The fire and explosions at Permaflex Ltd, Trubshaw Cross, Longport, Stoke on Trent, 11 February 1980

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Health and Safety Executive

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Summary

On the 11 February 1980 a fire and a series of explosions occurred at a warehouse in a factory at Trubshaw Cross, Longport, Stoke-on-Trent. On the morning of the fire the warehouse contained some 49 tonnes of liquefied petroleum gas (LPG) in cartridges and aerosol containers as well as about 1 tonne of petroleum mixtures in small containers, raw materials, and packaging materials. It is almost certain that the source of ignition was the electrical system of a battery operated fork lift truck.

Although the fire brigade was on the scene within three minutes of receiving a 999 call at 14.28 hours, the fire spread rapidly through the warehouse destroying it and damaging other buildings on the site. Minor damage to the roofs, guttering, windows and paintwork of nearby industrial, commercial and domestic premises was also caused. One employee was detained in hospital with burns and two members of the public received hospital treatment, one for minor lacerations and one for shock.

LPG is a well known fire and explosion hazard; the circumstances of the fire emphasise the need for occupiers of premises containing LPG to be adequately informed, by obtaining information and advice from authoritative sources, on the hazards of LPG and the precautions to be observed in its storage.

The main warehouse should have been classified as a zone 2 area for the purpose of the selection, installation and use of electrical apparatus, and only apparatus suitably explosion protected for such an area should have been installed or used in it. The electrical apparatus, including the battery-operated trucks were not so protected and were therefore unsuitable.

The storage of LPG in the main warehouse was unsatisfactory and did not comply with the HSE Code of Practice for the Keeping of LPG in Cylinders and Similar Containers*. In particular:

- although the walls of the warehouse were of brick construction all other elements of the LPG store such as doors, windows and ceilings were not of incombustible materials and of suitable fire resistance;
- the LPG store was not single storeyed;
- adequate permanent ventilation at both high and low level was not provided in the LPG store;
- materials other than LPG were kept in the store.

The report recommends that:

– The present regulations covering LPG exempt containers below a certain size from provisions relating to storage. It is probable however, that a wide variety of premises, particularly manufacturers and wholesalers, maintain large stocks of aerosols containing LPG which are not currently subject to specific regulatory control. The present regulations relating to the storage of highly flammable gases are not entirely satisfactory and this incident provides further justification for the current HSC/HSE programme of reviewing and updating the requirements.

* Now HSE Guidance Note CS4; obtainable from HMSO

– The present regulations relating to electrical apparatus and its use in flammable atmospheres apply to premises subject to the Factories Act 1961. Such apparatus is also installed and used in premises not subject to that Act. The circumstances of this incident endorse the need for reviewing the scope of the present regulations. This is currently being undertaken by HSC/HSE.

– Advice should be prepared on the selection of powered lift trucks for use in premises where LPG is stored.

– The guidance issued to fire authorities on the application of the Fire Precautions Act 1971 to separate buildings, including warehouses, within the close or curtilage of a factory, should be reviewed.

– Consideration should be given to the issue of further advice to fire authorities on the need for liaison with HM Factory Inspectorate before the decision is made that a separate building within the close or curtilage of a factory does not form part of that factory.

The site

Permaflex Ltd have occupied the site in the built-up area of Trubshaw Cross, Longport, Stoke-on-Trent since 1963. In February 1980 the company employed forty people in a range of manufacturing activities. These included the filling of pressurised fuel cartridges with liquefied petroleum gas (LPG) and the assembly and filling of metal aerosol containers. They also assembled and filled lighter fuel containers with liquid petroleum mixtures. A further fifteen people were employed in managerial, commercial and clerical functions.

The company's premises were approximately rectangular measuring some 100 x 65 metres and were bounded by the Trent and Mersey Canal and the A527. The premises included bulk storage, manufacturing, warehousing and office facilities (see the location plan). Warehousing was undertaken in two buildings. These are referred to as the main warehouse, (where the fire occurred) which stored finished products, empty cartridges and packaging materials, and the small warehouse in which only packaging materials were stored.

Butane and aerosol grade 30 and 40 LPG were used in the premises and stored in eight bulk tanks (six 2 tonne and two 3 tonne tanks) at least 60 metres from the main warehouse. Arcton 12/11 and bromo-chloro-difluoromethane were stored in 1 tonne pressurised vessels approximately 80 metres from the warehouse. In the same area, towards the northern end of the site was an underground storage facility for 1100 litres of petroleum mixtures, licensed under the Petroleum (Consolidation) Act 1928. In addition, 330 litres of industrial methylated spirits were stored in an articulated road tanker at the north west corner of the site. The raw material bulk storage facilities were not involved in the fire.

The process

Permaflex Ltd (a member of the British Aerosol Manufacturers Association) manufactured a range of products varying in size from 50–420 g (net content) in which LPG was used either as an aerosol propellant or as the product. The products were marketed under their own trade names or under contract. Manufacture of the products was carried out in accordance with the appropriate sections of the British Standard Institution Specifications – BS 3914: Part 1: 1974 Specification for Aerosol Dispensers and BS 5329: 1976 Specification for non-refillable metallic containers up to 1·4 litres capacity for LPG.

The process involved the filling of metal containers with product and, where necessary propellant. The principal propellants used were aerosol grades 30 and 40 LPG (where the number corresponds to the vapour pressure in psi at 70°F) through a small proportion of the product incorporated Arcton 12/11 or bromo-chloro-difluoromethane as the propellant. Once filled, pressurised containers were immersed in a hot water bath and examined for leaks. Test conditions were dependent upon the size, construction and content of the container. The average failure rate was between 10 and 20 containers per 30000 units of production. Containers satisfying the quality control procedures, were either shrink wrapped onto light plastic trays and then palletised and spiral wrapped, or packed in cartons before being palletised. Packed stock was then despatched directly by road haulage or stored in the main warehouse pending despatch.

The main warehouse

The main warehouse building, was a two storey brick built structure, constructed as a railway goods warehouse in the nineteenth century. It was taken over by Permaflex in 1978. The building measured 65 x 15 metres and was approximately 9 metres high to the eaves. The ground floor was of concrete with an area of approximately 975 sq metres. The external walls 0·45 – 0·90 metres thick incorporated windows on three sides at ground floor level; the exception being the west end wall. All glazing was plain glass. The windows were normally kept closed and each was covered externally with a metal mesh to prevent vandalism. There was no additional means of ventilation

within the building. Two wooden delivery doors, approximately 4·5 metres square, set 9 metres apart and a personnel door were located in the northern side of the building. All three doors gave access into the yard and provided means of escape in case of emergency.

The first floor was supported by fabricated steel joists, anchored into the external walls and centrally supported by a series of cast-iron columns. A new first floor had recently been laid over this supporting structure and consisted of 155 x 102 mm timber joists overlaid with flooring timber and covered by a proprietary floor covering. An enclosed stairway, located at the north east corner of the building provided the only means of access to the first floor.

The ground floor contained office accommodation of single breeze-block construction and consisted of four offices with a combined floor area of approximately 94 sq metres. Two mobile catalytic gas heaters were available for use within the offices, one containing a 15 kg LPG cylinder, the other a 7 kg LPG cylinder. These offices had been in use for approximately four months prior to the fire, pending completion of new office accommodation under construction at the northern end of the site.

The electrical apparatus in the warehouse, including the lighting circuits on both floors and the battery charging units on the ground floor, were not protected for use in flammable atmospheres.

The warehouse was designated a "No Smoking" area. Portable fire fighting appliances were provided but no fire alarm was installed.

The first floor was given over to the storage of palletised packaging materials and components, principally carboard, unfilled metal containers, plastic caps, valve assemblies, etc. The ground floor was used to store palletised packaging materials, components and packed stock (finished goods), both in cartons and spiral wrapping. Packed pallets were stored two high (approximately 3 metres) and pallets of packaging materials were generally stored three high (approximately 4·5 metres). At the time of the outbreak of the fire, there was approximately 49 tonnes of LPG and 1 tonne of petroleum mixtures in or within the vicinity of the building (see location plan for approximate layout). Some 38 tonnes of the LPG was butane, mainly in 420 g Calor Primus cartridges but also in 50 – 110 g lighter refill cartridges. The rest of the LPG was of aerosol grade forming the propellant in 250 g aerosol containers. The petroleum mixtures were also lighter fuel refills in unpressurised 110 cc containers on pallets towards the centre of the warehouse.

Three battery-operated trucks were normally provided for use within the buildings; a pedestrian-operated pallet truck on the upper floor and a second pedestrian operated pallet truck and a CESAB Model ECO/D20-2 48 volt fork-lift truck on the ground floor. The fork-lift truck was also used elsewhere on site. At the time of the fire one of the pallet trucks was not in the building. The three trucks were not electrically protected for use in flammable atmospheres.

The fire

On the afternoon of Monday the 11 February a full complement of staff was on site. Four members of the sales department and the two warehouse staff were at work on the ground floor of the warehouse.

At approximately 13.15 hours warehouse staff began transferring twelve pallets of 420 g Calor Primus butane fuel cartridges from the south west corner of the warehouse to a flat backed lorry parked in the yard, using the battery powered fork-lift truck. At some time between 14.15 and 14.25 hours, the truck entered the corner of the building, raised a load and began reversing along the main gangway towards the door marked "A" on the location plan. At the same time, the warehouse foreman was walking towards the truck along the same gangway. From a distance of about 10 m, the foreman saw a yellow flash emerge from the lower panel of the electrical contactor box on the right hand side of the truck. The flame flashed across the back of the truck to adjacent packaging materials and the truck was engulfed in a ball of flame. The driver leapt from the vehicle through the flame and ran up the gangway weaving past the foreman and into the yard through the door marked "A" on the plan before running back into the building through door "B". The foreman ran towards the eastern end of the building for a fire extinguisher, but finding that the fork-lift truck driver had re-entered the warehouse, he led him to a safe place within the factory complex. He advised the works manager of the fire and the alarm was raised in the production and main office areas. The Staffordshire fire brigade was promptly notified. The works manager and foreman returned to the warehouse with fire extinguishers, but by that time the fire was well established at the western end of the building and thick black smoke was billowing outwards.

Meanwhile a female member of the sales department on hearing an unusually loud noise in the main warehouse had investigated the cause and warned her colleagues of the fire. The four office staff left the warehouse, via the door marked "B". At about the same time, the haulage contractor whose lorry was being loaded, having seen the fork-lift truck driver running from the warehouse and then what appeared to be a red glowing furnace inside the building, promptly removed the lorry and another of his vehicles parked elsewhere in the yard, to allow the fire brigade access to the building.

Events following the outbreak of fire

The fire brigade headquarters at Stafford received the emergency call at 14.28 hours, and three appliances were immediately despatched from the Hanley and Newcastle-under-Lyme fire stations. The first appliance arrived at the south side of the building at 14.31 hours and the senior officer radioed for a further four appliances. By this time the whole building was on fire and aerosol dispensers and butane fuel cartridges were exploding and being violently ejected from the warehouse.

Between 14.32 and 15.12 hours, reassessment by the brigade resulted in the number of appliances in attendance being

increased to twelve, together with a foam tender and hydraulic platform. This level of response was maintained for approximately one hour, after which time appliances began to be released. From the outset, the brigade operated a policy of containment, limiting the fire to the building and not committing or exposing personnel to risk. This policy was continued throughout the afternoon and by 20.59 hours only two appliances remained on site together with 10 monitors (5 hand-held and 5 independent ground monitors) spaced evenly around the building. Water was taken from the town mains and from the nearby canal.

The Staffordshire constabulary in the meantime had sealed off the area. In view of the fire's intensity and the containers which were being continually ejected, local residents and industrial and commercial premises were evacuated shortly after 14.30 hours. By 17.00 hours, it was considered that the fire was under control and was sufficiently contained to allow local residents to return, but the area remained sealed to vehicular traffic.

By 19.30 hours the upper storey, roof, and part of the south wall had collapsed. At approximately 21.00 hours, two major explosions occurred almost simultaneously at the western end of the building where the fire had originated. Immediately beforehand this area had been one of the least active. Rising, spreading columns of flame (about 30 – 40 m in height) containing what appeared to be burning metal particles were seen. A substantial proportion of the damage to adjacent property was caused by these explosions. The area was re-evacuated and the fire brigade commenced a reassessment of adjacent property for secondary fires. A subsequent and apparently similar explosion occurred at approximately 24.00 hours, in the same area of the building.

Local residents and others employed in the vicinity of Trubshaw Cross began to return the following day. The fire continued burning, though with decreasing intensity for some 60 hours. The last area to be extinguished was in the centre of the building, where pallets bearing cans of petroleum mixtures were later discovered. Newcastle Street, Trubshaw Cross and Davenport Street, were reopened to vehicular traffic at 16.30 hours on Wednesday 13 February, by which time demolition of the remains of the building had begun. The fire brigade maintained a presence on site to counter any subsequent outbreak until 18.00 hours on Wednesday 20 February.

Injury and damage

Three people were taken to hospital as a result of the incident: the fork-lift truck driver suffering from severe burns to the hands and face was detained for treatment; but two members of the public were not detained. These were a pregnant woman suffering from shock after the explosions and a man with laceration injuries to the leg caused by flying glass.

The main warehouse and its contents were totally destroyed and the small warehouse located 23 metres away sustained sufficient damage through radiant heat and/or water to warrant partial demolition. Although no other building on site or the bulk material storage facilities were involved in the fire, minor damage was sustained to roofing materials, guttering, paintwork and windows at the southern ends of the main factory and office buildings. The fork-lift truck and pedestrian-operated pallet truck in the main warehouse were destroyed. In addition twelve cars and commercial vehicles on the site sustained varying degrees of damage; and seven vehicles were totally destroyed.

Eleven residential properties and six commercial premises in Newcastle Street, together with adjacent industrial premises, sustained damage including broken window panes, damaged guttering, blistered paintwork and dislodged roof tiles.

Investigation

The Health and Safety Executive was not formally notified of the outbreak of the fire, and it was not until the news was broadcast on the evening of Monday 11 February, that a number of HM Inspectors of Factories, independently became aware of the occurrence. One inspector from the Marches Area arrived at the factory shortly after 19.30 hours, by which time the upper storey, roof and part of the south wall had collapsed and exploding containers were being ejected. The area surrounding the building was littered with ejected containers to a radius of about 100 metres.

Detailed investigation began the following morning. Arrangements were made for technical and scientific support staff from the Midlands Field Consultant Group in Birmingham to assist in the investigation. Enquiries were made concerning all aspects of the company's operations on site. Special attention was given to those connected with the storage of finished goods etc in the main warehouse. The main warehouse itself was unsafe to enter and the contents were still burning. Containers continued to rupture, but were not generally being ejected.

The remaining structure of the main warehouse was considered to be unstable, and arrangements were made with the company for it to be demolished and made safe. Demolition commenced on 13 February 1980 under the supervision of one of HM Inspectors of Factories from the Construction Industry Group for the Marches Area. Following discussions with the company, fire brigade, the demolition contractor and Staffordshire County Council, it was decided that the most appropriate method of disposal for the rubble and debris was to transport it to a licensed toxic waste disposal site where it could remain undisturbed for a protracted period. This would allow natural corrosion and the safe release and dispersal of the flammable contents of any unruptured pressurised containers to occur.

As the clearance operation progressed, several hundred small butane lighter fuel cartridges were found unruptured within the debris. A number of containers ruptured during the following week as clearance continued. This was due either to frictional ignition or localised hot spots. The remains of the fork-lift truck and the pedestrian-operated pallet truck were recovered. The LPG cylinders associated with the portable heating appliances were not identified.

The eye witness account had indicated that the fork-lift truck was involved in the initiation of the fire, so an HM

Electrical Inspector of Factories joined the investigation. A detailed examination of the remains of the fork-lift truck was made and the supplier was visited in order to examine a functioning truck of the same design.

Initiation and development of the fire

LPG vapour is denser than air and therefore tends to accumulate at low levels and in confined or enclosed spaces. Where the concentration of the vapour in air lies within the flammable range of about 2-10% the mixture burns; outside these limits a vapour/air mixture will not burn. For a fire to be initiated, both a flammable atmosphere and a source of ignition need to be present simultaneously.

Although there were a number of potential sources of ignition in the main warehouse, such as the lighting installation, the battery charging units, the pedestrian-operated pallet truck and portable heating units, these can be ruled out as the source of ignition because fire was seen to be initiated in the vicinity of the fork-lift truck. The initial ignition was followed by the rapid passage of flame from the right to the left hand side of the truck. This was typical of a flash back to a pocket of a flammable gas/air mixture.

Once established, the fire spread rapidly through the ground floor from the west to east end of the building in approximately ten minutes. In view of the prevailing moderate south westerly wind, the quantity of LPG, petroleum mixtures and packaging materials, this rate of spread of fire was not surprising. Once the fire was established, the heat generated by the continual release of fuel from ruptured containers in the pack stock, would have been sufficient to ignite the first floor and roof structures. The temperature generated at the seat of the fire was estimated as being about 1500 – 1700°C. This was sufficient to cause the collapse of fabricated steel joists and the melting and fusion of packed stock containers.

The CESAB, Model ECO/D20-2, 48 volt battery powered fork-lift truck, had been purchased in June 1979 for use within the warehouse and external parts of the factory. In operation between June 1979 and 30 January 1980, the truck was reliable and trouble free. However, on the 30 January and again on the 31 January and 1 February, the vehicle developed faults resulting in traction malfunction. On all three occasions, it was examined under a maintenance contract by field service engineers from the supplier, was repaired, pronounced functionally sound and returned to service.

On the 8 February, whilst operating in the open air between the bulk LPG storage facilities and the factory building, a flash emerged from the lower right hand panel of the truck. The truck was immediately taken out of service and was examined by the field service engineer from the supplier. A thorough examination of the truck and its control circuitry were undertaken, but no fault could be found. The truck was reassembled, driven and all functions were tested and found to be operating satisfactorily. No fault could be identified consistent with the emission of flame from the vicinity of the control panel. Whilst at that time, the suggestion was made and accepted in the absence of any other plausible explanation by the field service engineer, that the vehicle had run over a pressurised container, there was no evidence to substantiate this. The truck was considered to be mechanically and electrically sound and on that basis it was returned to service.

When HM Electrical Inspector of Factories visited the fork-lift truck supplier and examined a model ECO/D22 fork-lift truck, he found that the inspection panel on the lower right hand side of the truck between the front and rear axles gave access to the main control panel incorporating contactors and auxiliary switches. The control panel was of conventional design, but was unprotected for use in flammable atmospheres, and in normal operation would give rise to some sparking. The main drive motor, a 48 volt series wound DC motor mounted between the frame members of the chassis, was an open unprotected type. The commutator and brush gear, which would spark freely in normal operation, were exposed. The hydraulic pump motor mounted on the left hand side of the chassis was again of an unprotected type. All these items were potential sources of ignition.

The extent of the damage to the fork-lift truck involved in the fire was such that few meaningful tests could be carried out on it. It was not possible to remove the remains of the battery to gain access to the main drive motor or to the hydraulic pump motor. However, the main and auxiliary contacts of the contactors were intact and could be closed by hand. There was no evidence of abnormal arcing. Continuity tests on the main fuses and links on the truck, established that these components were intact.

Whilst the initial source of ignition had been established with reasonable certainty, the origin of the flammable atmosphere sufficiently extensive to lead to a rapid escalation of the fire remains unresolved. Five hypotheses have been considered.

1 That a natural gas leakage from a source either within or outside the building occurred, resulting in the build up of a flammable atmosphere within the warehouse.
2 That major sewer maintenance work in Davenport Street, gave rise to a flammable concentration of methane or hydrogen-sulphide which infiltrated the warehouse from the main access shaft located 8 m away from the building.
3 That the fork-lift truck ran over, ruptured and subsequently ignited the dispersed contents of one or more pressurised containers.
4 That the fork-lift truck inadvertently punctured and subsequently ignited the dispersed contents of one or more palletised, pressurised containers.
5 That a leakage of aerosol or fuel cartridge contents occurred within the warehouse.

No evidence could be found to substantiate hypothesis (1), (2), (3) or (4). The presence of approximately 49 tonnes of LPG in the building on the morning of the 11 February was however relevant to hypothesis (5). Of the 49 tonnes, approximately 10 tonnes were in the process of being despatched between 13.15 and 14.25 hours. Any leakage from aerosol dispensers or butane fuel cartridges, might

have been expected to have been detectable by the warehouse staff either, by the perfume component in the former or, by the stenching agent incorporated in the latter. In still air however, owing to the high density of LPG vapour, a leakage could lead to a flammable concentration at low level which would be unlikely to have been noticed unless someone bent down. In the absence of adequate low level ventilation, dispersal of any such build up of vapour would have been very slow.

From the accounts of the warehouse staff, no unusual odours, either from aerosol or butane cartridge products were detected within the building immediately prior to the fire. However, with the exception of the fork-lift truck driver, there was no-one working within the vicinity of the south west corner of the building at that time. Thus, there is no evidence to support or deny an assertion that the initial source of fuel for the fire resulted from a leakage of packed stock. One volume of liquid LPG when vapourised completely will produce some 250 equivalent volumes of vapour at normal atmospheric temperatures and pressure, and this, in the ultimate if completely mixed with the appropriate quantity of air, will form 12500 equivalent volumes of flammable LPG/air mixture. Thus even a small leakage from packed stock could have given rise to a localised flammable atmosphere within the truck's operational area.

Of the packed stock within the warehouse, one batch, that being despatched at the outbreak of the fire, attracted particular attention. This batch consisted of palletised 420 gm Calar Primus butane fuel cartridges, stacked two pallets high in the south west corner of the building. The batch, manufactured in June 1979, had been rejected following routine quality control analysis by the customer's laboratory, not as a result of any physical defect in the containers or valve assemblies, but due to high propane content which gave rise to out-of-specification vapour pressure and specific gravity values. The incorrect composition had been traced to a delivery of aerosol grade 48 LPG instead of aerosol grade 30 LPG. Accordingly, the vapour pressure at 45°C was 8·13 bar as against the specification of 5·58 bar. Once rejected, the batch was placed into store within the main warehouse where it remained undisturbed until the 11 February when it was being despatched for disposal. The out-of-specification aerosol grade LPG within the bulk storage tanks had been removed and replaced once the error was discovered.

This batch attracted interest because, (a) the out-of-specification composition resulted in an increased pressure within the cartridges, (b) it had lain undisturbed over seven months, and (c) the remaining 2 tonnes of the batch was located at the seat of the fire. The increased pressure however was most unlikely to have exceeded that specified in the relevant British Standard for the construction of the cartridge, and there was no evidence to support any suggestion that this particular batch made any special contribution to the initiation and development of the fire.

A number of theories were advanced by way of explanation of the explosions between approximately 21.00 and 24.00 hours. It is considered most likely that the explosions resulted from the simultaneous rupture of pressurised containers. Away from the main seat of the fire a number of pallet loads may have been covered by debris and would thus have been protected from direct flame impingement and radiant heat. In consequence, the rise in temperature and pressure through a pallet load would have been almost uniform. Under such circumstances the rupture of one container could have triggered the simultaneous rupture of the pallet load(s). Any particles of aluminium from the ruptured containers, burning in the intense heat, would have been carried up in the column of flame, giving rise to the effects that were seen.

Legislation

The buildings and yards occupied by Permaflex Ltd constituted a factory subject to the Factories Act 1961. The factory had been registered with HM Factory Inspectorate since 1963. Occupation of the warehouse in which the fire occurred commenced in 1978. Since 1976 the only visit to the premises by HM Factory Inspectorate was on 10 October 1979 to investigate an accident. The inspector was not told of the occupation of the warehouse during the visit.

The factory was subject to the Electricity (Factories Act) Special Regulations 1908 and 1944 and to the Highly Flammable Liquids and Liquefied Petroleum Gases Regulations 1972. The Offices, Shops & Railway Premises Act 1963 and the Health and Safety at Work etc Act, 1974 were also applicable.

Regulation 27 of the Electricity (Factories Act) Special Regulations 1908 and 1944 requires that all electrical apparatus exposed to flammable surroundings or explosive atmospheres should be so constructed as to prevent danger. None of the electrical apparatus in the main warehouse, including the fork-lift truck, was suitable for use in flammable surroundings.

Regulation 7 of the Highly Flammable Liquids and Liquefied Petroleum Gases Regulations 1972 refers to the storage of LPG. For the purposes of the regulations the term 'cylinder' means any container. Suitable small closed vessels containing not more than 500cc of LPG are exempt from this regulation. The aerosols and butane lighter refills in the main warehouse were therefore exempt from the regulations but the storage of about 10 tonnes of Calor Primus cartridges was within the scope of the regulations. Such LPG cylinders are required to be kept in safe positions in the open air, or where this is not reasonably practicable, in a storeroom which is adequately ventilated, and is either in a safe position or is a fire-resisting structure. The storeroom may not be used for any purpose other than the storage of LPG. The requirements of the regulation were not met in the main warehouse.

In addition to the specific requirements of Regulation 27 of the Electricity (Factories Act) Special Regulations 1908 and 1944 and Regulation 7 of the Highly Flammable Liquids and Liquefied Petroleum Gases Regulations 1972, Sections 2 and 3 of the Health and Safety at Work etc act 1974

impose wider general requirements in connection with the storage of LPG and flammable liquids. Guidance on appropriate precautions is available in several publications including the HSE *Code of Practice for the Keeping of Liquefied Petroleum Gas in Cylinders and Similar Containers** and Guidance Note CS2 *The Storage of Highly Flammable Liquids.* The recommendations for the storage of LPG containers were not followed in the main warehouse.

Section 1 of the Fire Precautions Act 1971 requires a fire certificate to be issued in respect of any premises which are put to a use designated under the section. 'Premises' are defined in Section 43 of the Act as meaning 'a building or part of a building'. The Fire Precautions (Factories, Offices, Shops and Railway Premises) Order 1976 designates for the purposes of Section 1 of the Fire Precautions Act 'factory premises, office premises, shop premises or railway premises .... in which persons are employed to work'. 'Factory premises' are defined as 'premises constituting, or forming part of, a factory within the meaning of the Factories Act 1961, and premises to which Sections 123(1) and 124 of that Act .... apply'. Premises subject to Section 125-127 of Factories Act 1961, which include certain warehouses that do not form part of a factory, are not designated and do not therefore require a fire certificate. The definition of 'factory' in Section 175 of the Factories Act is complex. Subsection (1) defines 'factory' as meaning 'any premises in which, or within the close or curtilage or precincts of which, persons are employed ....'. This is, however, subject to the other provisions of the Section, and not every place within the close or curtilage of a factory is necessarily part of the factory; in particular, Subsection (6) excludes a place 'solely used for some purpose other than the processes carried on in the factory'. 'Premises' are not defined in the Factories Act. In contrast 'premises' are again defined in the Offices Shops and Railway Premises Act 1963 in terms of buildings or parts of buildings and would include wholesale and retail warehouses.

At the time of the fire, the building in which it originated was within the close or curtilage of the factory and formed part of the factory, but, because of the definition of 'premises' in the Fire Precautions Act 1971, it had to be considered separately for fire certification purposes. The building was not covered by the fire certificate issued in 1973 for the remainder of the factory. On a request for advice in connection with an unrelated matter, a member of the fire brigade visited the site in February 1978 and was informed by the factory manager that the building was to be taken over and used for the storage of raw materials, (new empty aerosol cannisters and valves). The officer was told that no heating would be provided in the building. In the light of the information given, it was considered that no processes were to be carried on in the building which, in the brigade's opinion, could be regarded as falling within the scope of Section 175 of the Factories Act. The brigade therefore concluded that the building was not one that required a fire certificate. Advice was, however, offered to the effect that if persons were to be employed on the first floor of the building, additional means of escape would be required. In fact, the building was used as a raw material store – a purpose clearly related to the processes carried on in the factory – and was therefore within the scope of both the Factories Act and the 1976 Order. However, owing to the numbers employed in the building and the nature of the materials stored in it, a fire certificate was not required for the building at that time.

At some time between 1978 and the time of the fire, the building began to be used additionally for the storage of packaging materials and finished goods including LPG and petroleum mixtures, and for four months prior to the fire part of the ground floor was used as temporary office accommodation. It was only at the time when highly flammable materials were first stored in it that the building came within the scope of the 1976 Order and the occupier should have made an application to the fire authority for the issue of a fire certificate relating to it. The fire authority was not informed of these matters, and no further visits to the building were made by fire brigade personnel until the week prior to the fire when two visits were made with a view to obtaining information required for fire-fighting purposes under the terms of Section 1(1) (d) of the Fire Services Act 1947.

The storage of petroleum mixtures was subject to the Petroleum (Consolidation) Act 1928. A petroleum licence had been issued for the external underground storage facility and the filling department in the main factory building. Application had not been made for a licence in respect of petroleum mixtures storage in the main warehouse at the time of the fire.

The total quantity of LPG stored in the factory did not exceed 100 tonnes. The premises were not therefore subject to the Fire Certificates (Special Premises) Regulations 1976. It should be noted however that the quantity of LPG stored in the factory was more than 30 tonnes and as such the premises would be notifiable under the proposed Hazardous Installations (Notification & Survey) Regulations.

Conclusions

There is little doubt that the fire at Permaflex Ltd, resulted from the ignition of a flammable atmosphere in the south west corner of the warehouse by an electrical source on the fork-lift truck. Whilst the gas source remains unidentified, it seems probable that it resulted from leakage of one or more filled pressurised containers. The resultant fire spread rapidly due to the nature of the materials in store. In the intense heat, pressurised containers ruptured violently and were ejected from the building. Given that the fire occurred in a busy and congested urban area and that it resulted in the total destruction of the building, it is fortunate that the damage to other property was limited. The evacuation of the area was carried out promptly, and effectively by the emergency services so that no member of the public was directly injured as a result of the fire.

The main warehouse should have been classified as a zone 2 area for the purpose of the selection, installation and use of electrical apparatus and only apparatus suitably explosion protected for such an area should have been installed or used in it. The electrical apparatus, including the battery operated trucks were not so protected and were therefore unsuitable.

* HSE Guidance Note CS4; obtainable from HMSO

The storage of LPG in the main warehouse was unsatisfactory and did not comply with the HSE Code of Practice for the Keeping of LPG in Cylinders and Similar Containers*. In particular:

- although the walls of the warehouse were of brick construction all other elements of the LPG store such as doors, windows and ceilings were not of incombustible materials and of suitable fire resistance;
- the LPG store was not single storeyed;
- adequate permanent ventilation at both high and low level was not provided in the LPG store;
- materials other than LPG were kept in the store.

The application of the Fire Precautions Act 1971 to warehouses, particularly where they are separate buildings within the curtilage of a factory, is complex. The fire authority, as the enforcing authority for the Act, concluded in 1978, in the light of the information and guidance then available to them, that the warehouse did not constitute or form part of the factory premises and accordingly fell outside their statutory control. On more detailed examination, this appears to have been a mistaken view. At that time however, a fire certificate was not required for the building. It was only when the occupier started to store highly flammable materials in the building that the situation altered. The building then came within the scope of the 1976 Order, and the occupier should have made an application to the fire authority for the issue of a fire certificate for the building.

The events indicate that the guidance, at present available to fire authorities on the application of the Fire Precautions Act 1971 and the 1976 Order to factory premises, particularly as it relates to separate buildings used for purposes incidental to the factory processes, is not as clear as it could be, and would benefit from revision. There appears also to be a need for fire authorities to be advised that when considering such cases in future, they should liaise with HM Factory Inspectorate of the Health and Safety Executive before concluding that a building within the curtilage of a factory does not form part of the factory premises.

* HSE Guidance Note CS4; obtainable from HMSO

LPG is a well known fire and explosion hazard. The circumstances of the fire emphasise the need for occupiers of premises containing LPG to be adequately informed by obtaining information and advice from authoritative sources on the hazards of LPG and the precautions to be observed in its storage.

Recommendations

Storage of aerosols containing LPG. The present regulations covering LPG exempt containers below a certain size from provisions relating to storage. It is probable however, that a wide variety of premises, particularly manufacturers, and wholesalers, maintain large stocks of aerosols containing LPG which are not currently subject to specific regulatory control. The present regulations relating to the storage of highly flammable gases are not entirely satisfactory and this incident provides further justification for the current HSC/HSE programme of reviewing and updating the requirements.

Protection of electrical apparatus. The present regulations relating to electrical apparatus and its use in flammable atmospheres apply to premises subject to the Factories Act 1961. Such apparatus is also installed and used in premises not subject to that Act. The circumstances of this incident endorse the need for reviewing the scope of the present regulations. This is currently being undertaken by HSC/HSE.

Lift trucks. Advice should be prepared on the selection of powered lift trucks for use in premises where LPG is stored.

Fire Precautions Act 1971. The guidance issued to fire authorities on the application of the Act to separate buildings, including warehouses, within the close or curtilage of a factory, should be reviewed.

Liaison between enforcing authorities. Consideration should be given to the issue of further advice to fire authorities on the need for liaison with HM Factory Inspectorate before the decision is made that a separate building within the close or curtilage of a factory does not form part of that factory.

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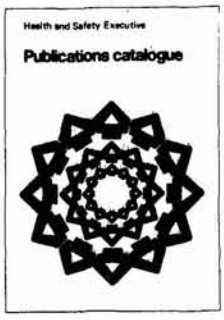

A catalogue of HSE publications is available on sale from government bookshops, Indexed by subject headings, the catalogue is an invaluable source of reference for anyone who needs access to advice and information on the requirements of the 1974 Health and Safety at Work Act and related legislation and publications issued prior to the formation of the Health and Safety Executive.

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