Step into our TestSafe Time Machine and revisit some of the amazing things that we have done over the years.

North Ryde Gas Explosion

Terry McKay, Assistant Principal Inspector, Hazard Management Group

In May 1997 a plumber's van was destroyed by a violent explosion in the early morning after standing overnight in a Sydney suburban street. The force of the blast tore apart the metal panels and framework from the outside of the van. The rear door landed 45 metres away. A typical plumber's ladder mounted on top of the van was thrown 50 metres, damaging the roof of a house in an adjacent street. The tradesman was killed by fragments from the vehicle as he was standing at the van, preparing to open the door. A small burnt out propane cylinder was found in the wreckage.

WorkCover Inspector (left) Frank Gilbert at scene of fatality

The explosion also sent shock waves throughout the plumbing trade where there had been in recent years , large scale conversion from open utilities to enclosed vans in order to secure their essential equipment and tools.

WorkCover's subsequent investigation concentrated on the physical chemical aspects of detonation of small amounts of flammable gas, whether any circumstances could have caused the propane to leak from the equipment and what ignition sources may have triggered the blast. This included investigating whether light switches on doors, a mobile phone, lighting a cigarette, static electricity, the ignition switch, activating the central lock system or deactivating the security alarm system may have initiated the blast.

Tests carried out at TestSafe Australia at Londonderry significantly confirmed that many components of the van's central locking system could ignite propane/air mixtures.

Officers from a nearby fire station, among the first arrivals at the scene, found that an acetylene cylinder and a portable propane cylinder (both dangerous goods Class 2.1 Flammable Gas), as well as an oxygen cylinder (Class 2.2) had been stored in the van.

They examined the condition of the valves on both the part-filled oxygen and acetylene cylinders which were strapped together on the end of an overturned steel storage shelf unit that layed on the ground at the rear of the wreck. They discovered that the valves were not open, were not leaking and still contained substantial gas under pressure. The propane cylinder, discovered in a demolished tool box behind the burnt seat frames, was empty.

Police Crime Squad experts carefully examined the wreckage and found no evidence of prepared explosive substances or fragments from any detonating device.

The Coroner, Mr. Hand, fortuitously was driving to his court chambers in peak hour traffic nearby and was able to divert and arrive at the scene shortly after for a timely inspection.

During the investigation by Inspectors Frank Gilbert and Terry McKay it became clear that the portable LP Gas cylinder of 0.34 kg capacity, was loosely attached to a hand-held brazing torch of a type commonly used in the plumbing, gasfitting and electrical trades. It was located behind the burnt-out cargo barrier frame on top of the remains of a metal tool box which contained burnt portable drilling equipment and larger mechanical tools.

The cylinder and torch, along with the remains of the tool box, the other equipment and combustible materials at the front of the van, had been damaged by the fire which followed the blast in the forward part of the wreckage. There was no residual propane in the cylinder. All the elastomer seals and o-rings in the torch and cylinder unit had been partially destroyed by heat.

Several small (500 mL) screw-cap cans part-filled with liquid adhesive, stored in the metal shelf racks inside the van, were found near the wreck. They had been squashed into an 'hourglass' shape by the explosion. In order to estimate the source blast pressure in the van one of the 'witness cans' was compared with identical new cans which had been subjected to controlled LP Gas explosive effects at the TestSafe explosion testing facility.

The 'witness can' comparison tests indicated that the actual pressure reached in the van blast could have exceeded 450 kPa (4.5 atmos or 4.5 bar pressure).

Many investigations of the combustion of propane have been documented which describe confinement conditions under which a *deflagration* may become a *detonation*, causing massively increased internal overpressures and consequential devastating explosive effects. Overseas researchers have documented a range of circumstances under which propane/air mixtures can detonate. These include blasts which may commence with a *deflagration* process, developing pressure loads of zero to several atmospheres, which then activate *detonation* throughout the remaining mass of flammable gas, generating sudden high pressure loads in the order of 50 atmospheres.

There was a substantial coverage of the incident by the media. Close-up photographs of the remains of the brazing torch on the propane cylinder were included in newspaper and television reports. As a consequence, several tradespeople contacted WorkCover to report their experience with similar units in their possession that had leaked after closing off gas flow.

There were at least two ways in which the brazing torch unit on the propane cylinder in the toolbox may have accidentally released LP Gas.

- the swivel-mounted burner nozzle, if impacted by a heavy tool or if inadvertently dropped into the tool box, may have provided added rotational leverage to disturb the O-ring seal where the torch was connected to the cylinder, allowing LP Gas to leak from the connecting collar of the cylinder.
- a rotational impact on the control knob of the torch may have re-opened the knob from its closed position, allowing propane to leak through the mixing jet in the turbo-burner nozzle and deliver a heavier-than-air gas mixture into the van at an optimum flammable concentration.

Other specimens of various models of the same hand-held torch units were handed in to WorkCover by members of the public who had recognised the burnt unit recovered from the wreckage displayed through the press reports of the incident. Some of these and other specimens of 'damaged' return units provided voluntarily by their NSW marketing agent exhibited various degrees of leakage of LP Gas when examined at TestSafe .

The units were tested by fitting them to a 0.34 kilogram Primus cylinder part-filled with propane and then immersing in water. A graduated glass cylinder was used to collect and measure any leakage observed.

Selected specimens were subsequently dismantled in the mechanical services workshop at Londonderry with the assistance of TestSafe Technical officer, Paul Tilbury. The elastomeric seals located in various components were examined for signs of operational deterioration.

TestSafe's Paul Tilbury testing the brazing tool

Whilst the number of specimens examined was insufficient to form any conclusive opinion of the effectiveness of the design of the several different models of the torches in the group tested, it was noted that the O-ring seal at the base of the torches was the component which most commonly showed signs of cracking and cutting under pressure or through frequent use. This O-ring is intended to maintain a leak-proof seal when a torch control unit is screwed into the self-seal connection valve of a Primus propane cylinder containing liquefied propane, typically at a constant pressure of 750 kPa.

Spare or replacement O-rings of the correct composition for use in LP Gas service were evidently not provided by the importer of the torches, resulting in the strong likelihood that plumbers regularly using this equipment might inadvertently replace a worn O-ring with a commonly accessible O-ring of a type of rubber composition suitable for water tap service. This grade of rubber is not intended for propane service as it rapidly deteriorates in contact with propane, thus providing the potential to unexpectedly (and suddenly) release flammable gas around the connection point.

Investigation at TestSafe of Assembled parts involved in the explosion

There were no witnesses to the incident who could describe what action the deceased may have actually performed that could have ignited the flammable vapour cloud inside his vehicle.

As a result, several scenarios and corresponding ignition sources, as set out below, were carefully considered for their likelihood of involvement in the sequence of the ignition. TestSafe engineers took into account possible spark energies as low as 96 microJoules, capable of igniting a test atmosphere of 5.2% propane in air, according to procedures outlined in Australian Standard AS 2380.7-1987, *Electrical equipment for explosive atmospheres - Intrinsic safety* .

Spark from light switch on the door

- A spark would not have been likely to occur on making firm metal-to-metal contacts for a non-active part of the vehicle circuit (ie light off, no current across contact prior to switch closure) on opening a door. Closing a door, however, with an interior light already on, could generate a small but “weak” spark at the switch as the contacts opened.

Mobile phone spark

- No sparking likely to occur at the aerial due to the relatively low energy of the radio transmissions, although a possibility exists that operating an unsealed switch or dropping a phone and dislodging its battery could result in a spark in a hazardous area containing flammable vapour (for instance whilst filling a car with petrol at a service station).

Lighted cigarette or lighting a cigarette

- A lighted match or a gas cigarette lighter were not likely to have caused this incident, unless the door had been opened, exposing a flammable concentration of gas to a cigarette lighter spark or flame, or unless the driver had entered the van and closed the door before using a lighter. Evidence showed the door latch was closed at the time the blast destroyed the door. The final position of the driver’s body across the street and the extent of injuries indicated that he had most likely been standing just outside the door as the blast occurred.

Static spark to door lock from hand-held key

- Sufficient spark energy can be generated but not likely in this particular incident, for the same reasons as above.

Turning on ignition

- Sufficient spark energy exists at unsealed contact components but not likely to have caused this particular incident, as the above evidence indicated that the driver had not entered the van.

Deactivating the security alarm system

- Not likely, as the unit was fitted under the kerb-side seat in the front compartment, although containing at least one component capable of generating incendive sparking, appeared to be enclosed within a vapour-tight case. The unit was capable of being operated by a remote hand-held radio key from outside the van. When installed, the system had not been linked to the central locking circuit.

- Alarm components were examined that were similar to those in the unit originally installed in his van by the tradesman. TestSafe examined these in an enclosed unit for intrinsic safety performance in accordance with the requirements of AS 2380, *Electrical equipment for explosive atmospheres – Explosion-protection techniques*, Part 7, *Intrinsic Safety* and found they presented negligible risk of igniting propane vapour, even though not originally designed or built for use in flammable atmospheres.

Activating the central locking system

- Highly likely, as the control relay unit under the front dashboard could project an incendive spark at internal contacts and simultaneously activate substantial spark sources at the commutator contacts of the small 12 volt electric motors fitted inside each of four exterior door locking mechanisms. The system could have been operated from outside the van with the door/ignition key.

- Detailed evaluations of the electrical characteristics of components of the central locking and remote control door entry system used in the Toyota van were carried out at the TestSafe laboratories. These showed that several switching and motor components of the system are capable of generating sufficient spark energy to ignite a flammable atmosphere mix of propane and air.

The NSW State Coroner held a formal Inquest into the incident on Wednesday 20 January 1999.

> *" FINDING: I find that on 30 May, 1997, at* [the stated location]*,*
> [the name of victim] *died of the effects of multiple injuries sustained then and there when a portable propane cylinder with a turbo torch and stored inside the deceased's motor vehicle, exploded, but what was the ignition source of the cylinder the evidence does not enable me to say.*
>
> ***RECOMMENDATION TO THE MINISTER FOR INDUSTRIAL RELATIONS***
>
> *A Working Party comprising WorkCover, Australian Liquefied Petroleum Gas Association, Road Transport Authority and any other interested party (as recommended by WorkCover) be established to investigate and consider the proposals submitted in this case.*
>
> *The Working Party should consider safety issues in the carriage of small gas cylinders, the storage within and the specific design of vehicles used for the carriage of such cylinders and the sale and packaging of the types of cylinder devices and attachments for these and similar cylinders.*
>
> *(D.W. Hand)*
> *State Coroner.*
> *20th January, 1999."*

WorkCover responded to the State Coroner's request at an early date. A Working Group was convened as requested and an extensive report on a range of issues arising from the incident was prepared that set out a number of recommendations that WorkCover and other agencies should consider implementing, with a view to preventing such incidents from recurring if at all possible.

Several initiatives arising from the Working Group Report have included the publication of a detailed Dangerous Goods Fact Sheet DG253, "*Transporting Small Gas Cylinders In Vehicles - Trade And Domestic Users*"

In addition a specific section on safety requirements in Australia for LP Gas powered hand-held tools has been recently incorporated into Australian Standard AS 2658-2003, *LP Gas portable and mobile appliances*. This Standard is currently referenced in NSW under clause 241 (1) of the *Dangerous Goods (General) Regulation 1999*, although the imminent repeal of this legislation under new risk assessment-based OH&S regulations will alter the present ability to enforce these provisions.

There still appears to be an element of reluctance by people to observe essential precautions that need to be taken when transporting or storing flammable gas in motor vehicles (including Class 2.1 flammable aerosol packs). Unfortunately, more recently, several similar incidents, have continued to occur although not with such a tragic outcome as this one.

All possible safeguards must be taken by the public and by industry to never keep flammable gas containers in unventilated spaces – especially inside motor vehicles and, even more importantly, after so many potential ignition sources in motor vehicles had been identified by TestSafe's investigation of this incident.

Flammable gas ignition hazards in motor vehicles

Unexpected ignition of flammable gas inside motor vehicles has resulted in explosions and fire on board, sometimes with tragic consequences.

Flammable gas leaks can occur from valves or connections on cylinders – as well as from attached equipment such as hand-held gas torches. The build-up of an atmosphere of flammable gas mixed with air in an enclosed vehicle or unventilated storage compartment can reach an explosive concentration that is capable of being ignited by quite a small electrical discharge.

TestSafe investigated a number of potential ignition sources inside a vehicle involved in a fatal explosion several years ago, especially its remotely operated central locking system, to determine if the components involved were capable of igniting flammable propane/air mixtures.

Tests indicated that typical ignition sources in vehicles can include items such as electric motors for the wipers and aerials, the engine's ignition system, remote locking system components, radios, cassettes and CD players.

The more obvious matches, gas cigarette lighters turning indicator and brake light switches, air conditioner switches and their speed control units, as well as static electric discharges, can also readily ignite flammable gas mixtures.