INCIDENT INVESTIGATION REPORT

Fuel tanker fire at Maddington 15 May 2009

Government of **Western Australia**
Department of **Mines and Petroleum**
Resources Safety

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Letter of transmittal

This report presents the findings of the incident investigation by the Resources Safety Division of the Department of Mines and Petroleum (DMP) into the fire at a service station site located at 207 Burslem Drive, Maddington, Western Australia, on 15 May 2009.

The object of the investigation was to identify, as far as practicable, the circumstances and causes of the incident and how to prevent such an incident recurring.

The report makes recommendations on:

- improvements in design and operation of service station fill points; and
- fuel tanker unloading operations.

DMP's investigation team comprised Lawry Lim, Dr Mark Comber and Peter Xanthis, who are Dangerous Goods Officers appointed under Section 27(1) of the *Dangerous Goods Safety Act 2004*.

Malcolm Russell
Chief Dangerous Goods Officer

22 March 2011

Reference

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Executive summary

At 13:43 on Friday 15 May 2009, a fuel tanker was unloading petrol into underground tanks at a suburban service station when a fire started at the fill point. The fire spread to the tyres of the tanker and later to its rear fuel compartments. Two of the rear compartments ruptured during the fire. One of the ruptures created a large fireball (about 60 m high and 20 m in diameter) that extensively damaged the petrol station building and associated infrastructure.

Fortunately, no-one was injured in the incident.

The fire was caused by the ignition of a mixture of fuel vapour and air close to the underground tank fill box. The source of the fuel vapour was probably within the containment sump, which was directly beneath the fill box. A definitive ignition source could not be identified.

During the early stages of the fire, the tanker driver did not use the fire extinguishers installed on the tanker nor those available at the petrol station. The fire spread from the fill point to the tanker. Use of the available fire extinguishers may have prevented the tanker from catching fire.

As a result of the investigation, recommendations to improve safety have been made in relation to the design and operation of underground petroleum storage systems and dangerous goods transport operations.

There is an urgent need to review the current practice of installing, for environmental protection, containment sumps beneath underground fuel tank fill boxes. This practice has had an unintended consequence — the accumulation of liquids (fuel–water mixture) in the sump can create a hazard that may be constantly present at the vapour recovery point if the sumps are not regularly checked and cleaned out. The petroleum industry should develop additional engineering controls to minimise this fire risk.

The petroleum industry should also review the design of existing fill boxes to ensure that minor leaks during fuel transfer operations are effectively contained within the fill box without the need to fit a containment sump.

Dangerous goods truck operators, particularly those carrying flammable liquids or flammable gases, should check the location of fire extinguishers on tanker vehicles to ensure their ready accessibility in an emergency. If it is impracticable for extinguishers to be more appropriately located, then procedures should be put in place to have a fire extinguisher alongside the driver while unloading fuel.

Contents

1

DESCRIPTIONS OF SERVICE STATION AND FUEL TANKER

1 Introduction

1.1 Maddington service station

Woolworths Ltd is the operator of the Caltex service station at 207 Burslem Drive in the Perth suburb of Maddington, Western Australia (see Figures 1, 2 and 3).

The company holds a Dangerous Goods Site Licence, issued by the Department of Mines and Petroleum (DMP), for the storage and handling of petroleum products and LP Gas at the “Woolworths Petrol Maddington” site.

Petrol and diesel are stored at the site in underground tanks. Bulk LP Gas is stored in an aboveground tank and exchange cylinders are stored in a metal wire cage.

Figure 1 *Aerial photo showing the location of the Woolworths Petrol Maddington service station [image generated using Google Earth]*

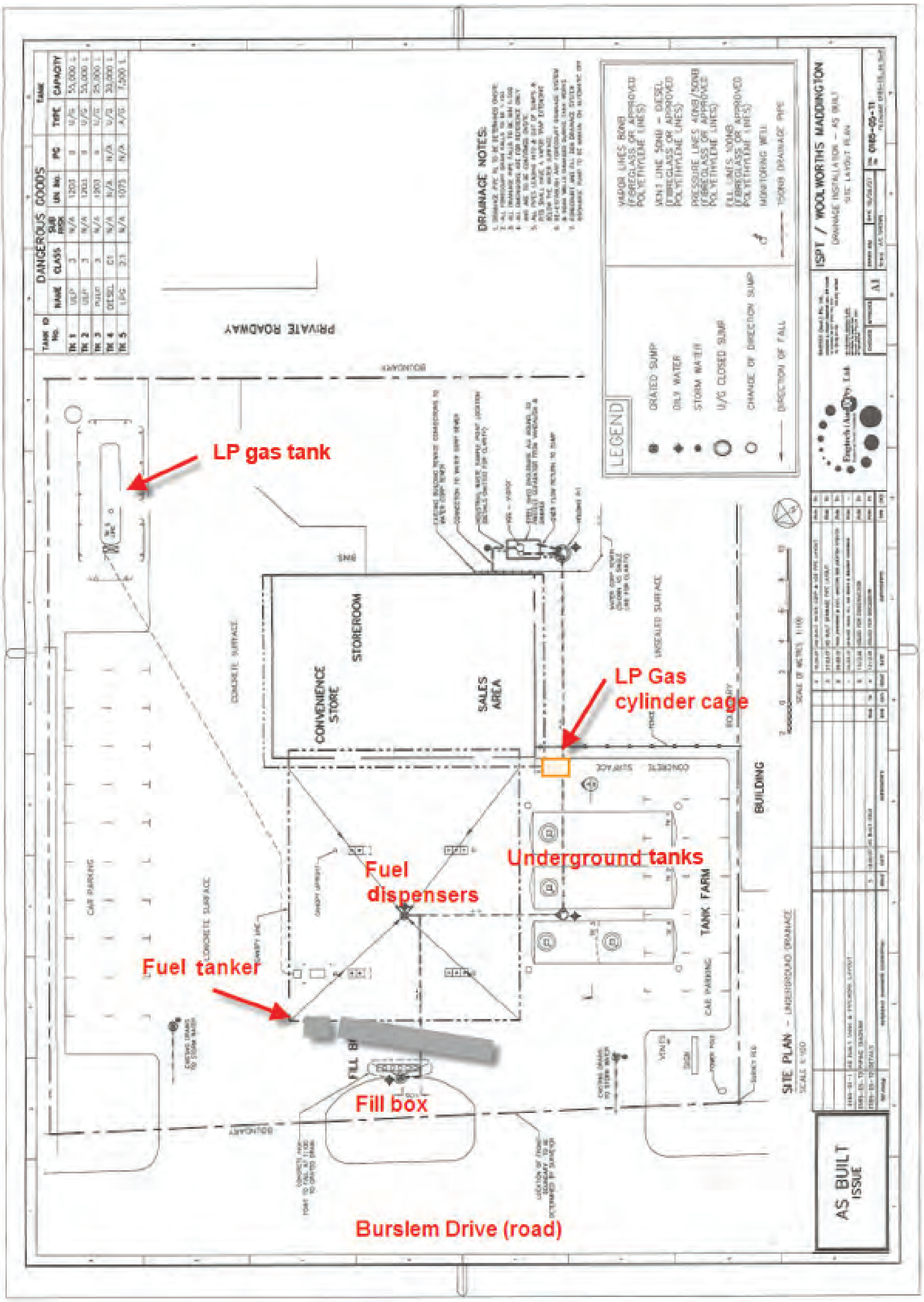

Figure 2 *Layout of the Woolworths Petrol Maddington service station showing the location of the fuel tanker during delivery [plan courtesy of ISPT Pty Ltd]*

Figure 3 *Street views of the Woolworths Petrol Maddington service station [images from Google Earth]*

Underground storage tanks

There are three underground fuel storage tanks at the site.

- Tank 1
  - 55 kL, unleaded petrol (dangerous goods Class 3, Packing Group II)
- Tank 2
  - 55 kL, unleaded petrol (Class 3, Packing Group II)
- Tank 3
  - 50 kL, dual compartment tank
  - Compartment 1, 30 kL, premium unleaded petrol (Class 3, Packing Group II)
  - Compartment 2, 20 kL, diesel fuel (C1 combustible liquid)

The tanks were designed and installed, in 2007, to the requirements of the Australian Institute of Petroleum's *Code of Practice CP4: Design, installation and operation of underground petroleum storage systems* (AIP CP4) and Australian Standard AS 1940:2004 *The storage and handling of flammable and combustible liquids*.

The tank installation incorporates a vapour recovery system for the petrol tanks only — the diesel tank is not linked to the vapour recovery system.

The tanks are double-walled, comprising an inner single-wall steel tank with an outer fibreglass wall. They are filled through individual 100 mm diameter plastic fill lines (Figure 4).

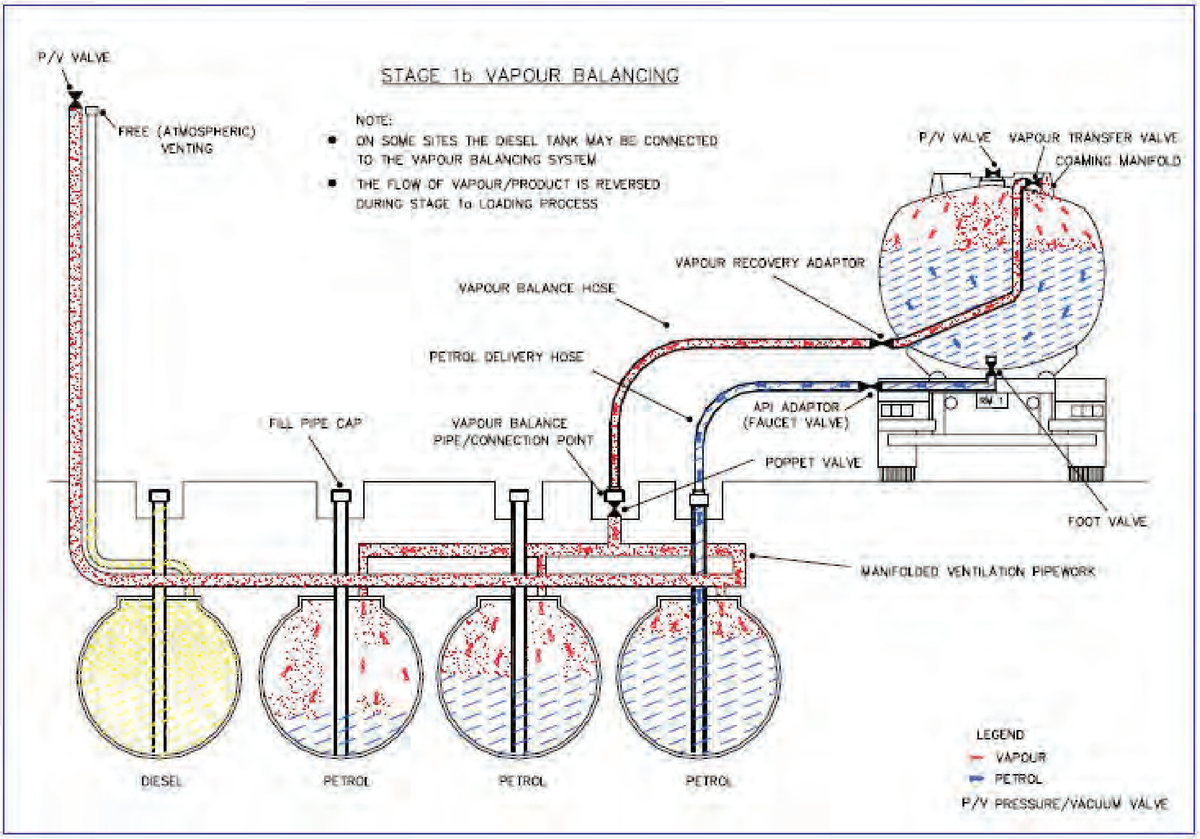

Figure 4 *Schematic diagram showing typical vapour recovery system [diagram courtesy of West Yorkshire Fire Service]*
Note: P/V valves are not fitted to service stations in Western Australia

Fill points at the Maddington site were inside a metal spill box assembly. Each fill point was protected by a metal lid, as was the vapour recovery point. Spill containment at each fill point was as specified in AIP CP4. The metal spill box assembly was directly above a fibreglass containment sump of about 900 mm depth (Figures 5, 6 and 7).

The spill box, fill points and vapour recovery point were connected to earth, and the earth lead was routed back through the tank turrets to an earth stake, which was located close to the service station building.

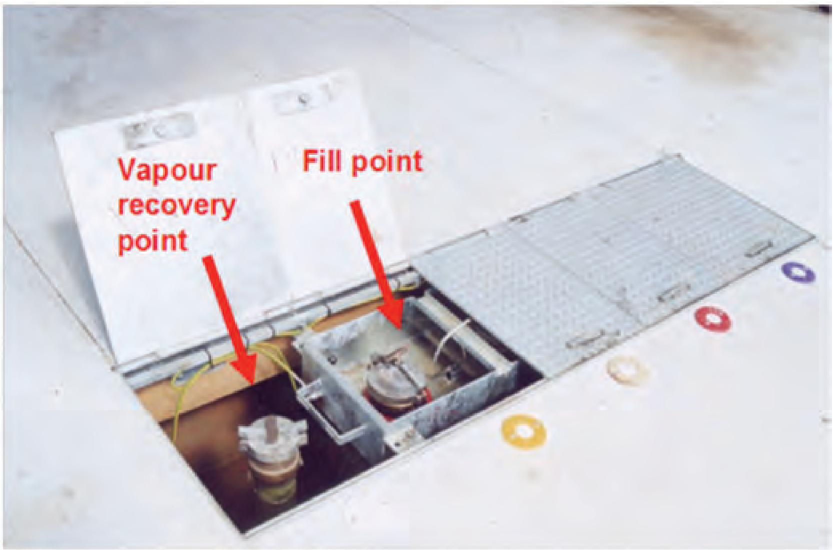

Figure 5 *Typical fill box assembly*

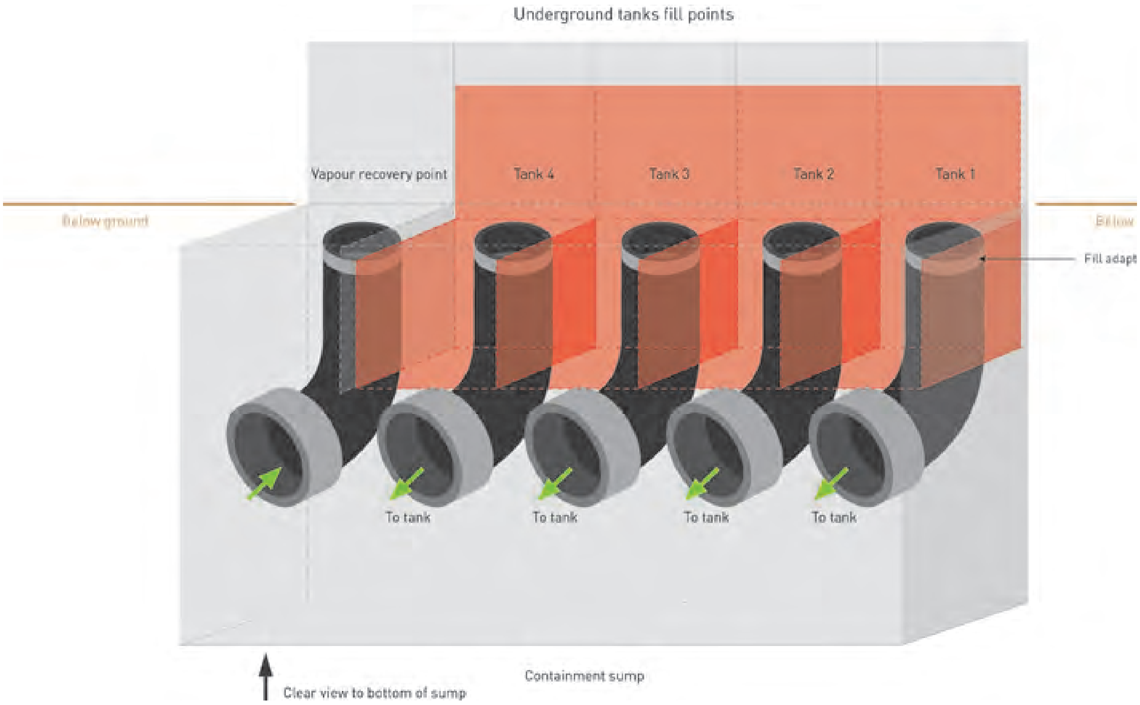

Figure 6 *Sketch of the Maddington site fill box assembly showing the containment sump underlying all fill points and the vapour recovery point. Red box indicates one metal box (spill box) for fill point spill containment.*
Note: Figure is diagrammatic and not to scale

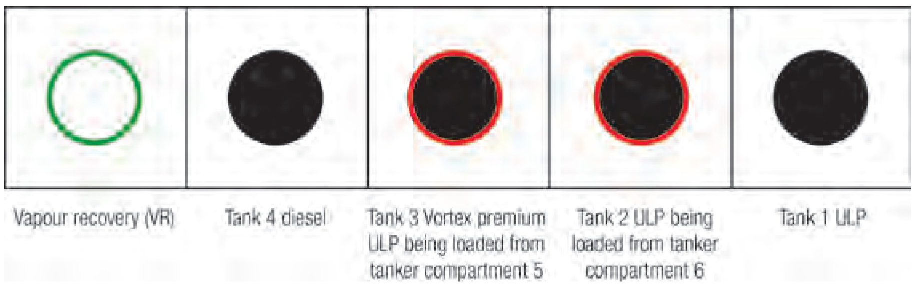

Figure 7 *Fill point arrangement at the service station at the time of the incident. Coloured circles mark the points to which tanker hoses where connected at the time of the fire (see Figure 9)*

LP Gas facilities

The Woolworths Petrol Maddington service station has a 7.5 kL aboveground LP Gas tank and a metal cage that accommodates exchange cylinders for up to 500 L of LP Gas (visible in Figures 2 and 3). The LP Gas installations were designed and installed to the requirements of Australian Standard AS/NZS 1596:2002 *The storage and handling of LP Gas.*

1.2 Fuel tanker

Fuel is delivered to the Woolworths Petrol Maddington service station by Toll Liquid Distribution (a division of Toll Pty Ltd). Toll Liquid Distribution operates a fleet of fuel tankers and employs licensed dangerous goods drivers.

On 15 May 2009, the Toll fuel tanker that delivered to the service station was a prime mover connected to a semitrailer tanker. The tanker semitrailer was a licensed dangerous goods vehicle. The Victorian Workcover Authority licence authorises it to carry Class 3 (flammable liquid) dangerous goods. The vehicle is permitted to operate in Western Australia with a Victorian Dangerous Goods Vehicle Licence.

The prime mover was registered in Victoria (registration number TBA 096) and designed for fuel transport. It was equipped with a shielded exhaust, battery isolation switch and protected wiring (see Figure 8).

Figure 8 *Prime mover after the fire [photograph courtesy of FESA]*

The tanker trailer (WA registration number 8WX 645) was made of aluminium and had six compartments, numbered 1 to 6 from the front to the rear of the trailer.

The tanker trailer was designed and built by Holmwood Highgate Pty Ltd in 1996 to the specifications of Australian Standard AS 2809.2:1990 *Road tank vehicles for dangerous goods – Tankers for flammable liquids*. It was designed to recover fuel vapours during filling of underground tanks (Figures 9 and 10).

Figure 9 shows the connections made from the tanker trailer to the underground tank fill points and vapour recovery point at the time of the fire.

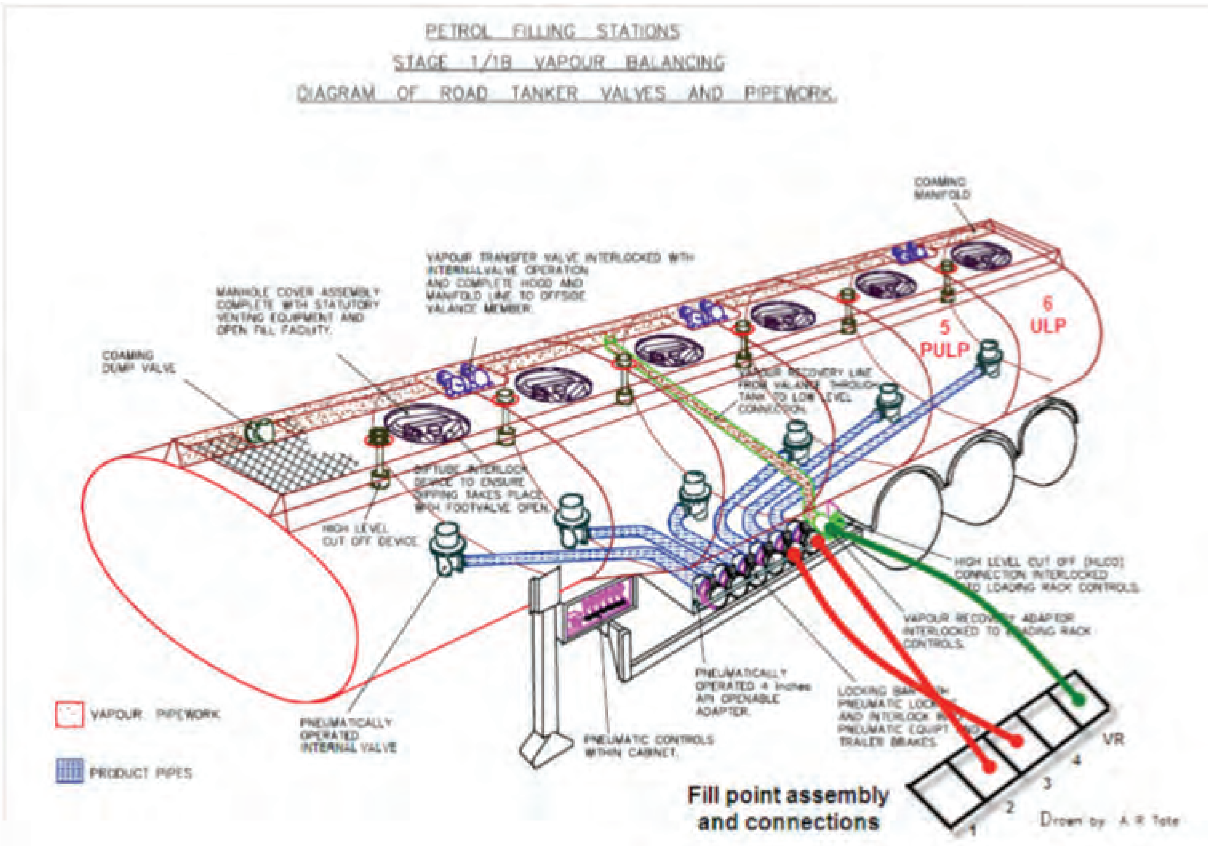

Figure 9 *Schematic diagram of a typical road tanker fitted with vapour recovery equipment. Solid red lines represent the two petrol transfer hoses at the time of the incident, and solid green line represents the vapour recovery hose [diagram courtesy of UK Institute of Petroleum]*

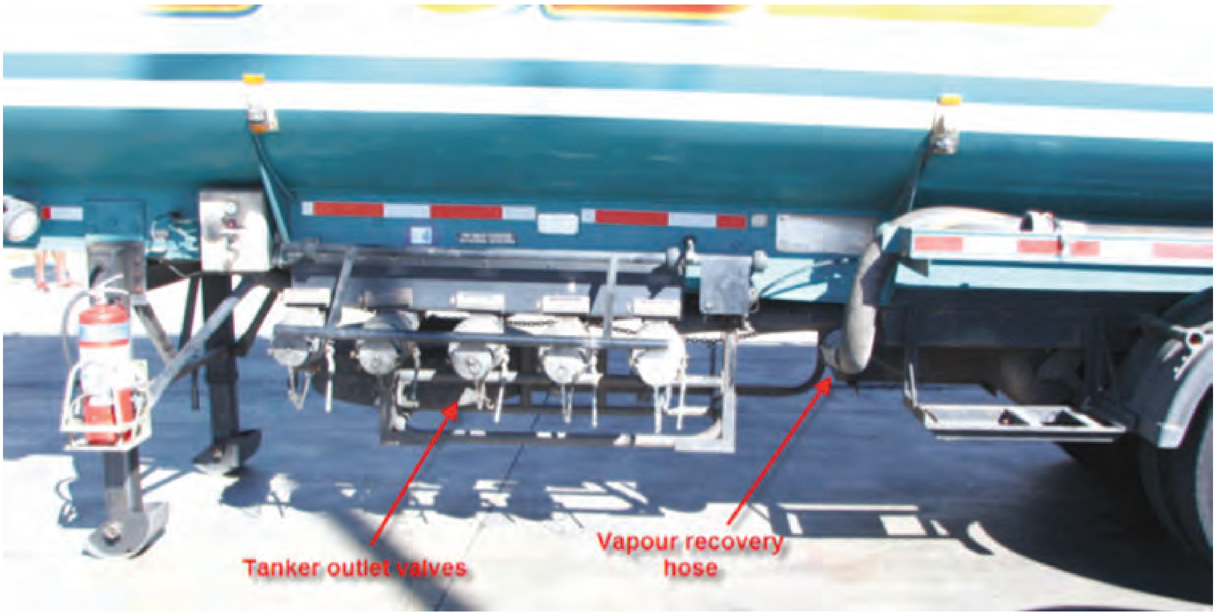

Figure 10 *Typical tanker outlet valve and hose arrangement*

On the day of the fire the total load of the tanker trailer was 41,350 L. Compartment loads are given in Table 1.

Tank approval number "QRT 461" was marked on the tanker (Figure 11). The last tank maintenance (marked "P" for hydrostatic pressure test) was shown as completed on 24 April 2006 (Figure 12).

Tanker maintenance records

Toll maintenance records for the tanker were examined and found to be satisfactory.

The fuel tanker had been hydrostatically tested and maintained as per the requirements of the *Australian Code for the Transport of Dangerous Goods by Road and Rail*, 7th edition (ADG7) and AS 2809 Set:2008 *Road tank vehicles for dangerous goods*.

The two tanker delivery hoses and vapour recovery hose used on the tanker were last tested in March–April 2009. The hoses and fittings passed the required pressure test, and the electrical continuity of the hoses was satisfactory.

Table 1 *Compartment loads for Toll tanker trailer on day of fire*

Compartment	Load	Product
1	7300 L	Unleaded petrol (ULP)
2	6650 L	ULP
3	6650 L	ULP
4	6800 L	ULP
5	5700 L	Vortex Premium ULP
6	8250 L	ULP

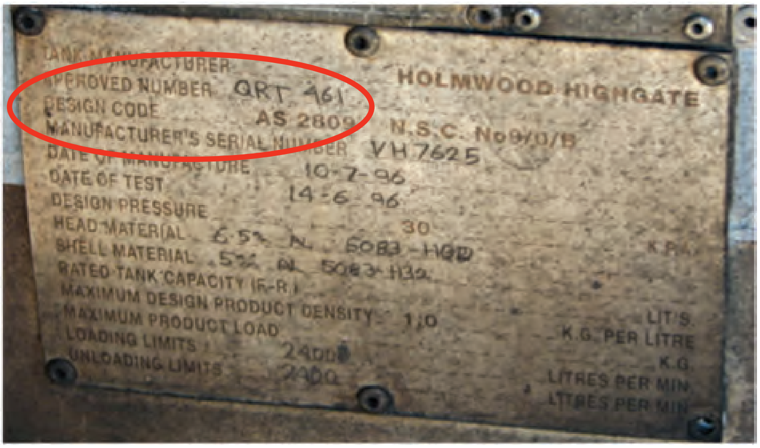

Figure 11 *Tanker trailer's data plate*

Figure 12 *Tanker trailer's maintenance data plate*

2

THE FIRE

2 The fire

2.1 Chronology

At about 13:43 on Friday 15 May 2009, a driver employed by Toll Liquid Distribution was delivering petrol into two underground fuel storage tanks at the Woolworths Petrol Maddington service station, 207 Burslem Drive, Maddington, when a fire started near the tank fill box.

A detailed chronology of events from before the fire started until it was extinguished is provided in Appendix 1. It is based on witness statements, and a review of photographs, video footage from local television news reports, CCTV cameras and the internet. The order of events is summarised in Figure 13.

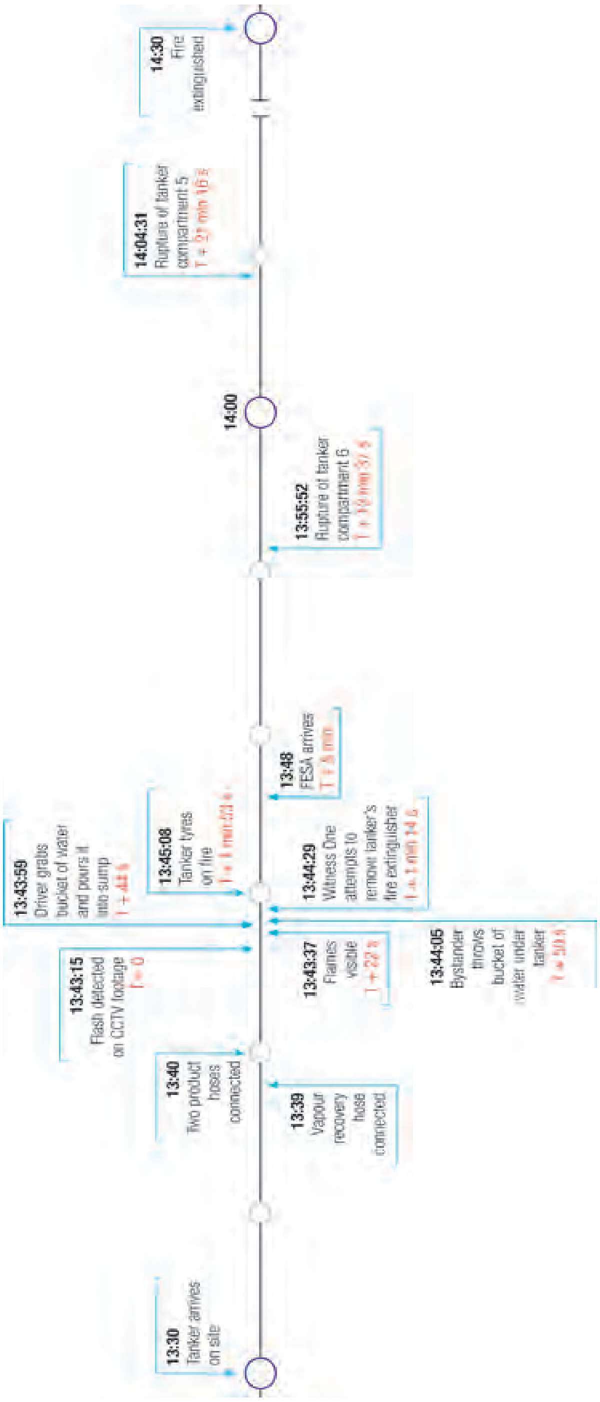

Figure 13 *Timeline of fire incident*

The fire spread first to the tanker tyres, then to the body of the tanker, and later to the service station canopy.

No-one was injured during the fire.

There was extensive media coverage of the fire. Numerous photos and videos were posted on websites and broadcast on television news programs.

At the height of the fire, the driver's side of compartment 6 ruptured. Compartment 5 ruptured a little less than 9 minutes later.

The most graphic video clip of the incident, posted on the YouTube website, captured the rupture of tanker compartment 6, which resulted in a fireball. The video clip can be viewed at http://www.youtube.com/watch?v=5m-VgWwfh0c

2.2 The fire and its effects

Figures 14 to 16 show the fire. Figures 17 to 20 show the damage to the service station and tanker.

- Flames were observed at the emergency vent of compartment 4, which is on top of the compartment. The tanker is designed to respond to a fire in this way, which reduces the risk of tank failure.
- The rupture of tanker compartment 6 resulted in a fireball that travelled about 20 m laterally towards the service station shop and reached a height of about 60 m.
- The fire caused extensive damage to the fuel dispensers, service station canopy and shop building.
- The contents of the 9 kg LP Gas exchange cylinders inside a cylinder cage caught fire. The tanker was about 15 m from the cage.
- Most of the tanker's aluminium discharge pipes were damaged or melted in the fire.
- Four of the tanker's six outlet valves were on the ground.

2.3 Agency responses

The Western Australian Fire and Emergency Services Authority (FESA) attended the scene soon after calls to the "000" emergency number were received.

FESA officers applied water to cool the tanker, predominantly to the side of the tanker facing the street.

The Hazmat Emergency Advisory Team (HEAT) assembled at FESA headquarters in Perth to assist with the management of the incident. HEAT maintained continuous communication with the FESA Incident Controller at the scene. Lawry Lim represented DMP at the meeting at FESA headquarters. Environmental monitoring was provided by the Department of Environment and Conservation.

Note: HEAT provides advice to the FESA Incident Controller at Hazmat incidents in Western Australia. The core members of HEAT include FESA, WA Police, DMP, Department of Environment and Conservation, Department of Health, and Chemistry Centre WA.

DMP's Mark Comber attended the site of the fire until the situation was made safe. Dr Comber also assisted the FESA Incident Controller when required.

A 500 m public safety exclusion zone was established around the incident scene.

At about 14:30 (some 45 minutes after the fire started), the fire was brought under control and arrangements made to transfer fuel from the undamaged compartments of the tanker to a recovery tanker (Figure 21).

Figure 14 *Tanker on fire [photograph courtesy of FESA]*

Figure 15 *Spread of fire from the tanker to service station canopy and building [photograph courtesy of Department of Environment and Conservation]*

Figure 16 *Fire on top of compartments 5 and 6, and burning LP Gas cylinders in cage in the background [photograph courtesy of FESA]*

Figure 17 *Position of the fuel tanker in relation to the service station canopy [photograph courtesy of FESA]*

Figure 18 *Tanker vehicle after the fire was extinguished. The aboveground bulk LP Gas tank is visible on the left of the photograph [photograph courtesy of FESA]*

Figure 19 *Fill point area after the fire was extinguished with metal covers in the open position [photograph courtesy of FESA]*

Chapter 2

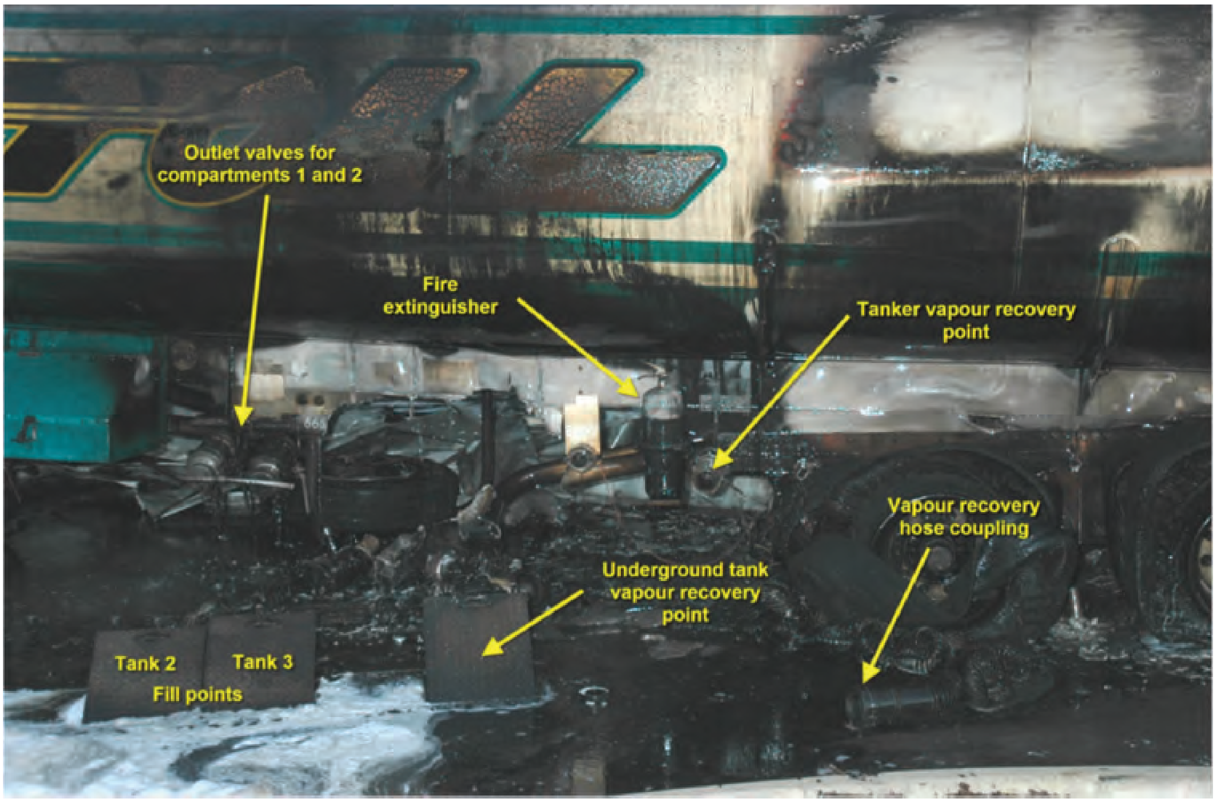

Figure 20 *Underground tank fill point area and tanker equipment after the fire was extinguished [photograph courtesy of FESA]*

Figure 21 *Transfer of fuel to the recovery tanker using an air-operated diaphragm pump*

3

POST-FIRE INVESTIGATION

3 Post-fire investigation

On 16 May 2009 (the day after the fire), DMP Dangerous Goods Officers Lawry Lim and Mark Comber continued the investigation into the cause of the fire.

3.1 Inspection of service station site

The DMP officers observed the following during the site visit.

- The site was secured with temporary fencing and access was controlled by a security guard.
- The fuel dispensers, service station canopy and shop building were extensively damaged by the fire (Figure 22). There was no evidence of blast damage.
- The fill points of the underground fuel storage tanks showed signs of fire damage (Figures 23 to 25). The fill points for tanks 2 and 3 appeared to have collapsed or fallen into the fill point containment sump directly underneath the fill box.
- The LP Gas cylinder cage (for 9 kg exchange cylinders) was extensively damaged by the fire (Figure 26).
- The 7.5 kL bulk LP Gas tank at the rear of the site was intact and showed no signs of fire damage.

3.2 Inspection of fuel tanker

The damaged tanker was taken to the Toll Liquid Distribution transport yard in Cloverdale after the remaining fuel had been transferred to a recovery tanker.

Inspection of the tanker by the DMP officers revealed the following.

- Two fire extinguishers mounted on the mid-section of the tanker were fire damaged. One was near the outlet valves, and the other was on the side opposite the outlet valves (Figure 27).
- Two rear compartments (5 and 6, driver side rear) of the tanker vehicle had ruptured (Figure 28).
- Of the six tanker outlet valves and product lines, only the two at the front of the tanker (compartments 1 and 2) were intact. Some of the product lines were deformed by the fire.
- The internal shut-off valves for compartments 5 and 6 were in the closed position.
- A section about 1.5 m long of the tank wall of compartment 6 (rear section of tank shell, driver side) was missing (Figure 29).
- Compartment 5 (mid-section of tank shell, driver side) was cracked, with the largest gap being about 200 mm wide (Figure 30).
- Compartment 6 (rear, passenger side) had a narrow crack (Figure 31).
- Of the twelve tyres on the trailer (three axles), all six on the driver side of the trailer were burnt out. Some tyre rubber remained on the passenger side of the trailer.
- Three tanker product lines were destroyed by the fire.

3.3 Tanker fittings and hoses

The DMP officers examined the tanker fittings that were recovered from the site and made the following observations.

- Three of the tanker product outlet valves had become detached from the product pipe work when it melted (Figure 32).
- All of the outlet valves were in the closed position.
- Sight glasses on the fill elbows for the underground tank fill points had melted (Figure 33).
- The three tanker hoses (two product hoses and one vapour hose) in use at the time of the fire were destroyed. The only remnants were the metal wire coils that surrounded the original hoses and the hose couplings (Figure 34).

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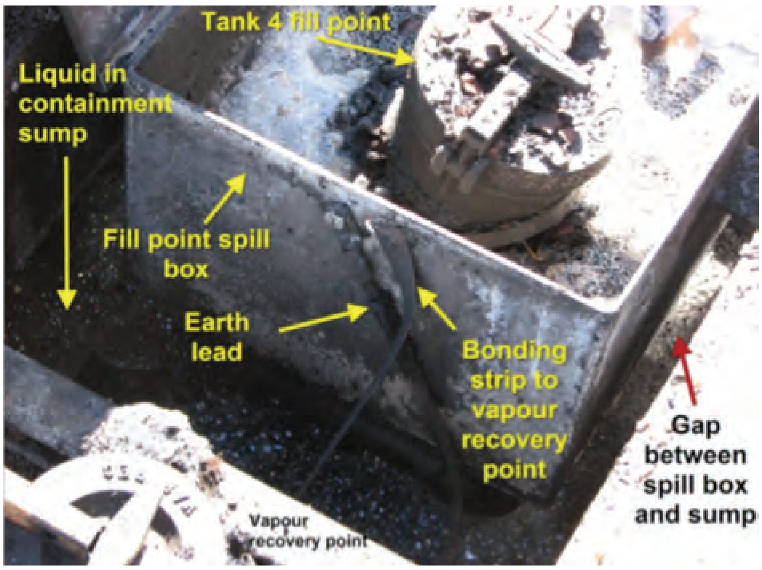
Figure 22 *Extensive damage to the service station canopy and fuel dispensers*

16/05/09

Figure 23 *Vapour recovery connection point*



16/05/09

Figure 24 *Vapour recovery connection point and fill point spill box*

16/05/09

Figure 25 *Tank 3 fill point with missing fill point*

16/05/09

Figure 26 *Fire-damaged LP Gas exchange cylinder cage*

16/05/09

Figure 27 *Damaged fire extinguisher beside the vapour recovery point, and one outlet valve still attached to the product line*

16/05/09

Figure 28 *Ruptured compartments on the rear driver side of the fuel tanker*

16/05/09

Figure 29 *Side view of the ruptured section of compartment 5*

16/05/09

Figure 30 *View inside compartment 6*

16/05/09

Figure 31 *Fine crack on the tank shell of compartment 6 (passenger side)*

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16/05/09

Figure 32 *Detached tanker outlet valves*

16/05/09

Figure 33 *Underground tank fill elbows. Central unit is the vapour recovery elbow*

16/05/09

Figure 34 *Remnants of the tanker hoses*

3.4 Follow-up examination

A further examination of the tanker on 22 May 2009 to review the condition of fittings on top of the tanker revealed the following.

- The top of each of the six tanker compartments was fitted with a manhole cover assembly. This assembly included an emergency vent and a pressure-vacuum vent. A vapour recovery vent and dip and fill points were also fitted to each compartment.
- The manhole cover assemblies were intact and showed no signs of failure (Figures 35 and 36).

Figure 35 *Manhole cover assembly for compartment 6*

Figure 36 *Inside surface of manhole cover with pressure-vacuum vent (top) and emergency vent (bottom)*

3.5 Reconstruction of hose connections

On 1 July 2009, the DMP officers revisited the Toll Liquid Distribution transport yard to reconstruct the vapour hose connection to the vapour recovery point of the underground tank at the service station. Their objectives were to:

- replicate the connections made by the tanker driver on 15 May 2009; and
- check for any abnormalities at the connection points from the tanker hose to the vapour recovery elbow and to the underground vapour recovery point.

Examination of the completed connection, as shown in Figure 37, revealed the following.

- The connection between the tanker vapour recovery hose coupling and the top of the vapour recovery elbow appeared to be a normal flush fit.
- The connection from the bottom of the vapour recovery elbow to the top of the vapour recovery point from the underground tank appeared to be a normal flush fit.
- Apart from major fire damage (Figure 38), which included a hole (Figures 39 and 40), the vapour recovery connection appeared normal.

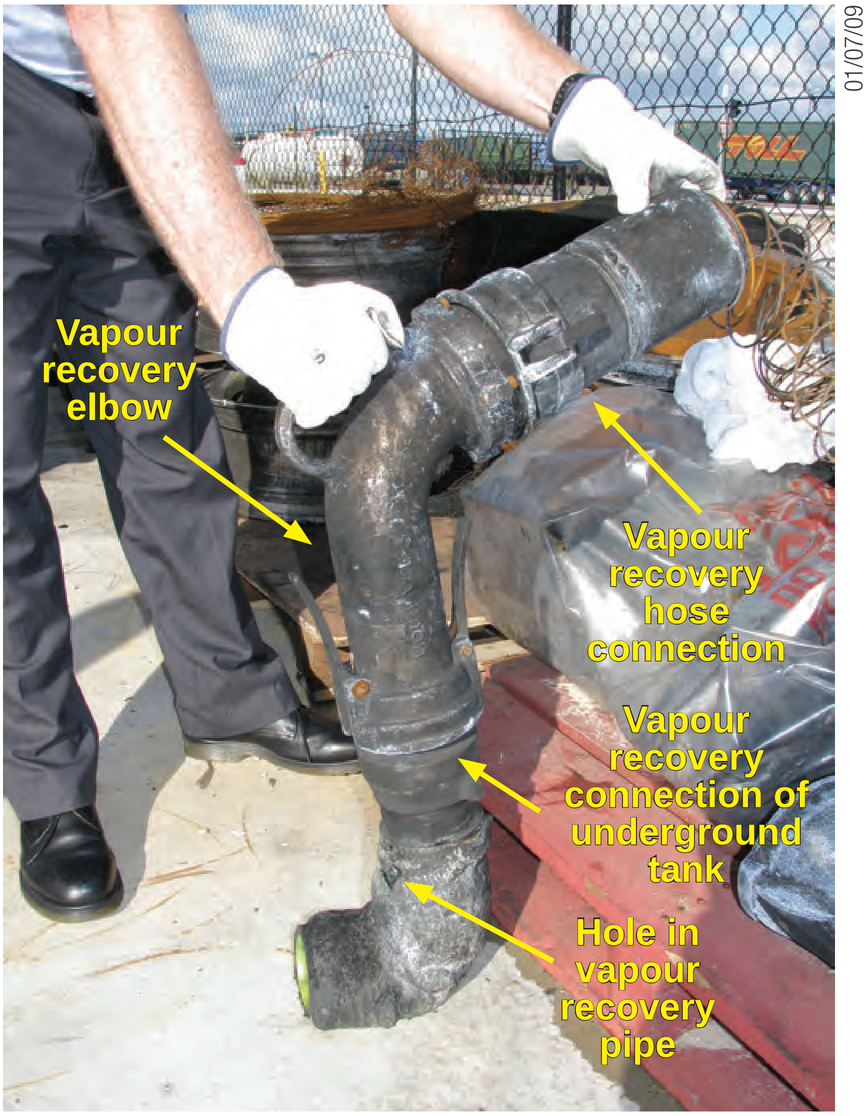

Figure 37 *Tanker vapour hose connected via the vapour recovery elbow to the underground tank vapour recovery point*

Figure 38 *Top section of vapour recovery elbow pipe, the hole in the elbow and melted plastic inside the pipe*

25/06/09

Figure 39 *Hole in vapour recovery elbow pipe and location relative to tank 3*

11/03/11

Figure 40 *Close up of hole in vapour recovery elbow pipe*

Chapter 3

3.6 Examination of fill point equipment at service station

On 13 August 2009, Woolworths Ltd fuel contractors removed the metal spill box at the service station to expose the fill point elbows of the underground tanks. Figure 41 shows the arrangement of the underground tank fill box before removal of the metal spill box (placed to the left of the tank fill box in Figure 42). The elbows of each tank fill point were cut from the fill pipes for closer examination by the DMP investigating officers and others.

The objectives were to:

- review the post-fire condition of the underground tank fill point equipment; and
- gather additional evidence to assist in the fire investigation.

Physical examination

Examination of the fill point equipment revealed the following.

- There was very little fire damage to the fill point elbow for tank 1 (Figures 43 to 45). No holes were visible on the elbow.
- There was moderate fire damage to the fill point elbow for tank 2 (Figure 46 to 48). No holes were visible on the elbow.
- There was major fire damage to the fill point elbow for tank 3 (Figures 49 to 51). The fire was so intense that the plastic fill line (to the underground tank) that attached to this elbow had softened and elongated. A hole was initially identified on a section of the fill point elbow but when this section was cut off for further examination, it was clear that the hole did not penetrate the inner wall of the fill line.
- The fill point elbow for tank 4 sustained major damage, with the elbow point softened and deformed by the fire (Figures 52 to 55).
- The vapour recovery elbow sustained major fire damage (Figure 40).

With the fire damaging the pipe elbows, a significant amount of fuel may have entered the containment sump after the fire started. The fuel is likely to have come from discharge hoses that melted in the fire. Burning liquid would have entered the containment sump through the small gap between the edge of the fill point assembly and the metal spill box (Figure 41).

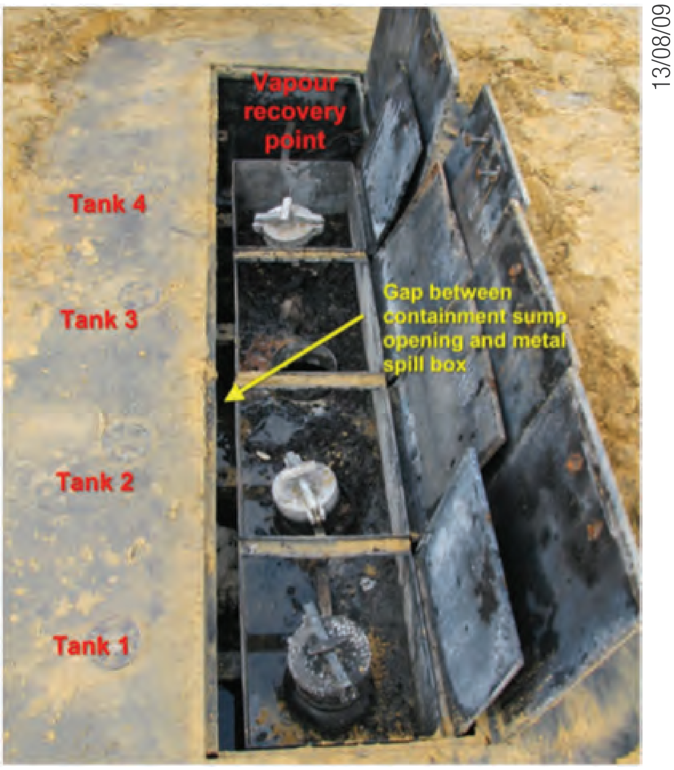

Figure 41 *In situ layout of underground tank fill box*

Figure 42 *Fill point elbows for the underground tanks after the metal spill box was removed*

Figure 43 *Tank 1 fill point opening — no melting of green plastic pipe*

Figure 44 *Tank 1 fill pipe inside containment sump — fill pipe is in good condition*

Figure 45 *Fill pipe elbow of tank 1 — pipe is not significantly fire affected*

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Figure 46 *Fill point opening of tank 2 — significant melting of green plastic pipe*

13/08/09

Figure 47 *Tank 2 fill pipe inside containment sump — fill pipe is fire affected*

13/08/09

Figure 48 *Fill pipe elbow of tank 2 — pipe is fire affected*

Figure 49 *Tank 3 fill pipe inside containment sump — fill pipe is significantly fire affected*

Figure 50 *Deformed fill pipe elbow of tank 3 after it was cut from the fill pipe*

Figure 51 *Fill pipe elbow of tank 3 — elbow is significantly fire affected, as shown in Figure 48*

Figure 52 *Fill point opening of tank 4 — noticeable melting of green plastic pipe*

Figure 53 *Tank 4 fill pipe inside containment sump — fill pipe is partially fire affected*

Figure 54 *Fill pipe elbow of tank 4 — elbow section is significantly fire affected, as shown in Figure 64*

Figure 55 *Fill pipe elbow of tank 4 — elbow section is significantly fire affected*

Electrical continuity testing

The electrical continuity of the components of the fill box assembly was assessed at the service station (Figure 56).

Due to operational safety needs on 16 May 2009, the day after the incident, fuel contractors cut off the vapour recovery elbow and fitting to seal the line. This prevented fuel vapours escaping to the atmosphere through the vapour recovery line. It was not possible, therefore, to measure the electrical continuity of the vapour recovery fitting.

Testing of the fill box and fittings (excluding the vapour recovery fitting) indicated that the fill box was electrically continuous.

The tank system had passed the required electrical continuity tests when it was commissioned.

Figures 23 and 24 show that, at the time of the fire, an earth lead was connected to the spill box and a bonding strip was connected from the spill box to the vapour recovery point.


13/08/09

Figure 56 *Measuring electrical conductivity at the service station after the fire*

4

WITNESS ACCOUNTS

4 Witness accounts

4.1 Tanker driver

The driver had been employed by Toll Liquid Distribution as a fuel tanker driver since October 2008. He held a valid Dangerous Goods Driver Licence issued by the Department of Mines and Petroleum.

On 15 May 2009, the driver started work at around 04:00. He travelled to the Caltex terminal at Bracks Street, North Fremantle, to collect the tanker. He was wearing a Toll issue uniform, which included a cotton long-sleeved shirt, cotton trousers, an anti-static safety vest, rubber gloves, safety glasses and boots.

He checked the oil, water, lights and tyres of the preloaded tanker before driving it to a service station at South Lakes for his first delivery of the day. He delivered fuel to two other service stations before making the delivery to the service station at Maddington. The driver had delivered fuel to the Woolworths Petrol Maddington service station "five or six times" before the delivery of 15 May 2009.

He arrived at the service station at around 13:30 and placed hazard cones in front of the fuel dispensers to restrict access to the tanker parking area. He proceeded to dip the underground tanks to ensure that there was sufficient capacity in the tanks to take the delivery. He then went to the underground tank fill point box (spill box) assembly on the service station forecourt and opened the hinged metal lids of the vapour recovery point and tank fill points. There, he noticed that there was "a fair bit of liquid" in the containment sump of the spill box.

The driver recalled that the liquid had been in the containment sump "for a while", and he had previously been told that it had been reported through Toll Liquid Distribution to Woolworths Ltd. He also recalled that the liquid level was about the same as it had been when he was last there, which was the late evening of the preceding Friday.

He did not recall any smell around the fill points.

The driver proceeded to connect the vapour recovery elbow to the vapour recovery point of the underground tank system and then connected the vapour hose from the truck to the elbow. He then connected the discharge hoses from compartments 5 and 6 through discharge elbows into underground tank fill points 3 and 2, respectively. Figures 57 to 59 show typical examples of fill point arrangements and hose connections.

The driver opened the outlet valves of the tanker to commence transfer of the fuel to the underground tanks. He then checked that there was no spillage in the area.

While the fuel transfer was in progress, the driver recalled that he was standing towards the front of the trailer and in full view of the product discharge point. He was "at the front of the truck and stepped into the cab and obtained a banana from my bag, which was one step up on the prime mover." When he heard a "bang and a whoof", which sounded like "two cars colliding", he looked forward of the cabin, and then to the side.

At this time, a man drove into the service station and either pointed or shouted to the driver about the fire. The driver turned around and saw that the sump was on fire. He observed that the flames at the sump were about knee high at that time (Figure 60). He went around the truck, grabbed a bucket of water, returned and poured water into the sump. A customer had also thrown some water under the truck. Initially, these actions appeared to have extinguished the fire, but it reignited a second or two later.

Figure 57 *Typical arrangement for a tanker delivering fuel into underground tanks at a service station*

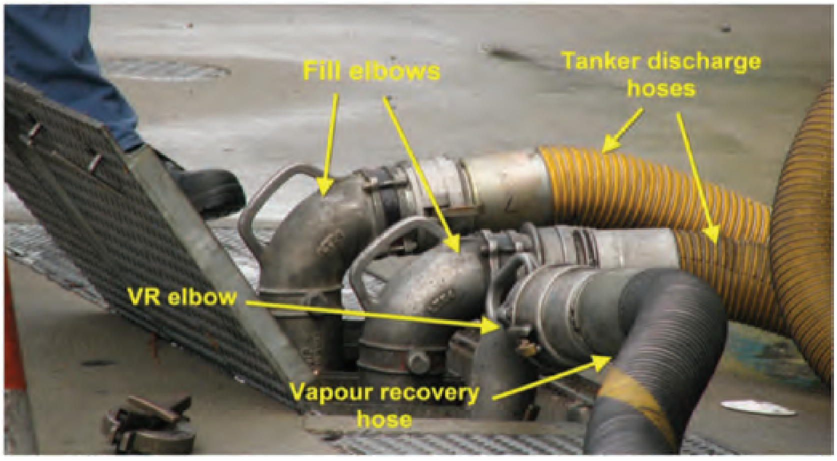


Figure 58 *Typical fill point connections to underground tanks*

Figure 59 *Typical tanker outlet valves in the open position (i.e. lever on right hand side of valve, parallel to hose)*

When the fire in the sump reignited, the vapour recovery hose and the discharge hoses were all on fire (Figure 61. The driver then shut off the outlet valves on the tanker by operating the levers manually. He removed the vapour hose coupling from the vapour recovery elbow with the intention of moving the truck. He planned to remove the hose couplings from the two tank fill points, but was not able to because of the heat of the fire. At this stage, the driver's gloves and one boot were on fire.

The driver went to the service station building to ensure the fire brigade was called and tell people to leave the building.

At no stage did the driver use either of the two fire extinguishers mounted on the truck (see Figure 60 for the location of the fire extinguishers on the tanker).

The driver and service station attendant then walked to the corner of Albany Highway.

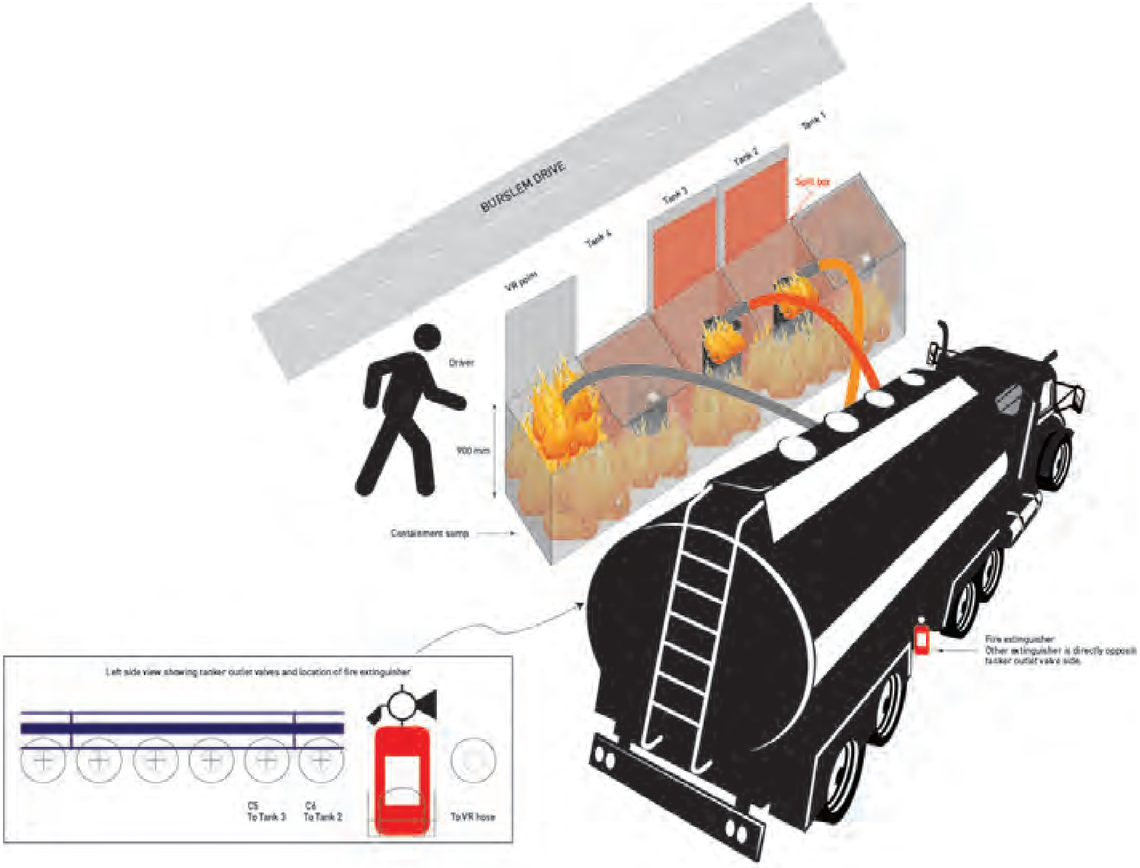


Figure 60 *Sketch showing the fire around underground tank fill points. Note: Figure is diagrammatic and not to scale*

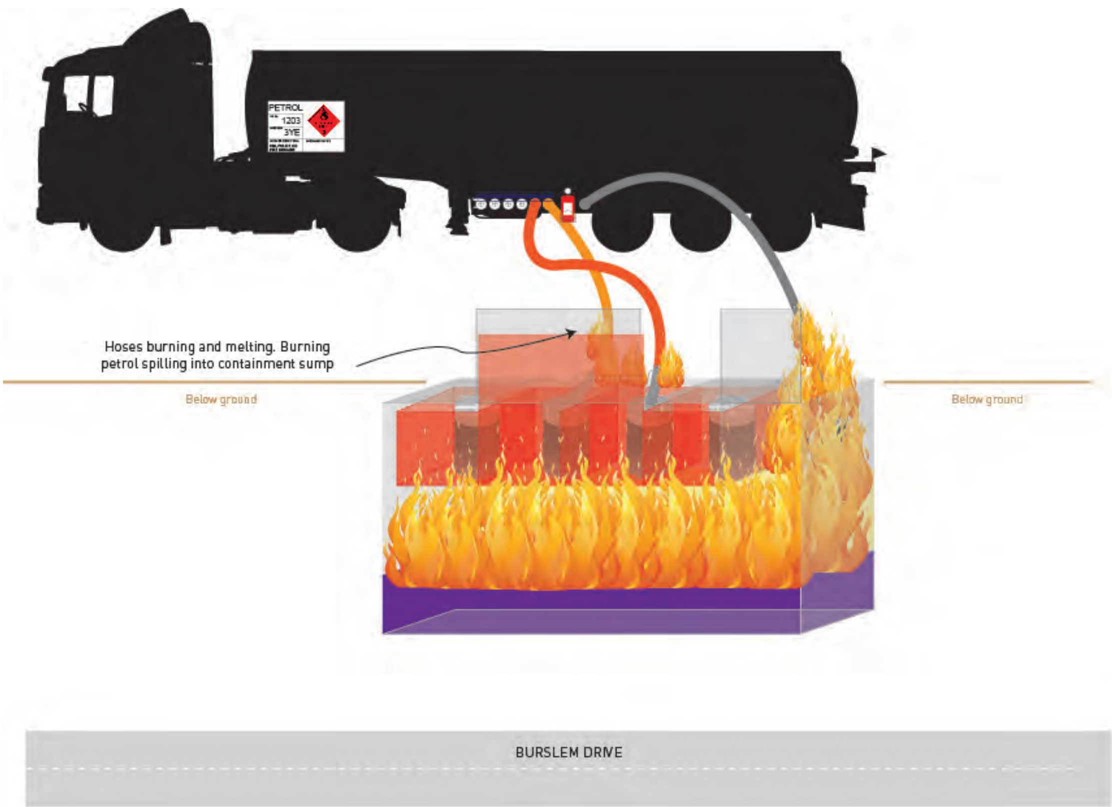


Figure 61 *Sketch showing fire spreading to vapour recovery and tanker discharge hoses. Note: Figure is diagrammatic and not to scale*

4.2 Woolworths customer (Witness One)

Witness One was the first person to see the fire in the fill point area. He had gone to the service station to refuel his vehicle, but could not recall the exact time. As he drove into the service station, he recalled seeing the tanker driver seated in the passenger side of the prime mover and looking downward.

When Witness One saw the fire in the tank fill point area he quickly alerted the tanker driver. He noticed orange-coloured flames about 30 cm high coming from the end fill box connection where a grey hose was connected to the ground. He saw the driver grab a bucket of water and throw it into the fire.

At one stage, Witness One tried to remove the fire extinguisher on the driver's side of the tanker, but could not do so because he could not undo one of the latches before he was overcome by heat and smoke.

He noticed that, in the meantime, a number of people had applied water to the fire.

The grey hose noted by Witness One was the vapour recovery hose. Witness One's observation of the initial location of the fire is consistent with that of the tanker driver, who said that the initial fire was near the vapour recovery connection point.

4.3 Other witnesses

Other witnesses were interviewed by FESA Fire Investigations staff and the Police Arson Squad but none reported seeing the fire start.

4.4 Observation

There is a discrepancy between the statement of the tanker driver and that of Witness One in relation to the driver's location in the early stages of the fire around the fill box.

Witness One saw the driver inside the cabin of the prime mover (passenger side) when he arrived at the service station.

Based on the statement by Witness One and corroborating video evidence, DMP believes, on the balance of probabilities, the tanker driver was inside the cabin of the prime mover, albeit briefly, when the fuel transfer was in progress.

5

CAUSE OF THE FIRE

5 Cause of the fire

In any fire investigation it is important to establish the presence of the three parts of the fire triangle — fuel, oxygen and ignition or heat source.

The fire at the Woolworths Petrol Maddington service station started during gravity transfer of unleaded petrol, a flammable liquid, from a road tanker through electrically conductive discharge hoses connected to the fill points of the service station underground tank storage system. The fill point assembly included a vapour recovery hose used to return fuel vapours to the tanker.

5.1 Fuel source

The service station's CCTV footage clearly shows that ignition occurred near the underground tank fill box assembly. The key question is "Where did the fuel come from?" Several potential fuel sources have been identified.

Leakage from delivery or vapour recovery hoses

There is no evidence to suggest that the delivery or vapour recovery hoses were faulty or leaking. The driver reported that everything appeared normal and there were no leaks around the fill lines or the vapour recovery point.

Recent (pre-fire) hose test records provided by Toll Liquid Distribution show that the electrical conductivity of the hoses was within acceptable limits and the hoses had passed the required pressure tests.

Leakage from vapour recovery point

Although there was a hole in the vapour recovery elbow, this appeared to be caused by the fire and there is no evidence to suggest that there was leakage prior to the fire.

No faults or defects were reported for the vapour recovery point by Toll Liquid Distribution delivery drivers between 7 April 2009 (date of last driver fault report) and 15 May 2009 (date of incident).

Woolworths Ltd fuel maintenance contractors inspected the service station on 28 April 2009 (17 days before the incident). They did not report any defects for the vapour recovery point.

In his statement made following the incident, the driver recalled that "there was no smell of product at all around the spill box area" after he had opened the discharge valves on the tanker to commence unloading fuel into the the two underground petrol tanks.

Faulty or leaking fill lines to the underground tank

Discussions with tanker drivers and petroleum tank installation companies during the investigation indicated that leaks are known to occur at the fill points (e.g. from the fill adaptor; see Figure 62) and fuel from these leaks find its way into the containment sump under the spill box. However, it is unlikely there was any leakage from the fill lines when the fuel transfer commenced on 15 May 2009 because the driver reported that everything appeared normal at the time. It is possible that there was a leak from one of the fill point elbows because, being covered by the metal spill box, they were not visible to the driver during the filling process. The vapour recovery elbow would have been visible to the driver.

The fill point and vapour recovery elbow joints have been examined for signs of fire damage (see Section 3.6). The fire caused significant damage to pipe elbows, and a significant amount of fuel may have entered the containment sump after the fire started until the tanker outlet valves were shut off by the tanker driver. The fuel is likely to have come from discharge hoses that had melted in the fire. Thus, burning liquid would have entered the containment sump through a small gap between the edge of the fill point assembly and the metal spill box (see Figure 41).

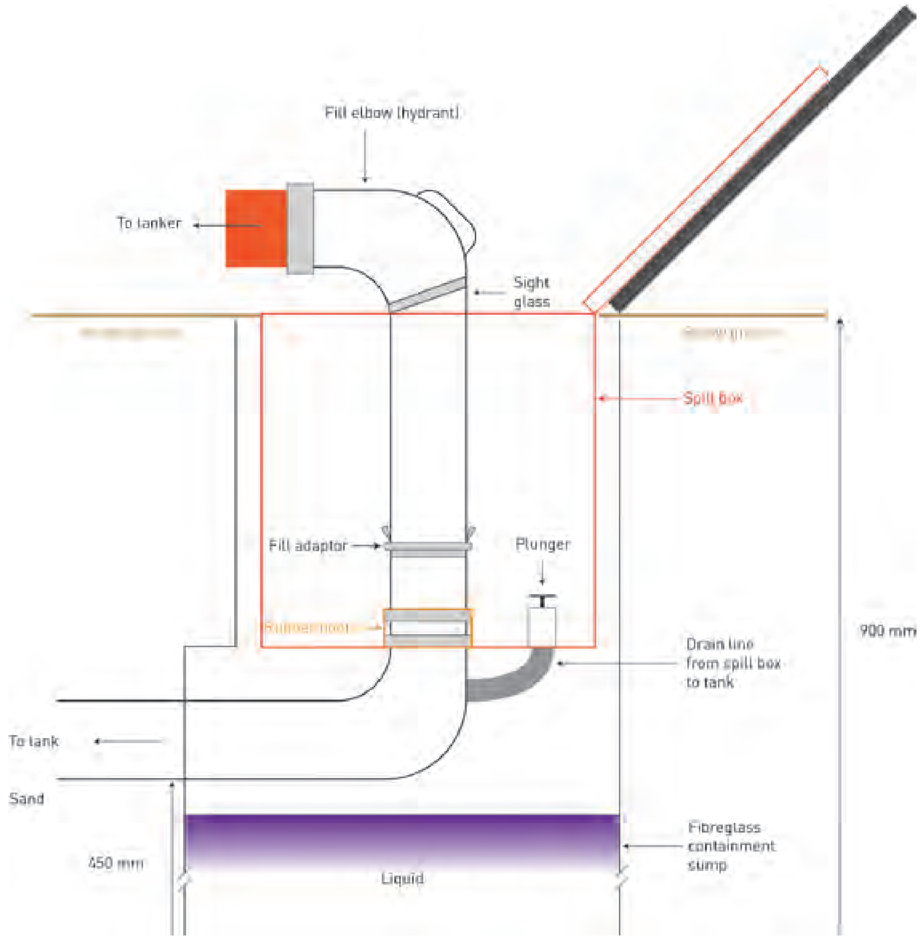


Figure 62 *Cross section showing fill box assembly and containment sump typical of modern service stations in Western Australia. Note: Figure is diagrammatic and not to scale*

Flammable liquid in the containment sump underneath the underground tank fill box

Most fill points at modern Western Australian service stations have a fibreglass containment sump under the metal spill box. The purpose of the sump is to protect the local environment by providing an additional barrier to any fuel that escapes from the fill box assembly (see Figure 62). However, the fill points at the Woolworths Petrol Maddington service station were inside a metal spill box designed to capture minor spills during fuel transfer. Spills collected in the spill box drained into one of the product tanks through a plunger valve in the spill box, which had to be opened manually to drain the collected fuel.

The containment sump at the Woolworths Petrol Maddington service station is 900 mm deep. In his statement, the driver said that there was "a fair amount of liquid inside the sump". He could have seen this only through the vapour recovery point.

The lowest points of the fill point and vapour recovery elbows were about 450 mm from the bottom of the containment sump. The observed fire damage to the fill point and vapour recovery elbows indicates that flammable liquid had filled the tank to a depth of about 400 mm.

The tanker driver recalled that he had seen liquid inside the sump on a previous occasion and believed that someone had reported it to Toll Liquid Distribution. A Toll Liquid Distribution unsatisfactory delivery condition report (UDCR) had been submitted by another driver on 17 April 2009 (about four weeks before the fire), and fuel and water was removed from the sump by a Woolworths contractor during a maintenance check on 28 April 2009.

In the four months before the fire, two Toll Liquid Distribution drivers had submitted UDCRs to report faults at the Woolworths Petrol Maddington service station. Overall, four UDCRs had been submitted noting leaks from the fill point or spill box into the containment sump. On receipt of the UDCRs, Toll Liquid Distribution staff reviewed them and, if further action was required, forwarded them to Woolworths for action. The reported faults were investigated and rectified in three of the four cases. There is no record of action being taken in response to the fourth UDCR. However, the fill points at the service station were checked, and liquid was pumped out of the sump by a Woolworths contractor 11 days after the fourth UDCR was submitted.

Between 28 April 2009 (last maintenance check by Woolworths contractor) and the fire on 15 May 2009 (an interval of 17 days), enough liquid had collected in the sump to be noticed by the driver on the day of the fire.

It appears that minor spills around the fill points were not being contained adequately in the spill box, and were leaking or overflowing into the containment sump.

The containment sump at the Woolworths Petrol Maddington service station has a volume about 800 L. When flammable liquids partially fill the sump, flammable vapours would fill the remaining volume. It is possible that every time the vapour recovery and fill point covers are opened, mixing of fuel vapour and air could produce a vapour–air mixture in explosive concentrations (1.2 to 7.4% fuel vapour).

Inferences

The fire at the service station was fuelled by a fuel vapour–air mixture in the containment sump. The source of the fuel was either past spillage into the fill point assembly, or leakage from one of the fill point elbows that was not noticed by the tanker driver during the transfer of fuel on 15 May 2009.

5.2 Possible ignition sources

Having established the likely fuel source, the next question is "What ignited the fuel vapour–air mixture?"

The following potential ignition sources have been considered.

External ignition sources

No evidence was found during the investigation to indicate that someone was smoking or had a naked flame in the general area of the fill point. The driver was not a smoker and the service station's CCTV footage did not show anyone smoking or exposing a naked flame near the fill point.

The tanker driver was the person closest to the fill point just before the fire started. He stated that although he had a mobile phone, it was inside the prime mover cabin at the time of the incident.

The shielded exhaust system fitted on the prime mover complied with Australian Standard AS 2809.2:1990 *Tankers for dangerous goods – Road tank vehicles for flammable liquids* and was at least 5 m from the fill points. The system is designed to discharge exhaust at a level above the height of the cabin. The heat produced by the exhaust would not have affected the area near the fill points because of the separation distances involved.

The wiring on the prime mover and trailer are enclosed in conduit.

Mechanical failure on vehicle (tyre or brake fire)

Toll Liquid Distribution and a third-party contractor reviewed the condition of the brakes and bearings of the wheels of the tanker trailer and found them to be in good condition.

CCTV footage indicates that the fire started in the fill point area and spread to the tanker, rather than spreading from the tanker to the fill points.

Electrostatic discharge

Compliance with Australian Standard AS/NZS 1020:1995 *The control of undesirable static electricity* was considered for the five aspects of the fuel transfer operation.

Tanker fuel transfer

The typical transfer rate from a tanker to an underground tank through a 100 mm flexible hose and fill line is about 1000 L/min, which means it takes about eight minutes to empty an 8000 L tanker compartment. At this flow rate, any static charge generated by fuel flowing through the pipework should be safely dissipated to earth, either through the discharge hoses or through the earth lead in the fill box assembly.

Reconciliation of the dip readings of the underground tanks before and after the fire suggests that the flow rate during fuel transfer on 15 May 2009 was typical for this mode of tank-filling operation.

Electrical conductivity of petrol

Australian Standard AS/NZS 1020:1995 *The control of undesirable static electricity* states that liquids with electrical conductivity readings of less than 10 pS/m can present electrostatic hazards.

The conductivities of samples of unleaded petrol from the tanker involved in the fire and another service station were measured and compared to determine if the conductivity of the petrol in the tanker on the day of the fire could have been a contributory factor (Table 2).

The results suggest that conductivity was not an issue. The high reading for the petrol sample from compartment 4 of the tanker may reflect the boiling off of lighter petrol fractions during the tanker fire. Compartment 4 adjoined compartment 5, which ruptured in the fire.

Table 2 *Comparison of electrical conductivity of petrol samples from the tanker and another service station*

Sample	Electrical conductivity (pS/m)
ULP from compartment 4 of Toll trailer 12001 (registration 8WX 645) Sampled 18 May 2009	72
Caltex ULP 91 from service station Sampled 5 August 2009	23
Electrostatic hazard range	**< 10**

pS/m = picosiemen per metre

Electrical continuity of discharge hoses

Through a third-party contractor, Toll Liquid Distribution regularly tests its hoses for compliance with ADG7.

Three hoses were carried on the tanker trailer on 15 May 2009. There were two flexible discharge hoses (yellow) and one vapour recovery hose (dark grey). These hoses were last tested on 6 March 2009, and all passed the required pressure and electrical continuity tests.

Electrical continuity of fill box assembly

The electrical continuity of the fill box assembly was assessed at the service station on 13 August 2009. It was not possible to measure the electrical continuity of the vapour recovery fitting, but testing of the fill box and other fittings indicated the fill box was electrically continuous.

The tank system had passed the required electrical continuity tests when it was commissioned.

At the time of the fire, an earth lead was connected to the spill box and a bonding strip was connected from the spill box to the vapour recovery point.

Static accumulation in a human body

In his investigation manual, Kuchta (1985) stated that a human body can accumulate hazardous static charges, and an average-sized human can produce a static discharge of 15 mJ, which is greater than the minimum ignition energy of most combustible–air systems.

The minimum ignition energy for n-hexane at atmospheric pressure is 0.29 mJ at 25°C. Charge dissipation is greater in a liquid than a dry gaseous medium.

Bureau of Meteorology weather data (at Jandakot) for 15 May 2009 indicate that at 13:30 the temperature was 23.9°C and the relative humidity was quite low at 25%. The low humidity on the day of the fire suggests that the likelihood of a static build-up was high. However, the driver advised that he was wearing standard issue Toll Liquid Distribution clothing comprising all-cotton shirt and trousers, high visibility anti-static vest, safety boots with anti-static sole, PVC single-dipped gloves and safety glasses.

Although the conditions were ideal for the generation of a static charge, it is unlikely that a static charge from the driver caused ignition. No leaks or spills that might have been ignited by a static charge were observed around the fill point area, and the driver was inside the cabin of the prime mover when the fire started.

Thermite reaction

A thermite reaction has also been considered as a source of an incendive spark near the fill point area. It has been suggested (Roger Marris, West Yorkshire Fire Service, written communication, July 2009) that this reaction can occur if an aluminium fitting hits a ferrous object (e.g. a rusty component on the fill box assembly)

As the driver was several metres away from the fill box area, and not handling any equipment when the fire started, it is unlikely that thermite reaction was the ignition source.

Inferences

A definitive ignition source could not be identified using the available evidence. External ignition sources, mechanical failure on the vehicle and thermite reaction have been ruled out as ignition sources for this fire.

There is some uncertainty about the possibility of an electrostatic discharge near the vapour recovery fitting as it was not possible to measure the electrical continuity of the vapour recovery point. Therefore, it cannot be definitively stated that the fill box and fittings were electrically continuous at the time of the fire.

5.3 Other information considered during the investigation

Fill point fires in Western Australia

The DMP investigating officers reviewed two fill point fires that occurred at a service station in Rivervale on 23 January 2006 and 16 January 2010. The Rivervale service station has a remote fill box with a spill box on top of a containment sump, which is a similar arrangement to that at the Woolworths Petrol Maddington service station.

The ambient conditions at the time of both incidents in Rivervale were similar, with warm weather and low relative humidity. These conditions are conducive to the generation of static electricity. In both cases, the fire around the fill point was quickly controlled using portable fire extinguishers and the fire did not escalate to involve the tanker vehicles.

In the 2006 incident, there was a substantial amount of petrol in the spill box when ignition occurred. The driver was using the plunger valve unit in the spill box to drain petrol into an underground storage tank. Ignition occurred and the driver suffered serious burns.

In the 2010 incident, the driver of the tanker had completed the transfer of premium unleaded petrol into an underground tank and had lifted the fuel transfer hose to drain the remainder of the petrol into the tank when a fire started near the fill point. The driver suffered minor burns.

Investigations into both incidents indicate that the ignition of a petrol vapour–air mixture in the fill point area was probably caused by an electrostatic discharge, most likely from the drivers, even though they were wearing insulating gloves, cotton clothing, and boots with anti-static soles.

At both incidents, fill points and associated equipment were correctly earthed and bonded.

In the case of the Maddington fire, the driver was well away from where the fire started, which was about 5 m from the prime mover cabin. Consequently, it is unlikely that an electrostatic discharge from the driver ignited the fuel vapour–air mixture.

Design of containment sump and spill box

The large volume of the containment sump at the Woolworths Petrol Maddington service station increases the hazard when flammable liquid, and hence flammable vapour, is present. This sump would be redundant if the spill boxes worked effectively.

Liquids in the spill box or boxes are generally drained immediately to an underground tank by the delivery driver, using a plunger valve

(Figure 62).

Any fuel in the containment sump must be removed with an external pump, and this is generally undertaken by external maintenance contractors, either when called for this specific problem, or during routine maintenance calls.

In summary, minor spills into the spill boxes are removed soon after they occur. This means that flammable vapour is present transiently during and slightly after a delivery, while any spill into the containment sump will result in flammable vapour being present until the sump is pumped out and dried, which may be days or weeks after the spill occurs.

The depth of the sump is such that after pumping it out it may be a considerable time before flammable vapour disperses.

The Toll Liquid Distribution UDCRs for the Maddington site in the months before the incident refer to leaks through the seals where the fill point pipes pass through the spill box, such that petrol leaked into the containment sump.

Although the metal spill box provided at the Woolworths Petrol Maddington service station satisfies the requirements of the current Australian Standard AS 4897:2008 *The design, installation and operation of underground petroleum storage systems* for each fill point to have provision for spill containment with a holding capacity of 15 L, this incident highlights shortcomings in the design.

6

LEGISLATIVE REQUIREMENTS

6 Legislative requirements

6.1 Applicable legislation

The fire at the Woolworths Petrol Maddington service station was related to the transfer of dangerous goods into underground tanks. This activity is subject to the *Dangerous Goods Safety Act 2004* and two sets of regulations:

- Dangerous Goods Safety (Storage and Handling of Non-explosives) Regulations 2007; and
- Dangerous Goods Safety (Road and Rail Transport of Non-explosives) Regulations 2007.

The transport regulations refer to ADG7, which directly refers to various parts of AS 2809 Set:2008 covering road tank vehicles for the transport of dangerous goods. The two parts of this Australian Standard relevant to the investigation are:

- AS 2809.1:2008 *Road tank vehicles for dangerous goods – General requirements for all road tank vehicles*; and
- AS 2809.2:2008 *Road tank vehicles for dangerous goods – Road tank vehicles for flammable liquids*.

6.2 Requirements for storage and handling of dangerous goods

The storage and handling regulations require sites storing above manifest quantities of dangerous goods to hold a Dangerous Goods Site Licence.

Dangerous goods storage and handling facilities must be designed, installed and maintained so that they can be operated with minimal risk to people, property and the environment.

New and replacement underground petroleum storage systems (post-1 March 2008) must comply with the requirements of Australian Standard AS 4897:2008 *The design, installation and operation of underground petroleum storage systems*.

Underground tank systems that were installed before 1 March 2008 were subject to the repealed Explosives and Dangerous Goods (Handling and Storage of Dangerous Goods) Regulations 1992 and the *Explosives and Dangerous Goods Act 1961*. The 1992 regulations required, as a minimum, compliance with AIP CP4.

Compliance of service station operator

- Woolworths Ltd leases the Maddington service station site from another company and has a site licence.
- The underground tank installation at this site was designed in compliance with the requirements of AIP CP4.
- Initial testing of the electrical continuity of the spill box when originally installed was done by an electrical contractor.
- An emergency service manifest was available as well as an emergency plan for the site.
- Fire extinguishers were available at the service station.
- On 28 April 2009, 17 days before the incident, Woolworths employed a contractor to conduct a maintenance check of the site, which included the removal of liquid from the containment sump.

6.3 Requirements for transport of dangerous goods

The transport regulations require the tanker vehicle design and operation to comply with the requirements of ADG7 and relevant Australian Standards.

Regulation 141(1) of the Dangerous Goods Safety (Road and Rail Transport of Non-explosives) Regulations 2007 and section 10.2.3 of ADG7 specify that vehicle cabins must not be occupied during dangerous goods transfer operations.

Tanker trailers for dangerous goods must be licensed by a relevant State Competent Authority. This is DMP in Western Australia.

Drivers of road tankers containing dangerous goods are required to be licensed by DMP. Before a Dangerous Goods Driver's Licence is issued, applicants must demonstrate that they:

- have attended and passed a dangerous goods driver training course;
- are in good health; and
- have a good driving record.

Compliance of Toll Liquid Distribution

- The tanker design complies with the requirements of AS 2809.2:1990 for flammable liquid tankers.
- Two dry powder fire extinguishers were fitted to the tanker trailer, but the driver did not use them. Both extinguishers were located in the middle section of the trailer (Figure 72).
- AS 2809.1:2008 states (as do the 1985 and 1999 editions) that, where practicable, one extinguisher should be placed towards the front right side of the tanker and the other unit diagonally opposite towards the back of the tanker. The location of one of the fire extinguishers on the Toll Liquid Distribution trailer was directly adjacent to the connected transfer hoses, which made it difficult to access during the fire.
- Tanker maintenance was conducted and complied with the requirements of the regulations and AS 2809.2:2008.
- The vapour and product discharge hoses were tested regularly. The hoses were last tested on 6 March 2009 and found to be satisfactory.
- A Toll Liquid Distribution transport emergency officer assisted with the fire emergency and the recovery of fuel from the damaged tanker.
- Toll Liquid Distribution had a procedure in place to deal with faults at service station sites. On four occasions (between January and May 2009), UDCRs were submitted to Woolworths for action. Three of the four UDCRs were investigated and rectified. Although there was no record of the fourth UDCR being dealt with, 11 days after it was raised by the tanker driver, the fill points at the service station had been checked and liquid pumped out of the containment sump by a Woolworths contractor.
- The tanker involved in the fire at Maddington was licensed by the Victorian Workcover Authority for transport of Class 3 (flammable liquid) dangerous goods. This vehicle is permitted to operate in Western Australia with a Victorian Dangerous Goods Vehicle Licence.

Compliance of tanker driver

- The driver holds a valid Dangerous Goods Driver's Licence issued by DMP.
- The driver followed Toll Liquid Distribution company procedure for pre-delivery checks at service stations.
- The driver did not use the fire extinguishers that were fitted on the tanker vehicle.
- The driver was inside the cabin of the prime mover at some stage during the fuel transfer operation. This is contrary to the requirements of section 10.2.3.3 of ADG7 and in breach of regulation 141(1) of the Dangerous Goods Safety (Road and Rail Transport of Non-explosives) Regulations 2007.

7

CONCLUSIONS AND RECOMMENDATIONS

7 Conclusions and recommendations

The investigation by DMP officers led to the following conclusions.

7.1 Cause of fire

The fire was the result of ignition of a mixture of fuel vapour and air near the fill point assembly.

It is likely, for the following reasons, that the fuel source (probably petrol) was in the containment sump before the driver started filling the tank.

- There were no leaks (vapour or petrol) observed by the driver when he commenced discharging petrol into the underground tanks. Previous leaks had been reported by other drivers, but no remedial actions were deemed necessary by a contractor hired by the service station management.
- Knee-high flames were observed coming from the vapour recovery point of the fill box and a small flame from the gap between the fill box assembly and the spill box. If the fuel source was the result of leakage from the fill point connections of the discharge hoses, the driver would have seen the fire coming from the metal spill box and not from the containment sump.
- There was no evidence of faulty pipework between the fill point elbow and the fill lines immediately before fuel transfer started.

DMP's investigation team, in collaboration with FESA and other parties, including representatives from Toll Liquid Distribution and Woolworths Ltd, have explored all likely ignition sources for this type of fuel transfer operation, but could draw no firm conclusions. Thus, the ignition source for the fire at Maddington is unknown.

Transfer operations involving flammable liquid will generate a static charge that can normally be safely dissipated through electrically conductive hoses and earthed spill boxes and fill points. However, because the vapour recovery point was removed to secure the safety of the underground tank installation the day after the fire, in situ examination of the vapour recovery point was not possible. It cannot be definitively stated that the fill box and fittings were electrically continuous at the time of the fire.

7.2 Spill box system

The current Australian Standard AS 4897:2008 *The design, installation and operation of underground petroleum storage systems* requires each service station fill point to have provision for spill containment with a holding capacity of 15 L, and the metal spill box provided at the Woolworths Petrol Maddington service station already satisfies this requirement.

Containment sumps were introduced to modern service station designs to improve environmental protection around fill points. However, most service stations in Western Australia do not have additional spill containment installed underneath the spill box. During this investigation, DMP officers inspected the fill points at 20 service stations in the Perth metropolitan area and found that four of the sites had containment sumps under the spill boxes — and all four contained a mixture of fuel and water. It seems likely, therefore, that containment sumps beneath service station fill point spill boxes routinely contain liquids. In many cases it may be water only but, in some situations, as at the Woolworths Petrol Maddington service station, it can be a mixture of water and fuel, with the fuel floating on top. The fuel could be petrol, diesel or both.

Hence, the presence of the containment sump has led to situations where petrol and petrol vapour are present near the fill point assembly. This was a significant contributing factor for the Maddington fire, as it was this fuel that burnt in the initial stages of the fire. Video footage and witness statements place the initial fire in and above the fill point and containment sump. The containment sump is not normally drained by delivery drivers or service station personnel. Instead, contractors are usually employed for this task. Consequently, under current procedures, the containment sump is not drained immediately before fuel delivery.

In effect, the introduction of containment sumps for environmental reasons has had an unintended consequence — the creation of an ignitable mix of air and fuel vapour that will be constantly present at the vapour recovery point if sumps are not are regularly checked and liquids drained. For this reason, the current practice of installing containment sumps under fill points for underground tanks should be reviewed in light of the hazard it introduces when fuel is present in the sump.

The safety of containment sumps can be improved by implementing the risk control measures described below.

- Consider whether a sump should be installed at all, as this would eliminate the hazard.
- Backfill the whole containment sump space with inert material such as sand or pea gravel (Figure 63).

- Provide additional engineering controls by redesigning the containment sump so that liquid can be detected or removed, at the same time minimising the exposed surface area where flammable liquid or vapour may be present.
- Regularly check to ensure fill points are clean and free of liquids, in both the spill boxes and sump.

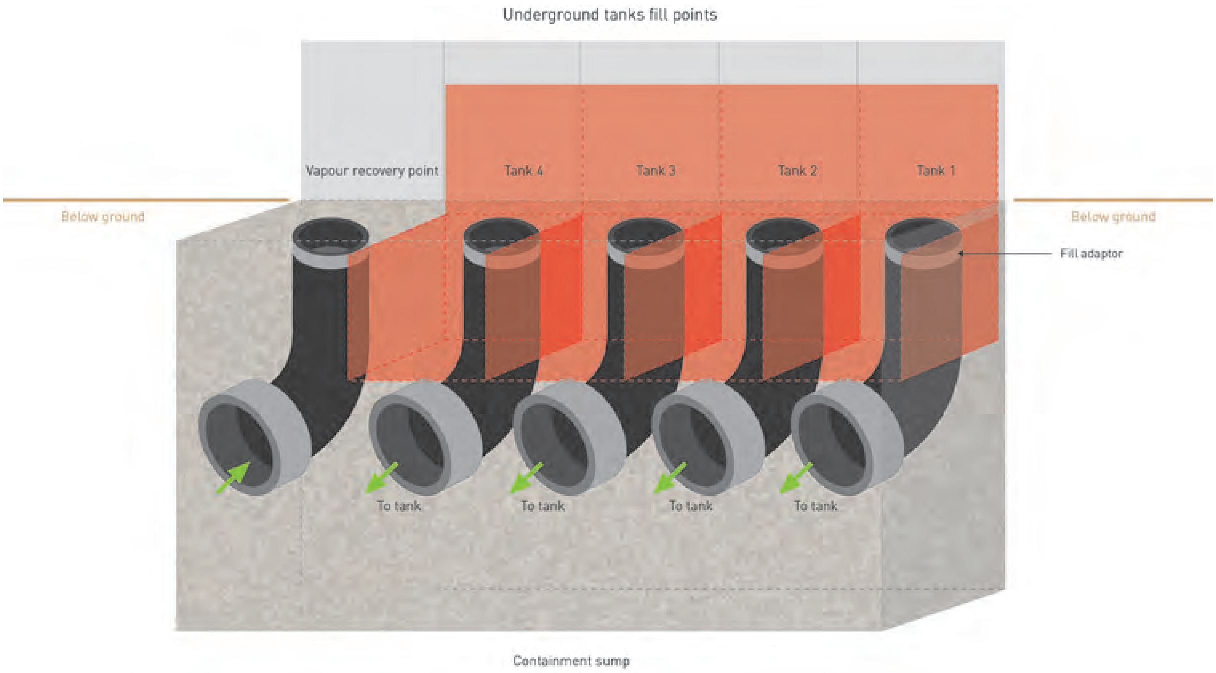


Figure 63 *Sketch of a fill box assembly sitting above a containment sump. The vapour recovery area and containment sump are back-filled with soil or crushed rock. Red box indicates one metal box (spill box) for fill point spill containment. Note: Figure is diagrammatic and not to scale*

There is also scope for the fundamental design of fill point systems to be reviewed to identify and address any flaws in the secondary containment provided by the spill boxes, such that containment sumps may be unnecessary.

The Toll Liquid Distribution UDCRs for the Maddington site in the months before the incident refer to leaks through the seals where the fill point pipes pass through the spill box, such that petrol leaked into the containment sump. If the seals (which are of elastomeric construction) had a more robust design, or were eliminated through having the pipes welded to the spill box assembly, there would be no leaks into the sump and the sump would be redundant.

Recommendation 1

The petroleum industry should review the design of spill boxes around underground tank fill points to ensure that they are liquid tight under operational conditions.

Recommendation 2

The petroleum industry should review the design and use of containment sumps under fill boxes for underground tanks to ensure that risk is minimised to people, property and the surrounding environment. The outcome of this review should be to eliminate or otherwise minimise the risk of fire in containment sumps under spill boxes. Emptying of sumps should not rely on ad hoc reports of the presence of liquid in the sumps.

Recommendation 3

Service station operators and transport operators need to be vigilant in checking for the presence of flammable liquids in containment sumps, if fitted, and have liquid removed from the sumps as soon as possible.

7.3 Location of fire extinguisher mountings on tankers

The fire extinguishers mounted on the Toll Liquid Distribution tanker involved in the Maddington fire were poorly placed for quick access in an emergency. The nearest extinguisher to the driver was too close to the place where a fire would most likely occur. Attempts to remove this fire extinguisher from the tanker during the fire were unsuccessful. It is not clear why the second fire extinguisher on the tanker was not used, nor why extinguishers were not brought from the service station to the fire.

Since the fire at Maddington, all drivers of Toll Liquid Distribution tankers have been instructed by the company that before commencing fuel transfer, they must remove one of the truck fire extinguishers from its mounting and place it close by for quick access in the event of a fire.

Other fuel tanker operators are urged to adopt this as part of their standard operating procedures.

Recommendation 4
Fuel tanker operators should review the location of fire extinguishers on tanker vehicles to ensure they are readily accessible in an emergency. Fire extinguishers should be removed from their mountings and placed beside the driver during fuel transfer, so that action can be taken quickly to extinguish any fire that may develop in the transfer area.

Recommendation 5
Tanker drivers should periodically receive practical refresher training in fire extinguisher use to ensure that they are ready to respond to an emergency when the need arises.

7.4 Electrical continuity in underground tanks storage systems

Australian Standard AS 4897:2008 *The design, installation and operation of underground petroleum storage systems* requires that the electrical continuity of the storage system is tested at the time of installation.

Regular continuity testing is specified in clause 9.8.12 of Australian Standard AS 1940:2004 *Storage and handling of flammable and combustible liquids*. However, there is no equivalent provision for underground tanks in Australian Standard AS 4897:2008 *The design, installation and operation of underground petroleum storage systems*.

Although it was not possible to determine whether an electrostatic discharge near the vapour recovery point was the ignition source, regular testing would ensure its exclusion as a risk factor.

Recommendation 6
Service station operators should regularly (at least six-monthly) check the electrical continuity of underground fuel tank systems.

Recommendation 7
Australian Standard AS 4897:2008 should be amended to require regular electrical continuity testing of underground fuel tank systems.

7.5 Legislative requirements and compliance

Shortcomings in regulatory compliance were identified during the investigation but enforcement action is not considered to be in the public interest. However, safety improvements are recommended in relation to the design and operation of underground petroleum storage systems and dangerous goods transport operations.

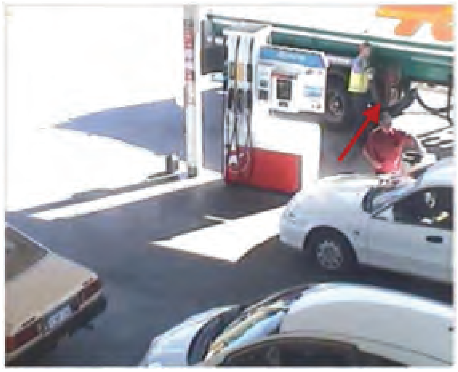
Recommendation 8
It should be emphasised throughout the petroleum industry that, as set out in section 10.2.3.3 of ADG7, fuel tanker drivers should not to be in the vehicle cabin while transfer operations are in progress. The driver's responsibility is to observe the transfer operation to allow early detection of anomalies that may have serious consequences.

APPENDICES

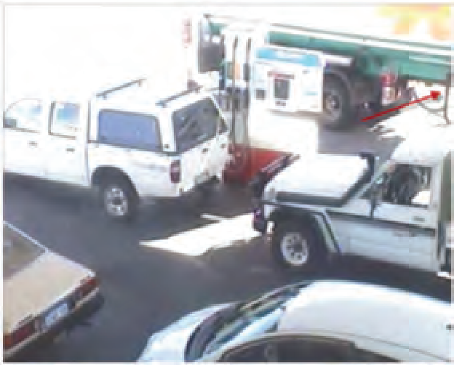
Appendix 1

Chronology of events based on CCTV footages

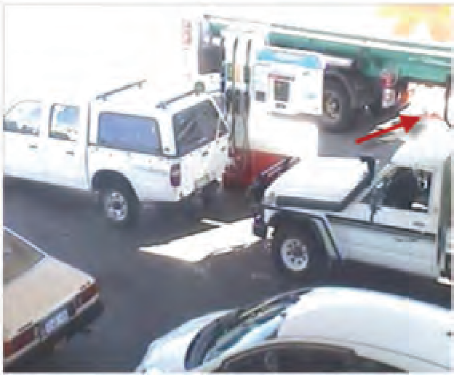
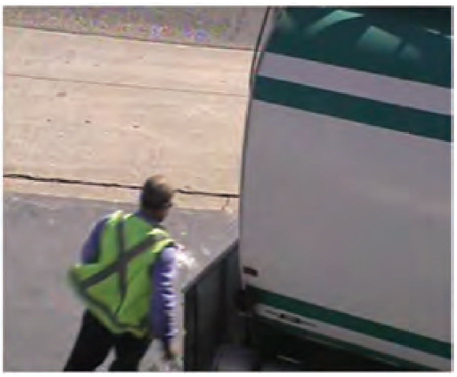
Event	CCTV time	Comments	Camera location	Image
Tanker arrives at Caltex Maddington 207 Burslem Drive Maddington See Figure 14 for location of tanker	13:30:43	Driver did not recall exact arrival time at the service station but wrote that he arrived at 13:45	Pump 5/6	
Driver sets up safety cones	13:33:15		Pump 5/6	
Driver dips one of the underground tanks	13:34:40	Driver dipped underground tanks to determine how much fuel he could transfer to the tanks	Pump 1/2	

Event	CCTV time	Comments	Camera location	Image
Driver connects vapour recovery hose from tanker	13:39:16	Red arrow points to vapour recovery hose	Pump 5/6	
Driver connects hose to compartment 6 of tanker	13:39:59	Arrow points to shadow of transfer hose connected to compartment 6	Pump 5/6	
Driver gets second hose from rear of trailer (driver side)	13:40:15	Driver standing next to one of the dry powder extinguishers mounted on the truck	Pump 5/6	
Driver connects hose to compartment 5 of tanker	13:40:37	After connecting the hoses, driver opened the valves on the tanker to commence transfer There was no smell of fuel around the spill box area Red arrow points to shadow of transfer hose connected to compartment 5	Pump 5/6	

Appendices

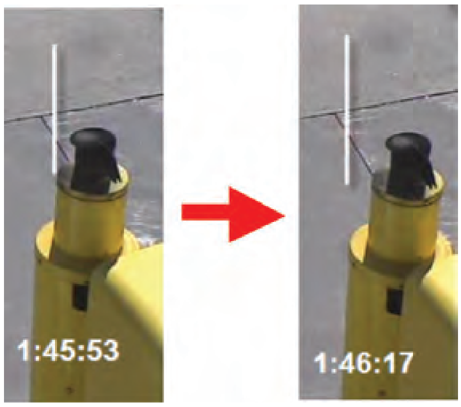
Event	CCTV time	Comments	Camera location	Image
Driver walks to the front of the vehicle, just behind passenger door of prime mover	13:40:57	Driver was standing towards the front of the trailer	Driveway entry 2	
Driver standing by passenger door of prime mover	13:42:04		Driveway entry 2	
Flash recorded on CCTV footage in the vicinity of the fill point	13:43:15	Driver heard a "bang" and a "whoof", which sounded like two cars colliding Driver was unsure of how much time had passed between start of fuel transfer and hearing the "bang" A witness in a vehicle pulled into the service station next to the prime mover and recalled seeing the tanker driver sitting inside the prime mover cab Witness alerted the tanker driver to the fire near the fill point	Pump 5/6	

Appendices

Event	CCTV time	Comments	Camera location	Image
Driver's head appears near passenger door of prime mover	13:43:28		Driveway entry 2	
Driver reacts to "bang"	13:43:30		Driveway entry 2	
Flames visible beneath tanker	13:43:37	Driver saw knee-high flames in the area of the vapour recovery connection and sump and low-level flames around two fill points Witness recalled seeing flames in the area of the vapour recovery hose connection	Pump 5/6	
Driver grabs a bucket of water and returns to tanker	13:43:59	Driver recalled grabbing bucket of water and pouring water into the sump	Driveway exit 1	

Appendices

Event	CCTV time	Comments	Camera location	Image
Fire appears to have been extinguished, but reignites a second or two later	13:44:05	Bystander threw a bucket of water under tanker	Pump 5/6	
Driver disconnects vapour recovery hose from vapour recovery connection	13:44:16	When fire reignited, vapour recovery and delivery hoses were on fire Tanker valves were shut off manually and vapour hose was removed from vapour recovery elbow Driver tried to remove the fuel transfer hoses from fill point elbows but was unable to do so Driver's gloves and boot on fire	Pump 5/6	
Witness One attempts to take a fire extinguisher from the driver side of the tanker, but heat and flames are too intense	13:44:29		Pump 5/6	

Event	CCTV time	Comments	Camera location	Image
Driver goes to service station building and asks people to phone 000 and evacuate the building	13:44:53		Store entry	
Tyres closest to the fill point, on passenger side of tanker, now on fire	13:45:08		Pump 5/6	
Vehicle has moved slightly forward, probably as a result of a tyre bursting	13:46:04	FESA Communications Centre alerted at 13:46 Maddington fire officers arrived at the scene at 13:48 FESA officer observed vapour recovery hose not connected	Drive entry 2	
Large fireball forms and extends from tanker towards shop building	13:55:52	FESA crews later advised that tanker compartment 6 ruptured about 13:53	Pump 5/6	

Event	CCTV time	Comments	Camera location	Image
Second fireball forms and extends from tanker towards shop building	14:04:31	FESA crews advised that compartment 5 ruptured about 14:00	Store entry	
Fire extinguished	~ 14:30			

Appendix 2

Bibliography

Australian Standards

- AS/NZS 1020:1995 *The control of undesirable static electricity*
- AS/NZS 1596:2002 *The storage and handling of LP Gas*
- AS 1940:2004 *Storage and handling of flammable and combustible liquids*
- AS 2809.2:1990 *Road tank vehicles for dangerous goods – Tankers for flammable liquids*
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