery probably occurred due to a spark during maintenance work. Three out of four LPG tanks were destroyed and the fourth was expected to burn out shortly after	LPG
4	01/01/1995	Japan	Liquefied petroleum gas (LPG) leaked from a storage tank following an earthquake forcing the evacuation of nearby residents. The leak rate increased with subsequent aftershocks. An investigation into earthquake prevention measures found that the leak came from the piping system connected to the tank	LPG
5	15/08/1994	Unknown	When heating synthetic tar in a portable kettle to repair the roof of a maintenance shop. A worker draining tar from the kettle into a bucket noticed that the surface of the tar had caught fire in the bucket. As he moved backward, the handle stuck to his glove and the bucket tipped over, spilling the burning tar on the ground. The tap on the kettle did not close as designed, allowing additional hot tar to drain and causing the fire to spread. The fire engulfed the tar kettle trailer and an adjacent utility trailer that held a 100 litre liquefied petroleum gas (LPG) cylinder. When the LPG cylinder exploded, the end cap was hurled about 40 metres, causing a small grass fire. A second LPG cylinder in the vicinity vented but did not explode. One worker sustained first degree burns to his forearm from splattered tar. The site fire crew were called to the scene to extinguish the fire. Damage amounted to the total loss of the tar kettle, the adjacent utility trailer, and the two 100 litre LPG cylinders.	LPG cylinder
6	26/06/1994	A'amshite; Byblos Area, Lebanon	Explosion and fire at fuel storage and gas depot after LPG from overfilled cylinder, at a filling machine, was ignited by a road truck engine. Gas cylinders exploded. Fatality	LPG cylinder
7	05/08/1993	Guangdong, China	A fire and explosion at a warehouse spread to a storage tank at a nearby LPG storage depot.	LPG
8	07/01/1993	South Korea	A fire detonated LPG storage tanks in basement of 4 storey apartment block and levelled the building.	LPG
9	07/12/1987	Kuwait	Act of sabotage led to a fire in an LPG storage depot. Fire fighting was effective and safety devices functioned, preventing escalation to the storage tanks.	LPG

LPG Storage Accidents				
No.	Date	Location	Description	Categories
10	18/11/1984	Mexico City	A leak of LPG formed a vapour cloud which was ignited by a plant flare. A fierce fire developed engulfing the LPG spheres and bullets. , with 4 spheres and many bullets failing one after the other in a series of BLEVEs. 50 (out of 54) vessels were destroyed.	LPG
11	06/06/1983	Rhode Island, USA	30 tanks of propane exploded at an LPG storage facility.	LPG
12	21/01/1980	Barking, Essex, UK	Fire at a warehouse spread to LPG cylinder and numerous chemicals.	LPG
13	01/05/1979	Belgium	A release of LPG from a burst rail tanker resulted in an explosion at a railway station. The vapour cloud reached 300m by 400m and was ignited by overhead power lines when the train started to pull out of the station. The resulting explosion caused the tanker to rise 10m into the air and blew the manhole cover 100m.	LPG
14	15/09/1977	USA	An LPG storage vessel was overfilled due to a faulty level gauge. The relief valve failed to open and the vessel ruptured. The resulting vapours ignited leading to fires and explosions involving 2 other vertical tanks and 4 horizontal bullet tanks.	LPG
15	06/02/1977	Florida, USA	A train derailed and crashed into a LPG cylinder store, destroying 9 cylinders.	LPG
16	30/03/1972	Brazil	An LPG tank was being filled with relatively high temperature LPG which led the pressure to rise above the safe working pressure. The tank was fitted with only a single pressure relief valve (which failed) and a single drain valve. Operators were thought to have opened the drain valve. LPG was released and the drain valve froze, preventing it from being closed.	LPG
17	04/01/1966	France	Human error during the draining of water from an LPG sphere led to a resulting vapour cloud which spread until it reached a road and was ignited by a passing car. The fire spread back to the liquid pool that had formed within the bund, resulting in a BLEVE of the sphere. A BLEVE of a neighbouring tank and rupture of 3 other spheres then occurred.	LPG
18	01/10/1961	Kentucky, California	A substandard installation of a 1,000 gallon LPG storage tank fell from its concrete block foundation. This damaged the outlet connection and produced a vapour cloud that spread over a large area. After 15 minutes, the cloud was ignited resulting in an explosion.	LPG
19	13/07/1954	California, USA	The driver of an LPG delivery tanker had filled his tanks from a storage tank and drove away while the transfer and vent lines were still connected. LPG flooded the area and was ignited 10 minutes later. There were also secondary fires. The storage tank eventually ruptured.	LPG
20	27/01/1952	USA	A buried tank leaked into the surrounding earth through a threaded connection. 216 buildings were damaged as a result of the fires and explosion.	LPG
21	07/10/1950	Georgia, USA	A transfer line between an LPG tanker and 1000 gall storage tank broke at the tank. The vapours were ignited.	LPG

LPG Storage Accidents				
No.	Date	Location	Description	Categories
22	25/04/1945	USA	Escaping vapours from a 100 tonne LPG storage tank ignited.	LPG
23	18/06/1905	Zambia	A leak from an LPG storage tank, caused by human error, led to an explosion.	LPG
24	06/06/1905	Cleveland	A shrub fire spread to a chemical waste disposal site and caused a BLEVE of an LPG storage tank.	LPG
25	01/06/1905	Turkey	An LPG storage tank exploded at an oil refinery.	LPG
26	14/05/1905	California, USA	During the draining of water from a horizontal LPG tank, a connection failed and released LPG through a 1" hole. The cloud was ignited within a minute resulting in a fire that caused the failure of all six storage tanks on site within 35 minutes, some failing violently.	LPG

Table 8.7.4 Road Tanker Accidents

Road Tanker Incidents from the IchemE Database				
IchemE Ref	Date	Location	Accident Cause	Material
1247317	01/04/2000	Fayette County, USA	Collision causing rollover. Vapour release	Propane
1289824	01/04/2000	Gateshead, UK	An explosion occurred at an LPG plant in a gas bottle storage area killing one and injuring two others. The incident occurred during unloading of a road tanker.	LPG
1224307	01/03/2000	Basingstoke, UK	Tanker hit by another vehicle after breaking down. 20 out of 30 gas canisters exploded	Propane
122291999	01/01/2000	Australia	Approximately 10,000 litres of LPG escaped to atmosphere when the driver of a road tanker drove off without disconnecting the filling hose. Fortunately the gas did not ignite. Nearby residents were evacuated as a precaution	LPG
1222717	01/11/1999	Texas, USA	An explosion occurred on a liquid propane gas line. Two people were injured. The most likely cause of the explosion is thought to have been due to two passing trucks igniting a vapour cloud, which had formed from a leak in the pipeline.	LPG
1139913	01/12/1997	Taiwan	An explosion and fire destroyed an LPG tank and nearby gas oil and fuel oil pipelines. Cigarettes and a bottle of wine were found at the site	LPG
8842	14/09/1997	Visakhapatnam, India	A pipe carrying LPG from harbour to refinery leaked setting off an explosion that triggered a fire which engulfed 18 storage tanks. Seven tanks containing LPG and crude oil were completely destroyed. 100,000 people were reported to have left the area following the incident. All within a 500 metre radius of explosion were killed	LPG
1136915	01/09/1997	India	A leak of LPG occurred on a pipeline whilst unloading a marine tanker causing an explosion and igniting six storage tanks, some containing kerosene. The fire burned for two days and damaged 19 tanks, a two storey office block and five other buildings. The smoke caused the port to be shut down and 100,000 people evacuated.	LPG
8163	07/05/1995	Port Harcourt, Rivers State, Nigeria	Transportation. Gas supply interrupted by explosion on pipeline which carries liquefied petroleum gas (LPG). It was reported that the fatalities were saboteurs who were killed by the unexpected force of the explosion.	LPG
2482	11/04/1995	Edgeworthstown, County Longford, Ireland	A road transportation incident. A road tanker containing 20,000 litres of LPG came off the road at a bend into the village and ended in the front garden of a house. Gas leaked from the tanker and about an hour later ignited and destroyed the house.	LPG
6646	27/07/1994	White Plains, New York, USA	Collision with bridge support. Leak ignited. Explosion	Propane
5300	08/04/1991	Toronto, Canada	2 PRVs sheared off when passing through underpass. Vapour release	Propane
4721	21/09/1989	Baltimore, USA	Leak from tanker wedged under bridge. Vapour release. No ignition	Propane
4367	30/11/1988	Elkridge, USA	Tanker overturned	Propane
3272	01/04/1985	Dijon, France	Tanker crashed and caught fire	Propane

Road Tanker Incidents from the IchemE Database				
IchemE Ref	Date	Location	Accident Cause	Material
2351	02/01/1982	Italy	Highway collision in foggy conditions leading to tanker explosion	Propane
1939	28/12/1979	Briton ferry, Wales, UK	Valve on tanker froze open. Vapour cloud. No ignition	Butane
1735	07/09/1978	Hartburn Bank, Stockton, UK	Tanker overturned but no release	Butane
1698	27/07/1978	Harton, Yorks, UK	1te cylinder broke loose after tank stuck on verge. Valve fractured and leaked. No ignition	Propane
50	11/06/1941	USA	8.7m3 tanker involved in collision. Butane vapours covered large area. No ignition.	Butane

Table 8.7.5 Natural Gas Accidents

Natural Gas Facilities Accidents				
Source	Date	Location	Description	Categories
eMARS	07/05/2003	EU	<p>The accident occurred at a site falling within the scope of the Seveso Directive for the storage of gas but governed by the regulations of the Mining Code (regulating the underground storage of compressed gas)</p> <p>The estimate of the amounts of gas released is not precise for the time being (between 2500 and 25000 Nm³ of natural gas) but even considering the worst-case estimate, the amount released corresponds to less than 1.8 tonnes. In this case the accident is classified at level 3 of the accident gravity scale, as officially published in February 1994 by the Committee of Competent Authorities for the implementation of the Seveso Directive applying the criteria on amounts of substances (1% to 10% of the upper threshold).</p>	Natural Gas
MHIDAS	25/06/2001	Kazakhstan	Corrosion. Six metres of a one metre diameter pipe was thrown forty metres in the blast. Corrosion of the pipeline is thought to have led to the leak that caused the blast. Fire quickly extinguished and supplies resumed through an alternative pipe after three hours.	Natural Gas
MHIDAS	10/04/2001	USA	Mechanical failure. Residents were evacuated for about three hours after a volatile gas cloud formed over a natural gas facility. The source of the leak was tracked down to a section of pipe, which was repaired.	Natural Gas
MHIDAS	28/12/2000	Canada	Explosion at a natural gas pumping station rattled windows 1.5 miles away. There was no rupture of the pipeline itself and the cause of the incident remains unknown. One man severely injured and gas pressure to customers affected	Natural Gas
MHIDAS	28/05/2000	Canada	Mechanical failure. A section of the forty two inches pipeline ruptured during pressure-testing of the pipe.	Natural Gas
MHIDAS	18/11/1998	UK	Workmen caused a main gas pipeline to fracture, sending a 30 ft plume of gas into the air. Local residents were evacuated and roads sealed off. It was several hours before the pressure had dropped enough for the pipe to be sealed off. No one was injured.	Natural Gas
MHIDAS	14/08/1998	USA	Lightning strike set fire to a natural gas compressor station. The resulting explosions sent a fireball 600 ft into the air. Five people were injured. Gas supplies to the whole of the Florida peninsula were shut off. Residents within two miles were evacuated.	Natural Gas

Natural Gas Facilities Accidents				
Source	Date	Location	Description	Categories
MHIDAS	02/04/1998	Russia	The metering unit of the natural gas distribution station was rocked by an explosion. A fire also occurred.	Natural Gas
MHIDAS	27/06/1997	USA	Gas escaped from a pipeline when equipment being used to take a metering station out of commission fractured a valve. No injuries were reported. People within a mile of the rupture were evacuated. No fire or explosion occurred.	Natural Gas
MHIDAS	18/12/1995	Russia	Section of pipeline exploded due to high pressure in pipe.	Natural Gas
MHIDAS	19/03/1995	USA	Thirty six inches gas pipe ruptured. Leak caught fire & damaged reported 300 ft section. Gas rerouted to two parallel lines	Natural Gas
MHIDAS	29/07/1993	UK	1,000 workers were evacuated as building contractors ruptured a mains pipe sending 40 ft gas into the air. Roads were sealed off for about an hour while the leak was brought under control.	Natural Gas
MHIDAS	18/05/1989	Germany	Repairs to product pipeline possibly caused explosions/fires which destroyed refinery pumping/mixing station. Blaze burned for four hours as fire fed by 100 tonnes of fuel leaking from broken pipe system.	Natural Gas
eMARS	10/10/2012	EU	The explosion occurred on 10 October 2012, just before midday, when the unit was being restarted. Earlier that morning, we had switched over to oil fuel in order to scan for defective non-return valves on the water-injection purging circuit. A transfer from natural gas to oil fuel takes place every 15 days in the period mid-October to March to prevent problems with fuel solidifying in ducts due to colder external temperatures. After the test we switched back to natural gas and proceeded to restart the unit at approximately 11:48. During each start-up, the gas valves (regulating valve SRV and on off valves VS4, GCV1, GCV2 and GCV4) are tested for tightness. The test did not detect any problems. We therefore proceeded with the start-up by opening the gas supply and activating the spark plugs. At approximately 11:58, excessive vibrations were detected, corresponding to the time of the explosion (methane deflagration) in the boiler. This triggered the shutdown of the gas turbine and the whole unit.	Natural Gas

Natural Gas Facilities Accidents				
Source	Date	Location	Description	Categories
eMARS	13/10/2008	EU	Explosion and fire caused by an unexpected and incidental flow of unburned Syngas in the room of the waste-heat boiler of the "Module 1" unit, for a wrong operation during the procedures of stop and purging for the maintenance of the turbogas (TG) of "Module 1". The operation was controlled by subcontracted person and directed and coordinated by a shift head in the control room.	Natural Gas
ARIA	15/11/2007	USA	An explosion occurred at around 11.30 am in a natural gas treatment facility. It resulted in four injuries, two of them were severe.	Natural Gas
ARIA	23/09/2002	USA	In a natural gas treatment facility, a flash fire like event occurred in the central part where the raw natural gas is washed to remove impurities. Four of the nearby employees are injured, three suffered severe burns and intoxication.	Natural Gas
ARIA	28/05/2000	Canada	A forty two inches pipe transporting natural gas ruptured during a pressure test. Authorities indicated that the gas inlet was promptly shut down; environmental effects were therefore assumed to be zero.	Natural Gas
ARIA	04/01/1999	USA	In a substation of a natural gas pipeline, a leakage led to an explosion and a fire destroying a house and workshop. The incident, visible from thirty kilometres was taken care of by firemen and controlled within four hours. Two firemen suffered mild injuries.	Natural Gas
ARIA	08/02/1997	USA	A leakage occurred on a natural gas pipeline of 660 mm diameter. The gas cloud exploded and a 100 m high flame occurred. Nearby houses were shaken by the deflagration	Natural Gas
ARIA	01/01/1997	Turkey	A natural gas leak occurred on a badly closed valve on a pipe (pressure= 20 bar). This incident led to death by asphyxiation of the two employees who entered in the room, one equipped with an inappropriate mask and the other without equipment.	Natural Gas
ARIA	22/11/1995	Russia	An explosion followed by a fire occurred on a 0.5 m diameter natural gas pipe. Corrosion is at the origin of the accident. 240 m of pipes were destroyed.	Natural Gas

Historical Accidents related to Naphtha

A review of the MHIDAS database for historical accidents pertaining to Naphtha storage and transfer was carried out. The causes of the historical accidents is summarized in Table 8.7.6.

Table 8.7.6 Historical Accidents associated with Naphtha

Hazardous Events	Cause
Tank Fire	Earthquake, Fire escalation, lightning
Bund Fire	Spillage/Pipe Leakage and subsequent ignited
Pool Fire	Tank/Pipe Leakage or Spillage and subsequent ignited
Release but not ignited, bund contained	Earthquake lead to tank rupture

Hazards identified with Naphtha

Failures of gas facilities are subject to various initial events as shown in Table 8.7.7

Table 8.7.7 Hazards associated with Naphtha

Location	Categories	Potential initial events
Naphtha Filling line	Loss of containment	Naphtha leak from filling piping
Gas Plant – Naphtha Storage Tank	Loss of containment	Naphtha leak from tank Naphtha leak from pipework
Gas Plant	Loss of containment	Naphtha leakage

Table 8.7.8 Table C3 Hazards associated with Towngas

Location	Categories	Potential initial events
Gas Station Gas Plant – Reforming Process Gas Plant - Pipeline	Spontaneous failure	Pipeline failure Process vessel failure Pumps Failure
	Partial failure	Process vessel leakage Pipeline leakage Blown seal

Failure of a process vessel can be cold catastrophic failures and pipeline failures are line ruptures. These may occur due to thermal and pressure loading, material or construction defect leading to instantaneous release of Towngas. In cold partial failure, it results in continuous release of Towngas to the atmosphere through a crack or leak.