



KINGS DOCK CAR PARK FIRE

PROTECTION REPORT

April 2018

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TERMS OF REFERENCE

Following the major fire incident at Kings Dock car park on 31st December 2017, Merseyside Fire and Rescue Service (MF&RS) commenced investigations into the incident and has commissioned this report into the fire protection considerations surrounding the fire.

The purpose of this report is to provide information for other United Kingdom Fire and Rescue Services (UKF&RS) and stakeholders to highlight a fire of special interest. It will incorporate and consider the fire protection issues influencing the incident, including:

- The legislative fire protection, fire design and construction requirements for this type of building
- The specific design of Kings Dock Car Park and how the fabric of the building behaved in the fire
- The causes of the fire spread during the incident
- The role of MF&RS protection department
- The roles and management of the building by Liverpool City Council (LCC), Arena Convention Centre Liverpool (ACCL), Outsourced Client Solutions Uk Ltd. (OCS) and the Liverpool International Horse Show and Bolesworth Events (LIHSBE)
- Human behaviour in fire
- Identify lessons learned and share with stakeholders.

The terms of reference do not extend to reviewing or commenting on the operational response element of the incident, other than to timeline the arrival of MF&RS, commencement of offensive firefighting and withdrawal of Breathing Apparatus (BA) teams for firefighter safety. In addition, this report will not explore the cause and origin of the fire, other than in the simplest terms, based on CCTV evidence.

The review methodology comprises:

- Witness accounts from the above organisations and LIHSBE personnel
- Site visits with Building Research Establishment (BRE), ACCL, LCC
- Scrutiny of internal and external CCTV supplied by LCC and ACCL; scrutiny of documents supplied by internal and external stakeholders
- Photographs taken by MF&RS Incident Investigation Team (IIT)
- A drone survey commissioned by LCC
- Research of current and previous legislation, guidance documents and research papers on fires in car parks.

EXECUTIVE SUMMARY

BRIEF TIMELINE

Time	Date	Details
16:29	31.12.17	Internal car park CCTV - first signs of fire (smoke) from the vehicle
16:37	31.12.17	External CCTV – first signs of smoke in Plaza area (pedestrian space between the car park and ACCL)
16:42	31.12.17	First call to the Fire and Rescue Service (999 call from member of public)
16:43:	31.12.17	First fire alarm actuation (break glass call point)
16:43	31.12.17	Two fire appliances mobilised
16:44	31.12.17	First call received from LCC at venue.
16:45	31.12.17	Event firefighting team arrive at main entrance, under blue lights
16:50	31.12.17	MF&RS appliance in attendance at main entrance
16:56	31.12.17	Assistance message – “Make pumps 3”
16:56	31.12.17	External firefighting begins
17:01	31.12.17	Assistance message “Make pumps 6”
17:08	31.12.17	First BA team (Alpha 1) committed from stairwell 2 into level 3 (Sector 2)
17:31	31.12.17	Assistance message – “Make pumps 8”
17:40	31.12.17	BA crews report up to 30 vehicles involved and running fuel fire between rows of cars
17:41	31.12.17	Assistance message – “Make pumps 12”
17:52	31.12.17	Internal CCTV – first signs of flame from level 4, in location away from ramps and above initial fire on level 3
18:07	31.12.17	First BA team (Bravo 1) committed from stairwell 1 to level 3 (Sector 3) . Report clear view of fire due to wind conditions. Fire confined to two rows of vehicles, away from ramps
18:20 - 18:25	31.12.17	All BA crews withdrawn from sector 2 due to untenable fire conditions
18:38	31.12.17	Emergency evacuation of all teams due to concerns over firefighter safety

The Incident

MF&RS were alerted to a car on fire on the 3rd floor of the Kings Dock Car Park at 16:42hrs, New Year's Eve, Sunday 31st December 2017. The resulting blaze led to the loss of approximately 1,150 vehicles and so severely affected the fabric of the building, that demolition is the likely outcome.

Fire Investigation activities began at the Kings Dock Car Park at 18:22hrs on 31st December with the attendance of the MF&RS Incident Investigation Team (IIT). Over the following weeks MF&RS Protection Department worked closely with IIT and various stakeholders (ACCL, LCC, OCS, BRE, LIHSBE and WH Management).

CCTV footage shows that the fire started in a vehicle on level 3. Attending fire crews reported rapid lateral fire spread, running fuel fires, vertical fire spread from level of origin and a "waterfall" of fire from the ceiling of level 3. It was initially thought that fire spread was via the central ramps, but upon further investigation it is considered that the drainage system was the likely cause of vertical fire spread.

Building Regulations & MF&RS Involvement with the Building

Kings Dock car park is an 8 level, open-sided construction, comprising a ground and seven upper floors. Construction was completed in 2007. The car park is an 'open-sided' car park, subject to natural ventilation.

MF&RS took part in the Building Regulations consultation process on the car park. As a result of MF&RS submissions, it was agreed that firefighting shafts would be installed within the building. This was due the building's size and the lack of access afforded to external firefighting appliances, on two of its elevations. The building was constructed to these specifications. When it opened in November 2007 it complied with Building Regulations.

On 2nd November 2012 and on 2nd December 2015, MF&RS Fire Safety Inspectors audited the premises under the Regulatory Reform (Fire Safety) Order 2005 (RR(FS)O 2005). On both occasions the outcome was broadly compliant, although the use of advertising on the external facia of the ground level of the car park was identified as potentially affecting cross ventilation.

Due to the complex and diverse nature of the events that are held at ACCL and the inherent changes in fire strategies associated with these complexities, MF&RS had served ACCL with an Alterations Notice in 2008 (see Appendix 2).

Fire Spread in Car Parks

In 1968, The Ministry of Technology and Fire Offices' Committee Joint Fire Research Organisation researched and concluded that fire spread from one vehicle to others would not occur and that if it did, the Metropolitan Brigades would invariably be in attendance within 3 to 4 minutes. "This research underpinned the recommendations in Approved Document B." (Fire Spread in Car Parks BD 2552 p.15). The fire resistance requirements under Building Regulations have not increased since the 1968 paper.

In 2006, the Department for Communities and Local Government (DCLG) commissioned the Building Research Establishment to carry out a 3 year project titled "Fire Spread in Car Parks" (BD 2552). Although there had been few deaths or injuries recorded to that date in the UK, there were concerns regarding new and emerging risks from modern cars and alternative fuels.

This research demonstrated, amongst other things, that:

- sprinklers are effective in both controlling a developing and fully developed fire
- running fuel fires spread the fire
- current methods to calculate ventilation openings from open-sided car parks and mechanical ventilation in enclosed car parks needed to be considered
- the ease with which a car fire in a car park spread to nearby cars and once a very severe fire has developed, fire will spread to other cars separated by an un-filled parking bay, and
- fire conditions in partial and fully closed car parks are much more severe than in open sided car parks.

The report concluded that the current fire resistance recommendations for car parks in ADB needed to be kept under revision and that calculations for smoke control and smoke clearance need to be carefully considered (BD 2552 p.98).

Fire Protection and Management of the Building

The active and passive fire protection measures within the building complied with regulatory requirements and performed beyond the required standard during the incident.

The complex relationship between ACCL and LCC has led to a somewhat over-complicated management of fire safety within the building. This appears to have led to some confusion amongst staff as to who is responsible for the management of the building. This has the potential to become further complicated during large events, such as the Liverpool International Horse Show.

Observations and Recommendations

Fire will spread from vehicle to vehicle in car parks, be they open air, open-sided or enclosed. This has been proved in both simulated experiments in the UK and abroad and in actual incidents, such as Boomtown Festival, Monica Wills (see Related Incidents p.51) and Kings Dock fires.

Fire may spread beyond floor of origin. In the case of Kings Dock this was likely to have been through the drainage system and failure of the ribbed slab floors in the early stages of the incident, although the geometry and central ramp design, combined with running fuel fires, certainly contributed later on.

Running fuel fires, due to failure of plastic fuel tanks, in early stages of vehicle fires can be expected. It is estimated 85% of European vehicles have plastic fuel tanks.

Sprinklers are effective in both controlling a developing and fully developed fire. Without sprinklers fire is likely to spread from car to car and dangerous levels of smoke are likely for long periods (BD2552 p.46). Designers should seriously consider sprinkler provision to avoid multiple vehicle fires, resulting in huge insurable losses and the possible loss of life.

Fire may spread beyond floor of origin. In the case of Kings Dock evidence would suggest that this was initially through the failure of the drainage system. Designers should give serious consideration to the implications of drainage design that could aid fire spread between levels.

The fire safety management of buildings needs to be simplified and clear to all.

Although not a contributory factor during this incident, careful consideration should be given to using car parks for purposes other than the parking of vehicles, in future.

Current building regulations for car parks should be reviewed in light of this incident.

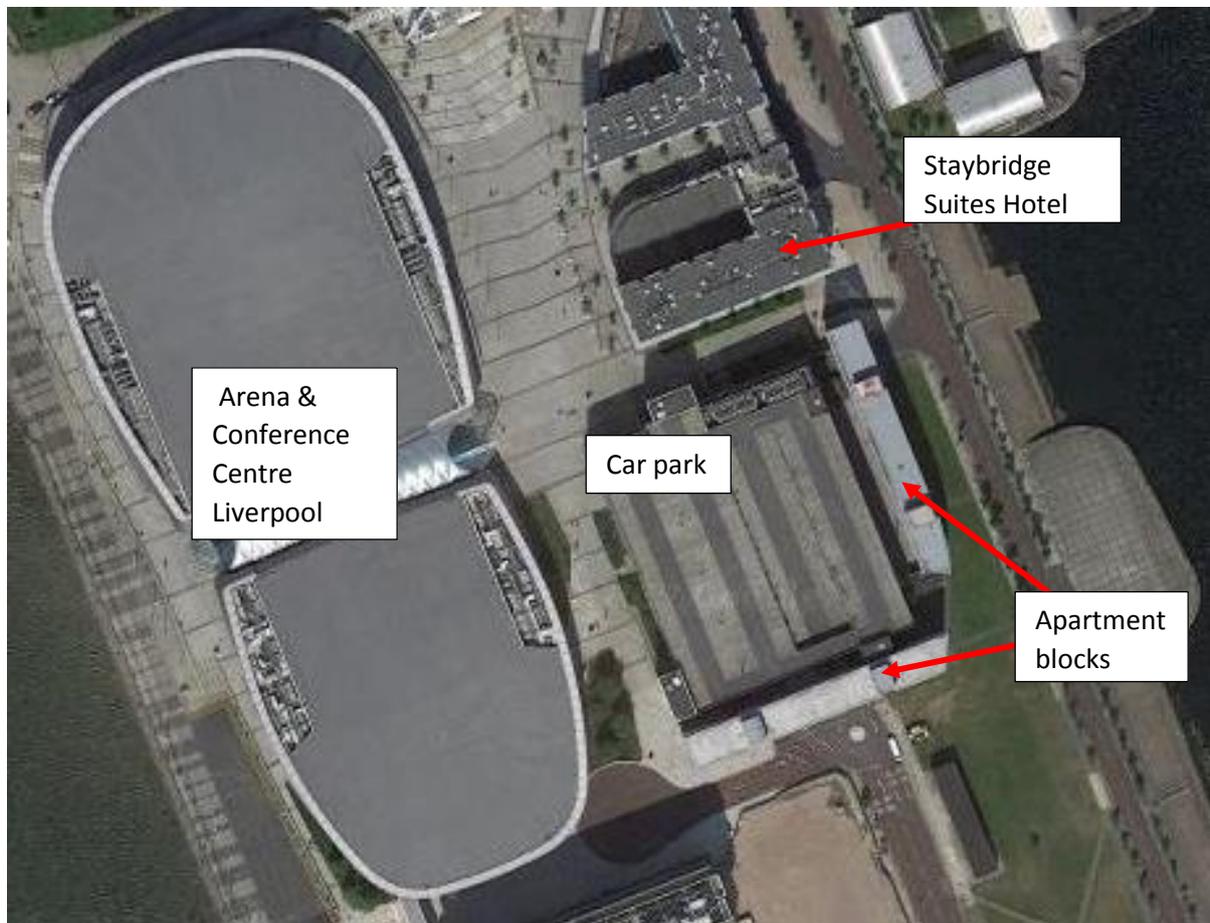
Private response teams should make every attempt, as far as is reasonably practicable, to ensure that their personnel, equipment and vehicles are not mistaken for emergency services. The requirement for response under blue lights by such teams is questionable.

MF&RS would advocate more public information as to what their actions should be upon discovering a fire and the potential positive and negative effects of members of public recording and streaming live emergency incidents and the impact this has on the emergency services and any potential victims

INTRODUCTION

Kings Dock car park is an 8 level, open-sided construction, comprising a ground and seven upper floors, the seventh being roof top parking. The footprint is 4930m². The construction method is concrete columns and beams, with tied in reinforced pre-cast ribbed concrete floors. The building is surrounded to the south and east by blocks of serviced apartments, which lie in very close proximity (6m) to the car park, and to the north by the Staybridge Suites Hotel, which is separated from the car park by a 15m concourse. To the west, lies the Arena and Convention Centre Liverpool (ACCL). There is a service road running under the concourse between the car park and the Staybridge Suites, which leads to a loading bay and this is used for importing and exporting equipment, people and animals for shows and conventions held in the Echo Arena.

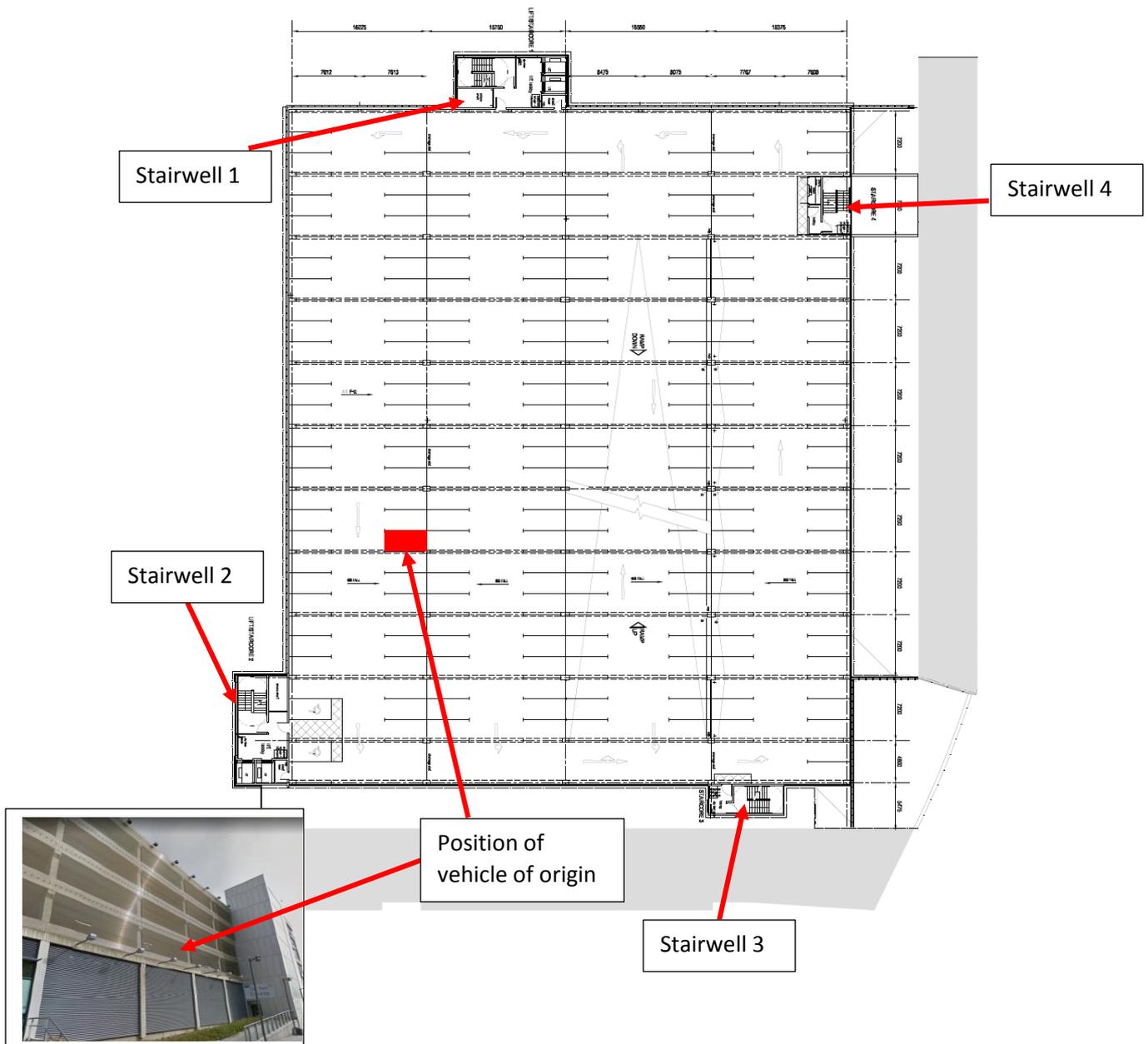
Figure 0.1: Aerial view



A planning application for the car park was submitted to MF&RS for consultation in 2005 and construction was completed in 2007. There is capacity for 1,600 cars and unlike many public car parks, the occupancy is likely to be extremely high at the start and end of concerts in the ACCL. The capacity is reduced to 1,460 for events where the ground floor is used for purposes other than parking.

MF&RS were alerted to a car on fire on the 3rd floor of the Kings Dock Car Park at 16:42hrs, New Year’s Eve, Sunday 31st December 2017. The resulting blaze led to the loss of approximately 1,150 vehicles and so severely affected the fabric of the building that demolition is the likely outcome. A visiting contingent from the Building Research Establishment (BRE) on 10th January 2018 likened the fire to a petrochemical fire; due to the heat generated and the behaviour of the concrete structure (evidence of explosive spalling, floor failure and structural element damage).

Figure 0.2: Level 3 floor plan



1. BUILDING CONSTRUCTION AND DESIGN FIRE REQUIREMENTS

1.1 Design Specification

The design construction submission for the Kings Dock car park was submitted as follows: an 8-storey structure built of precast reinforced concrete. The form of construction is portal frame providing clear span across the parking bays, which, in turn, supports a precast reinforced concrete floor deck. The beams and columns are connected using grouted rebar and coupled rebar. The top section of the beam is cast in-situ, which forms a monolithic connection between slab, beam and column.

The car park is an 'open-sided' car park, subject to natural ventilation (**see Section 4. Natural Ventilation**). Stability is achieved by the long ramp augmented by the stair cores, which are constructed in 170mm thick precast concrete walls with tied precast landings. The designer was responsible for all in-situ concrete groundworks, retaining structures and below ground drainage layouts. The ground floor slab is designed as load bearing.

Under the fire design table, contained within the submission, the following information is given:

- 15mins fire resistance – open sided car park.
- 2hr to stair walls/1hr to compartment floors provided by slabs (additional fire protection may be provided by spray applied system).

Observations and recommendations

1. The solid elements of structure (columns beams and walls) meant that the building was able to structurally withstand the fire for a period well in excess of the 15 minute requirement under the guidance in ADB (see **1.2**). Under the current Integrated Risk Management Plan, MF&RS response standard is 10 minutes on 90% of occasions. Therefore, 15 minutes fire resistance to any building will severely restrict safe firefighting operations capabilities.

1.2 Building Regulations

In Approved Document B, Volume 2 (buildings other than dwelling houses) 2010, section 11.2 gives the following general principles for buildings used for parking cars:

- a. The fire load is well defined; and
- b. Where the car park is well ventilated, there is low probability of fire spread from one floor to another

11.3 gives the following requirements to conform to the definition of an open sided car park:

- a. there should not be any basement storeys;
- b. each storey should be naturally ventilated by permanent openings at each car parking level, having an aggregate vent area not less than $1/20^{\text{th}}$ of the floor area at that level, of which at least half ($1/40^{\text{th}}$) should be equally provided between two opposing walls;
- c. where one element of structure supports or carries or gives support to another, the fire resistance of the supporting element should be no less than the minimum period of resistance for the other element (whether that element is load bearing or not).
- d. If the building is also used for any other purpose, the part forming the car park is a separated part and the fire resistance of any element of structure that supports or carries or gives stability to another element in the other part of the building should be no less than the minimum period of fire resistance for the elements it supports; and
- e. All materials used in the construction of the building, compartment or separated part should be non-combustible, except for:
 - i. Any surface finish applied to a floor or roof of the car park, or within any adjoining building, compartment or separated part to the structure enclosing the car park, if the finish meets all aspects of the guidance on requirements B2 and B4;
 - ii. Any fire door
 - iii. Any attendant's kiosk not exceeding 15m^2 in area; and
 - iv. Any shop mobility facility

Figure 1.2.1: ADB Vol.2 Table A2 Minimum Periods of Fire Resistance

ONLINE VERSION

B PERFORMANCE OF MATERIALS, PRODUCTS AND STRUCTURES

Table A2 Minimum periods of fire resistance

Purpose group of building	Minimum periods of fire resistance (minutes) in a:					
	Basement storey ⁽⁵⁾ including floor over		Ground or upper storey			
	Depth (m) of a lowest basement		Height (m) of top floor above ground, in a building or separated part of a building			
	More than 10	Not more than 10	Not more than 5	Not more than 18	Not more than 30	More than 30
b. car park for light vehicles:						
i. open sided car park ⁽³⁾	Not applicable	Not applicable	15*+ 30*	15*+ ⁽⁴⁾ 60†	15*+ ⁽⁴⁾ 90	60 120#
ii. any other car park	90	60				

Single storey buildings are subject to the periods under the heading "not more than 5". If they have basements, the basement storeys are subject to the period appropriate to their depth.

\$ The floor over a basement (or if there is more than 1 basement, the floor over the topmost basement) should meet the provisions for the ground or upper storeys if that period is higher.

* Increased to a minimum of 60 minutes for compartment walls separating buildings.

** Reduced to 30 minutes for any floor within a flat with more than one storey, but not if the floor contributes to the support of the building.

Reduced to 60 minutes for elements not forming part of the structural frame.

+ Increased to 30 minutes for elements protecting the means of escape.

† Refer to paragraph 7.9 regarding the acceptability of 30 minutes in flat conversions.

Notes:

- Refer to Table A1 for the specific provisions of test.
- "Sprinklered" means that the building is fitted throughout with an automatic sprinkler system in accordance with paragraph 0.16.
- The car park should comply with the relevant provisions in the guidance on requirement B3, Section 11.
- For the purposes of meeting the Building Regulations, the following types of steel elements are deemed to have satisfied the minimum period of fire resistance of 15 minutes when tested to the European test method:
 - Beams supporting concrete floors maximum $H_p/A=230m^{-1}$ operating under full design load.
 - Free standing columns, maximum $H_p/A=180m^{-1}$ operating under full design load.
 - Wind bracing and struts, maximum $H_p/A=210m^{-1}$ operating under full design load.
 Guidance is also available in BS 5950 Structural use of steelwork in building. Part 8 Code of practice for fire resistant design.

Observations and recommendations

1. ADB states: "the fire load is well defined." This is based on out-dated research on old vehicles and requires further consideration.
2. ADB states: "Where the car park is well ventilated, there is low probability of fire spread from one floor to another." This was clearly not the case at this incident and requires revision.
3. The sheer size of Kings Dock Car Park brings into question the validity of categorising it as open-sided. Even the more up to date research, which was conducted in relatively small rigs by BRE (see **section 1.4**), could not possibly replicate smoke dispersal and heat release within a 24,000m² structure. Current methods for calculating ventilation openings for smoke clearance from open-sided car parks should be reviewed.
4. Under current guidance in ADB, there is no requirement for sprinklers within an open-sided car park. Serious consideration should be given to the provision of sprinklers.

1.3 Background Research into Car Fires

In 1968, The Ministry of Technology and Fire Offices' Committee Joint Fire Research Organisation produced Fire Note No.10, "Fire and Car-Park Buildings". This document was the result of a research experiment, exploring the likelihood of fire spread from one vehicle to another, which would, in turn, determine the fire resistance requirements of the structures. The structures were classed as 'light storage' and had, up until then, been mainly constructed from reinforced concrete, which was the cheapest construction material that would comply with fire resistance of 1 hour under the Building Regulations 1965.

However, the document noted that if fire resistance requirements were removed, then a steel frame construction would be cheaper. It states in its summary, **"The experimental work carried out.....confirms the fact that an outbreak of fire, within a single parked car, is unlikely to result in uncontrollable fire spread in the car park or in serious damage to the structure of the building."**

This research formed the basis of fire resistance requirements in car parks under Building Regulations and although newer research has taken place in England (BRE conducted a 3 year experiment and published its findings in 2010 – see 1.4) and around the world, the fire resistance requirements under Building Regulations have not increased since the 1968 paper. With this in mind, it is worth noting the following facts, findings, calculations and assumptions from the research and on which Fire Note 10 was written. Viz:

- "...the parking area for each car is considerably larger than the floor area which each car covers" (Spacing of Vehicles Fire Note 10 p.2). This indicates that cars manufactured in the 1950's are considerably smaller than the parking spaces provided under regulatory requirements and this would give a greater distance between cars, thus reducing effects of radiated heat. However, cars are now considerably larger, reducing the distance between parked vehicles.
- "One of the major hazards considered was the disruption of the petrol tanks and the flowing of petrol under other cars in the vicinity via the sloping concrete ramp. In no case did this occur." (Fire Note 10 Explosion Risk p.7). It is estimated 85% of European vehicles have plastic fuel tanks (BRE Fire Spread in Car Parks BD 2552 p.12).
- "From visual observations made during the tests, the smoke layer was mainly at ceiling level and would have caused the fire brigade little or no difficulty in dealing with the outbreak" (Fire Note 10 Risk of Smoke Obscuration p.8)
- "...in Metropolitan Boroughs the fire brigade attends 4 out of 5 fires within 3 min and it is therefore difficult to see how a sustained fire could take hold." (Fire Note 10 An assessment of the Risk p.9)

Observations and recommendations

1. The cars used and the materials they were constructed from have a far lower calorific value than modern vehicles.
2. The cars used for the experiment were far smaller than most modern vehicles.

1.4 BRE Fire Spread in Car Parks BD2552

In 2006, DCLG Sustainable Buildings Division commissioned BRE to carry out a 3 year project titled "Fire Spread in Car Parks". As a result, document BD 2552 was produced in December 2010. Although there had been few deaths or injuries recorded to that date in the UK, there were concerns regarding new and emerging risks from modern cars and alternative fuels. The overall aim of the project was to gather information on the nature of fires involving the current design of cars and to use this knowledge as a basis, if necessary, to update current guidance in ADB Vol.2 on fire safety strategies for car parks (**see section 1.2**). Historical research was conducted and a number of different scenarios were tested over the 3 years and the following notable observations and conclusions were made:

- Average heat release per vehicle of 4.75 MW at the Monica Wills car park fire 2006. (BD 2552 Car Fires p.14)
- "In a number of incidents, a running fuel fire was reported, which spread the fire." (BD 2552 Car Fires p.14).
- "Sprinklers are effective in both controlling a developing and fully developed fire, without sprinklers fire is likely to spread from car to car and dangerous levels of smoke are likely for long periods." (BD 2552 Research p.15).
- "Fires in open car parks behave in a very similar manner to fully closed car parks in terms of obscuration and toxic product concentrations." (BD 2552 Research p.15).
- "Fire conditions in partial and fully closed car parks are much more severe than in open sided car parks." (BD 2552 Research p.16).
- In Test 1, car 1 (Renault Laguna petrol 2002) burnt for 20minutes at 2MW, but within 2 minutes of car 2 (Renault Clio petrol 1998) igniting, the intensity reached 16MW and a ceiling temperature of 1100°C. There was extensive spalling of concrete roof slabs during this test. (BD2552 2.9.1 Observations and Results p.39).

- “Fires in car parks for which the building is classified as ‘flats’ show an injury rate that is quite high compared with other types of premises” (BD2552 Statistics p.95).
- “...serious concerns regarding car ‘stackers” (BD2552 Car park design p.95).
- “Timber framed and other innovative designs need to be kept under review” (BD2552 Car park design p.95).
- “The Monica Wills incident is the most recent incident to demonstrate that fire can spread between cars and that, in extreme cases, very many cars can burn out with a very high heat release rate (and substantial structural damage); the “traditional” view that car fires do not spread was substantially refuted by this incident.....**However, there is no evidence to indicate that the current provisions in ADB for the protection of car parks need revision.**” (BD 2552 3.5 Fire Development).
- “As well as the structural damage caused, spalling can be dangerous for firefighters.” (BD2552 Fire Resistance p.97).
- Although there were no cases of structural collapse of a car park due to fire in the UK, there have been cases in Europe. Notably, Gretzenbach in Switzerland, where an underground car park collapsed, resulting in the death of 7 firefighters (BD2552 Fire Resistance p.98).
- “Current methods to calculate ventilation openings...from open-sided car parks, and....enclosed car parks need to be considered,” (BD2552 3.9 Ventilation and smoke control p.98).
- “The ease with which a car fire in a car park might spread to nearby cars has been demonstrated. Once a very severe fire has developed, fire will spread to other cars separated by an un-filled parking bay.” (BD2552 4.1 General Conclusions p.99)

Observations and recommendations

1. The more modern the vehicle, the higher calorific potential (Natural fires in closed car parks: Car Fire Tests, Daniel Joyeux 1997). Further research on modern vehicles should be commissioned, in order to ascertain conformity to current fire resistance standards under building regulations.
2. Radiated heat and direct flame impingement, due to larger vehicles in restricted spaces and low ceilings, will give temperatures in excess of 1100°C (BD2552 p.64). Spacing of vehicles and ceiling height in car parks should be reviewed.
3. Sprinklers are effective in both controlling a developing and fully developed fire. Without sprinklers fire is likely to spread from car to car and dangerous levels of smoke are likely for long periods (BD2552 p.46). Designers should seriously consider sprinkler provision to avoid multiple vehicle fires, resulting in huge insurable losses and the possible loss of life.

2. FIRE SPREAD

2.1 Initial Considerations

Fire Investigation activities began at the Kings Dock Car Park at 18:22hrs on 31st December with the attendance of the MF&RS Incident Investigation Team (IIT). Over the following months MF&RS Protection Department have worked closely with IIT and various other stakeholders (ACCL, LCC, BRE, Liverpool International Horse Show, WH Management).

From initial observations, CCTV and open Social Media sources it could be seen that the fire, once sufficiently developed, moved rapidly up through the structure. Early thoughts around this concentrated on vehicles being parked on the ramps between floors as a possible factor in fire spread.

Figure 2.1.1: Level 3-6 floor plan with drainage and ramp system



Once initial crews and officers were de-briefed it became apparent that the fire, prior to evacuation and cessation of internal firefighting on Level 3, was surrounded and confined to the second and third rows of cars. However, the fire had already spread to Level 4. This, therefore, ruled out the ramps as the initial reason for fire spread upwards. Although this was, no doubt, a major contributory factor in later fire spread through the structure, acting as a chimney.

BA teams and external firefighting personnel had reported spalling or exploding concrete, with BA teams seeing debris falling down from the ceilings on level 3. The later BA teams also reported holes in the ceiling on level 3 and ignited fuel running down like a waterfall from the floor above.

Figure 2.1.2: Photograph of ramp from level 6 to level 7



The explosive spalling of the concrete, particularly of the precast ribbed floor slab, may have provided an additional route for fire development between levels. However, the fire severity for this event to occur would be well in excess of the fire design resistance period. The integrity of the concrete and its resistance to spalling will depend on many factors, such as water content; whether the concrete is reinforced and the aggregate and materials used.

Observations and recommendations

1. Rapid spread of fire, once two or more vehicles are fully involved will occur. Fire will “leap” across empty bays, due to its intensity, in particular the temperature of the smoke/ceiling jet (BD2552 p.39). In the Kings Dock car park incident crews reported that additional vehicles became involved “every 30 seconds”. The rate increased exponentially up to rapid fire development on level 4, just after the crews withdrew. Sprinklers will delay fire development and prevent fire spread to multiple vehicles before the attendance of the Fire and Rescue Service.
2. Early firefighting intervention, or automatic suppression is imperative to controlling fire spread.

2.2 Drainage System

Further investigation by MF&RS Protection has shown that there is a drainage system built into the car park floor to take away any excess surface water. The drainage system design varies on different parts of the floor level, i.e. the drains adjacent to the ramps are designed as grids that run through plastic pipe and into the column, whereas the drainage system design to the ACCL side of the ramps, adjacent to where the vehicle of origin was situated, comprises a 15mm wide neck drainage slot that runs between columns (**Figure 2.2.3 p.21**). This slot drains into a system of aluminium trays, attached to the ceiling of the level below and running the length between columns. These trays empty, at either end, into the concrete support columns via a plastic drainpipe elbow (**Figure 2.2.1 p.20**).

This is considered as the likely cause of initial fire spread between level 3 and 4.

Figure 2.2.1: Photograph of intact drainage system type adjacent to vehicle of origin



Figure 2.2.2: photo view of the drainage slot from above, Level 7 Roof



This drainage slot runs between columns with two rows of three cars parked between each column (see fig.2.1).

Figure 2.2.3: Extract from Level 2 Structural GA drawing 04248/15

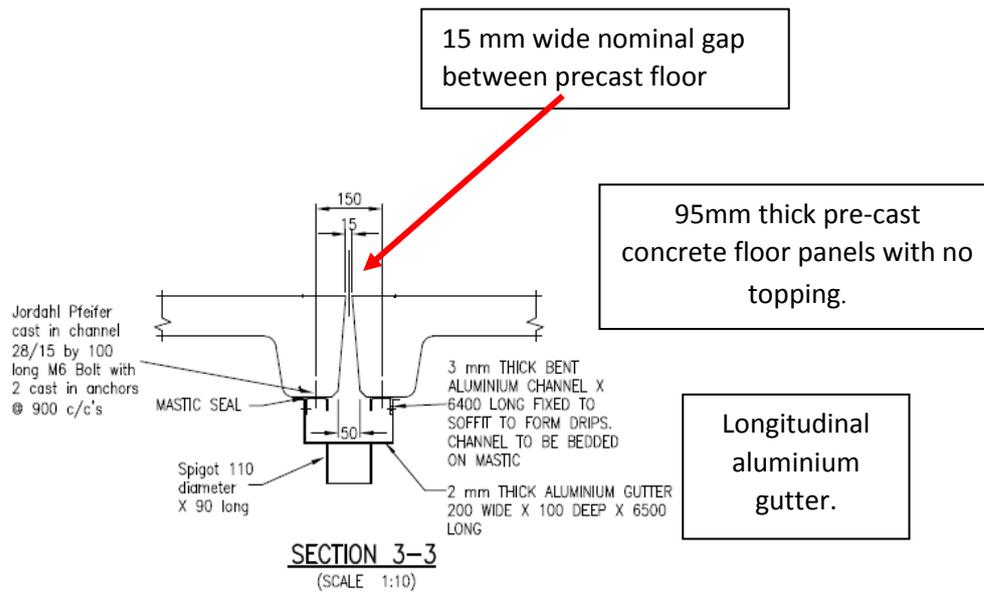


Figure 2.2.4: section of aluminium guttering in place.

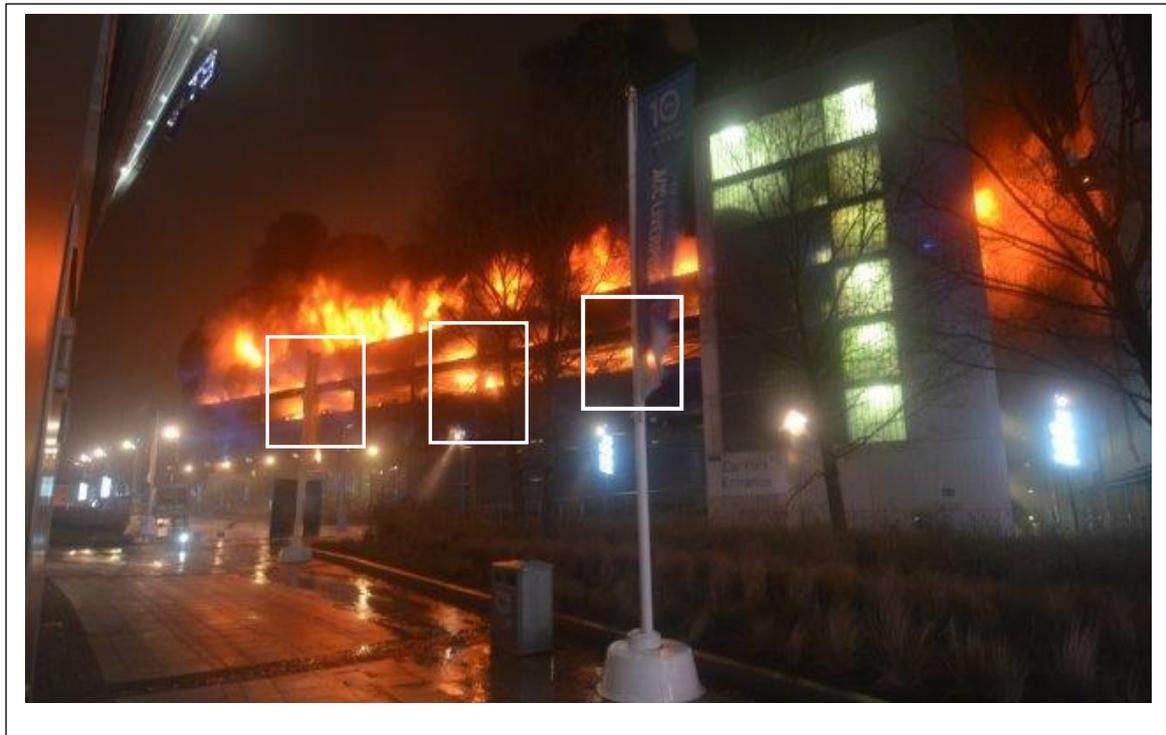


Plastic drainpipe elbow burnt away.

Aluminium guttering

The external CCTV image below (**fig.2.2.5**) appears to show vertical walls of fire at equidistant positions along the length of the level. This would appear to be further evidence of drainage failure and the “waterfalls of fire” that BA crews alluded to.

Figure 2.2.5 External CCTV image



With temperatures in excess of 1,200°C, very early failure of plastic elbow pipes would have occurred and with a melting point of 660°C, the aluminium drainage trays would also have been subject to failure (**see fig.2.2.6**) prior to the spalling of the concrete ribbed floor slabs. Failure of the aluminium tray would expose the drainage channel and allow hot gases and flame to be directed to the floor above and impinge on the two rows of cars adjoining this channel.

Figure 2.2.6: melted aluminium drainage tray and visible drainage slot



A section of undamaged drainage tray from the car park has undergone testing by BRE. This has confirmed it to be 2mm thick aluminium, which would fail at around 660°C.

MF&RS first attendance was 16:50hrs and internal firefighting commenced on level 3 at 17:08hrs. At 17:35hrs BA crews had reported “waterfall of fire” coming from the ceiling of level 3 and at 17:40hrs reported 30 vehicles involved in fire.

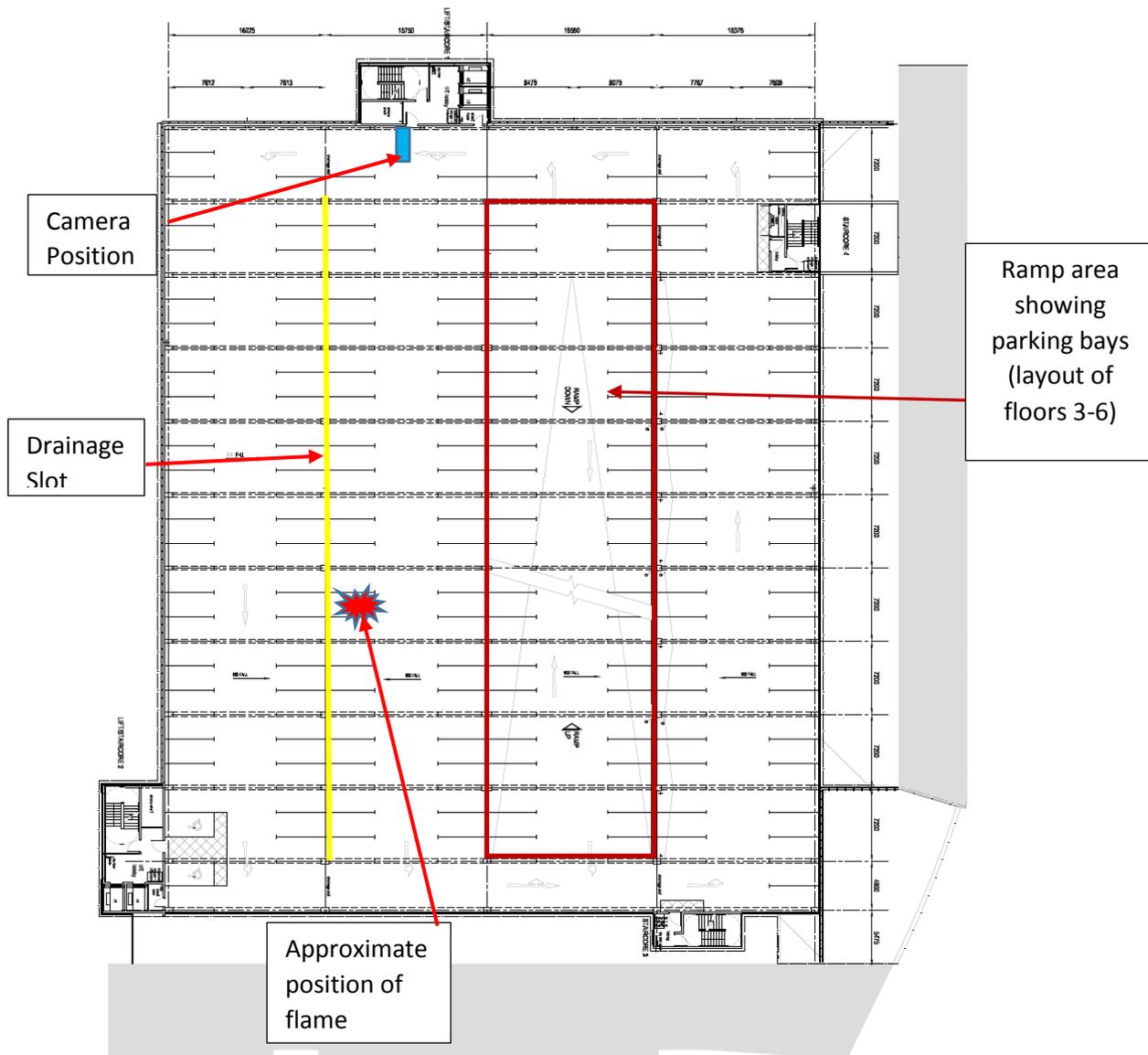
Observations and recommendations

1. Fire may spread beyond floor of origin. In the case of Kings Dock evidence would suggest that this was initially through the failure of the drainage system and was later exacerbated by the failure of the ribbed slab floor. Although the geometry and central ramp design, combined with running fuel fires, certainly contributed at a later stage in the incident. Designers should give serious consideration to the implications of drainage design that could aid fire spread between levels.

2.3 Fire on Level 4

The following plan and images show the first signs of flame captured by CCTV camera outside stairwell 1, level 4 at 17:53hrs (**figure 2.3.2**) and then a well-developed fire at 18:11hrs (**figure 2.3.3**), with several vehicles involved. A major fire event occurred on level 4 shortly afterwards and fire crews were withdrawn for firefighter safety.

Figure 2.3.1: Level 4 floor plan and position of fire break through



This evidence is further proof that the fire spread occurred through the floor, via the drainage system, as the flame is practically directly above where the original fire started. None of the cars adjacent to the ramp are involved in fire at this point. The images showing fire development on level 4 also mirror, to a great extent, the BRE experiments conducted between 2006 and 2009, where multiple vehicles become totally involved in fire in a short period of time, approximately 20 minutes after first ignition.

Figure 2.3.2: First Sign of Flames on level 4 at 17:53hrs



NB flames may have been present on level 4 earlier than 17:53 but they were not captured by CCTV due to smoke obscuration. Firefighters on level 3 had reported “waterfall of fire” at 17:35, when they returned to BA entry control point.

Figure 2.3.3: Developed fire on level 4 at 18:11hrs



2.4 Running fuel fires

Running fuel fires were witnessed by BA crews and this undoubtedly led to fire spread through the drainage system, down ramps and along the rib slab floor. This was also highlighted in the BRE experiments conducted between 2006 and 2009:

- “Running fuel fires due to failure of plastic fuel tanks in early stages of vehicle fires can be expected. It is estimated 85% of European vehicles are thought to have plastic fuel tanks.” (BRE Fire Spread in Car Parks BD2552 p.12).
- For two minutes, the tank, fixed as on the vehicle, must be exposed to flame. There must be no leakage of fuel from the tank” (The United Nations Economic Commission for Europe (UNECE) Regulation 34, Annex 5, paragraph 5.1).

Areas of the roadways within the car park, sited away from any parked vehicles, appear to have suffered spalling.

Figure 2.4.1: Photograph of Spalled Concrete: Level 3



The image above appears to show a distinct difference in surface temperature of the concrete on level 3. The different colouring and the spalling of the floor towards the bottom of the photograph, combined with the two lines of burnt delivery hose, having been vaporised beyond the line of colouration change, would appear to support evidence of very high localised temperatures. In the early stages of the incident, wind direction was coming north easterly (coming towards the camera view for this photograph) and firefighters had to withdraw from this area due to the untenable conditions.

Observations and recommendations

1. Running fuel fires will lead to fire spread in car parks. Designers should consider the likelihood of running fuel fires, when designing floor layouts and ramping systems that incorporate vehicle parking.

3. FIRE PROTECTION AND MANAGEMENT OF THE BUILDING

3.1 Fire Strategy

There are some complexities regarding the management of the premises, the fire risk and the fire evacuation strategy within the premises. Following interviews and reports submitted by the two stakeholders (LCC and ACCL), it has been established that:

On a day to day basis,

- The Echo Arena and car park were commissioned and are owned by LCC
- ACCL leases the Echo Arena and car park from LCC
- LCC staff the car park
- LCC is responsible for H&S and fire strategy within the car park; although ACCL commissioned Omega Fire to complete a fire risk assessment on the building
- ACCL are responsible for H&S within the Echo Arena and the service road and loading bay area, which runs adjacent to the car park and under the plaza. ACCL is not responsible for H&S on the roads throughout the site, these are common parts and are managed by CBRE on behalf of Kings Waterfront Estate Ltd.

During major events and the Liverpool International Horse Show, in particular,

- The car park is managed and falls under the responsibility of the LCC staff. As part of the event, LIHSBE organised for WH Management (an events management company) to enhance the onsite monitoring; to assist in fire safety measures for the stables; to deal with car, bin and lorry fires; and to assist in any emergency evacuation.
- ACCL subcontract OCS UK Ltd. to supply stewards, cleaning and security for Echo Arena, service road and loading bay area, the plaza and the pedestrian walkways around the site. The stewards should operate in the external venue areas; e.g. directing vehicles to pick up and drop off points and guiding people across the roads. There should be no need for ACCL staff/ security to assist in the car park as LCC should have adequate staff levels required for busy periods.
- In the event of fire, LCC should evacuate the car park and ACCL staff should help in evacuation, in as much as they form a perimeter to block entry to members of the public to the car park. There is no formal agreement or requirement to do this. However, in the event of any emergency situation ACCL stated that their staff/security would assist a neighbouring organisation where needed. This would be dynamically assessed as to the level of support provided.
- ACCL, in conjunction with LIHSBE staff & WH Management staff, Online Safety Solutions (OSS) staff are responsible for H&S, fire strategy for the Arena and the evacuation of the ground floor given over to stables and the service road area. WH Management were contracted to manage an evacuation of the ground floor (stables level). LCC still had overall control of the building and the LCC staff evacuate public from other floors.

3.2. Previous MF&RS Protection Department Involvement

King’s Dock Car Park was an integral element of the King’s Dock Development project, which was commissioned by LCC in 2004. MF&RS took part in the Building Regulation consultation process on the car park, which commenced in 2005 and it was agreed in this consultation process that the car park would be considered a stand-alone building. MF&RS, Liverpool City Council Local Authority Building Control (LCCLABC), the architects and the developers took part in this process.

During the process, the design consultants submitted proposals to reduce the width of staircases, based on the assumption that the occupancy would never fulfil its full potential due to the transient nature of a typical car park occupancy. MF&RS insisted on the stair widths remaining at the original submissions (1500mm), due to the fact that the car park would serve a large event arena and that this would realise a predictable large peak time activity (before and after shows and events).

The design consultants also submitted that the building did not require firefighting shafts because it was not 18m in height. MF&RS countered this submission, stating that: “...although the building was less than 18m, it did not comply with Table 19 in ADB....The gross floor combined area exceeds 24,000m² and consequently requires 100% perimeter access for pumping appliances and high rise appliances. The future apartments, when constructed, will restrict 50% of the access area, consequently reducing our access to 50% of the building. As a result the firefighting shafts become a necessity and a requirement.” As a result of MF&RS submissions, it was agreed that firefighting shafts would be installed within the building with a minimum 1500mm staircase. The building was constructed to this standard and opened in November 2007.

Figure 3.2.1: Table 19 ADB Volume 2

Table 19 Fire and rescue service vehicle access to buildings (excluding blocks of flats) not fitted with fire mains				
Total floor area ⁽¹⁾ of building m ²	Height of floor of top storey above ground ⁽²⁾	Provide vehicle access ⁽³⁾⁽⁴⁾ to:	Type of appliance	
Up to 2000	Up to 11 Over 11	See paragraph 16.2 15% of perimeter ⁽⁵⁾	Pump High reach	
2000–8000	Up to 11 Over 11	15% of perimeter ⁽⁵⁾ 50% of perimeter ⁽⁵⁾	Pump High reach	
8000–16,000	Up to 11 Over 11	50% of perimeter ⁽⁵⁾ 50% of perimeter ⁽⁵⁾	Pump High reach	
16,000–24,000	Up to 11 Over 11	75% of perimeter ⁽⁵⁾ 75% of perimeter ⁽⁵⁾	Pump High reach	
Over 24,000	Up to 11 Over 11	100% of perimeter ⁽⁵⁾ 100% of perimeter ⁽⁵⁾	Pump High reach	

Notes:

- The total floor area is the aggregate of all floors in the building (excluding basements).
- In the case of Purpose Group 7(a) (storage) buildings, height should be measured to mean roof level, see Methods of measurement in Appendix C.
- An access door is required to each such elevation (see paragraph 16.5).
- See paragraph 16.8 for meaning of access.
- Perimeter is defined in Diagram 48.

On 2nd November 2012 and on 2nd December 2015, MF&RS Fire Safety Inspectors audited the premises under the Regulatory Reform (fire safety) Order 2005 (RR(FS)O 2005). On both occasions the outcome was broadly compliant and a medium risk level was determined. Under the MF&RS Risk Based Inspection Strategy, this would mean that the building would not require a further audit for a further 36 months. Following the 2012 audit, Liverpool Protection Department North wrote to the responsible person, stating: “Temporary hoardings that have been positioned to the ground floor may have considerably reduced the cross ventilation facility provided to this open-sided car park. This may impact on firefighting access and firefighter safety.” (See **section 4. Natural Ventilation**).

Due to the complex and diverse nature of the events that are held at ACCL and the inherent changes in fire strategies associated with these complexities, MF&RS had served ACCL with an Alterations Notice in 2008 (see Appendix 2)

This was in no way a punitive action by MF&RS and should not be viewed as such. This action was taken due to the diversity of shows, events and conferences that are held at ACCL. With this in mind, MF&RS were informed of the proposed change in strategy for the inaugural Liverpool International Horse Show in December 2016. Liverpool Protection Department North wrote a comprehensive note for case on the arrangements which involved the car park and ACCL itself. Liverpool Protection Department North submitted Operational Action Information Note (Ref. 11E/00306) to the Operational Planning Department and this information was disseminated to operational crews on a Public Events Briefing Note.

Observations and recommendations

1. MF&RS were appropriately consulted in the construction of this car park and were able to contribute effectively to ensure public and firefighter safety. This demonstrates the importance of good consultation between developers and the Fire and Rescue Service in ensuring that appropriate safety measures are implemented.
2. The close proximity of the serviced apartments to the southern and eastern elevations of the car park meant that aerial appliance access was very limited and firefighters faced extremely difficult conditions in order to save these buildings from fire. Designers and approved inspectors should give due regard to firefighter safety when considering design requirements of their buildings.

3.3 Fire Risk Assessments (FRA)

Kings Dock Car Park has 4 separate fire risk assessments completed on it by different stakeholders, two of which are for the day to day running of the car park and two are for the car park during the Liverpool International Horse Show. These are:

- **LCC** produced a FRA, specifically for the day to day running of the car park, dated 30th June 2017. It does not identify any non-compliance issues.
- **ACCL** commissioned Omega Fire to carry out a FRA, specifically for the day to day running of the car park, dated 9th February 2017. This was a comprehensive and detailed FRA, identifying several minor deficiencies.
- **ACCL** commissioned Omega Fire to carry out a FRA for all areas of the King's Dock Development given over to the Liverpool International Horse Show, including the Arena, ground floor of the car park, the pontoon and the service tunnel/loading bay. This was a comprehensive and detailed document, identifying hazards and risks and a fire strategy for the event.
- **LIHSBE** commissioned WH Management to manage certain aspects of the event, including a fire evacuation strategy, basic firefighting and a 24hr fire watch. WH Management commissioned Online Safety Solutions (OSS) to provide a FRA for the event, for all areas of the King's Dock Development during the Liverpool International Horse Show, including the Arena ground floor of the car park, the pontoon and the service tunnel. This was a comprehensive and detailed document, identifying hazards and risks and a fire strategy for the event.

RR(FS)O 2005, Article 9 states: "The responsible person must make a suitable and sufficient assessment of the risks to which relevant persons are exposed for the purpose of identifying the general fire precautions he needs to take to comply....under this order."

and

RR(FS)O, 2005, Article 22(1) states: "Where two or more responsible persons share, or have duties in respect of, premises (whether on a temporary or permanent basis) must –

- a) Co-operate with the other responsible person...to comply with....this Order.
- b) (taking into account the nature of his activities)...to co-ordinate the measures he takes to comply with... this Order with the measures the other responsible persons are taking to comply with...this Order.
- c) Take all reasonable steps to inform the other responsible persons concerned of the risks to relevant persons...

A suitable and sufficient FRA is an analysis of hazards and associated risk within a premises. Having more than one can potentially complicate matters. Such arrangements may make it difficult for the responsible person(s) to determine which FRA is the most comprehensive and the most appropriate to adopt. Also, where part of the building has essentially undergone a change of use, has increased in risk and is under the control, to some extent, of another responsible person, there should be a tacit understanding of roles and responsibilities of all employees in case of fire.

It should be noted that the FRAs and fire strategies for the event were detailed and comprehensive. Co-operation and co-ordination between the responsible persons were fairly robust, with pre-event planning and table top exercises taking place prior to the event. This preplanning extended to an emergency planning meeting and one of the scenarios was how to deal with fire in the stables.

During the incident, the evacuation of people from the car park was prioritised and a co-ordinated plan (**see Figure 3.3.1**) was in place to evacuate the horses. This plan took into account the potential risk to people, if the horses were to be evacuated at the same time. The impact on emergency service response and activities should also be considered. On actuation of the fire alarm, the system is interfaced to ACCL and has the effect of closing the entry barriers and opening the exit barriers of the car park.

This design feature is to stop vehicle access to and enable vehicle egress from a potential fire. However, the disciplined evacuation of the horses via the front entrance to the car park could have been jeopardised by interventions of worried members of the public applying pressure to employees, who, in turn may not have been aware of the strategic decisions around the co-ordinated and controlled evacuation plan.

Figure 3.3.1: extract from OSS Event FRA

Procedures for the evacuation of horses within a fire emergency.

Horses within the ground floor stables areas shall only be evacuated in an extreme emergency and under a dynamic risk assessment procedure undertaken by the Event Safety Adviser and the Show Director.

Horses shall only be evacuated in extreme circumstances, and initially the following procedures shall be implemented;

- The horses will remain in the stables until they are safe to move to the horseboxes**
- If unavailable, the horses will be evacuated to the horseboxes and then transferred off site.**
- If unavailable then horses will be led by the grooms to a designated safe muster point**

The designated fire muster point for the collection of horses is defined as the land adjacent to Loading Bay 3.

CCTV footage indicates that there may not have been strict adherence to the delineation of roles and responsibilities outlined in the different FRAs and fire strategy documents. It clearly shows staff from OCS and LISHBE accessing areas that fell under the responsibility of LCC. It must be noted, however, that their presence and actions did contribute to the safe evacuation of levels 1 to 7

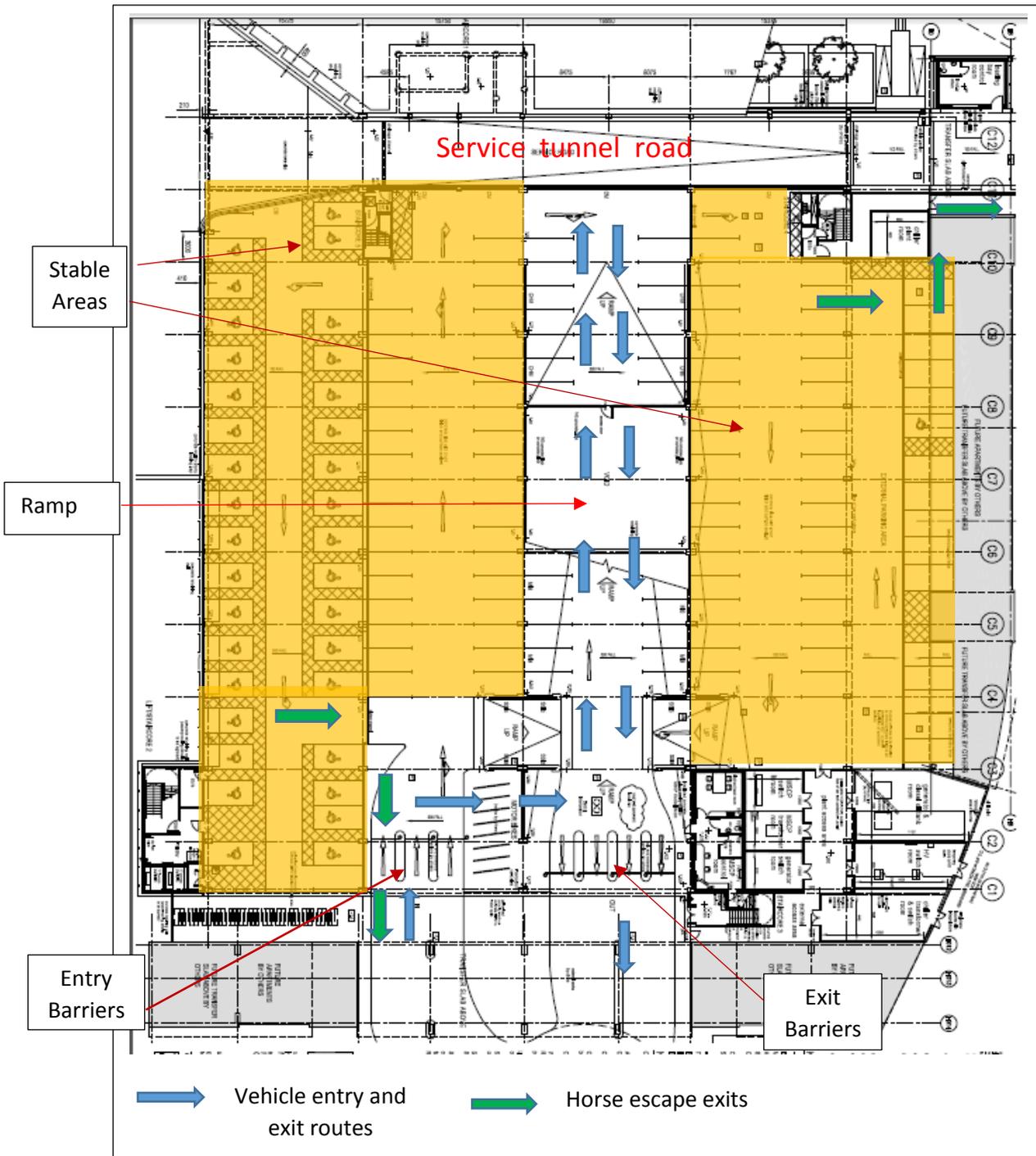
LCC staff priorities were, once the evacuation of people from levels 1 to 7 had been completed, to prevent vehicular and pedestrian access to the car park (under the fire strategies, they were to be aided by ACCL staff with this task).

On actuation of the fire alarm the exit barriers open, to allow vehicular egress and the entrance barriers close to prevent vehicular access. One of the predetermined escape routes for the horses was via the entry barriers on the ground floor.

This situation, combined with considerable pressure from worried horse owners, had the potential to lead to an uncontrolled evacuation of horses into oncoming fire appliances and adversely affect firefighting operations.

Although tensions were raised at this critical time, LCC and ACCL and LIHSBE staff managed a well-controlled and co-ordinated evacuation of the horses, as per the pre-planning.

Figure 3.3.2: Ground Level floor plan



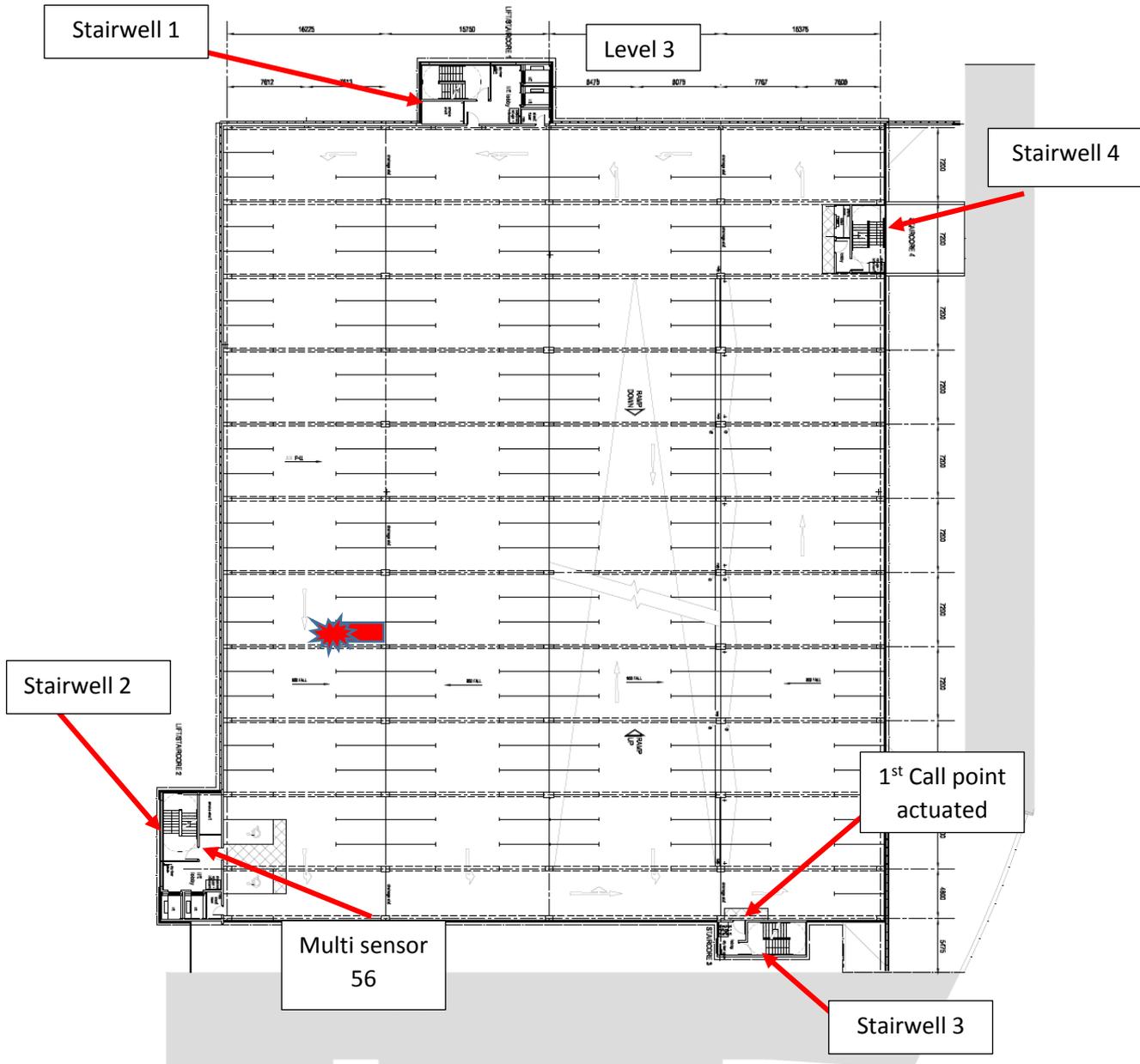
Observations and recommendations

1. LCC should review all fire risk assessments for their car parks
2. Although not a contributory factor during this incident, careful consideration should be given to using car parks for purposes other than the parking of vehicles, in future.

3.4 Fire Protection Measures

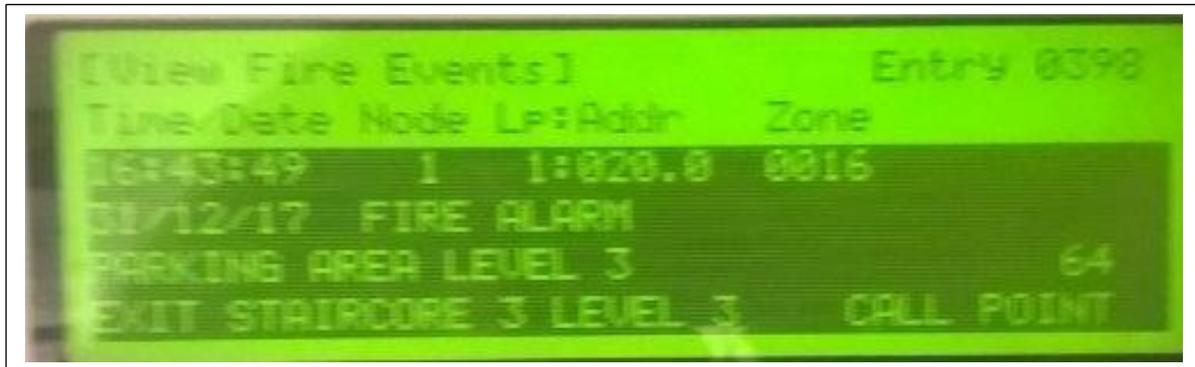
The car park is served by a combination of a manual and an automatic fire alarm system, complying with BS5839-1. There are manual call points on all levels of the car park, adjacent to protected stairwell exits.

Figure 3.4.1: Level 3 floor plan



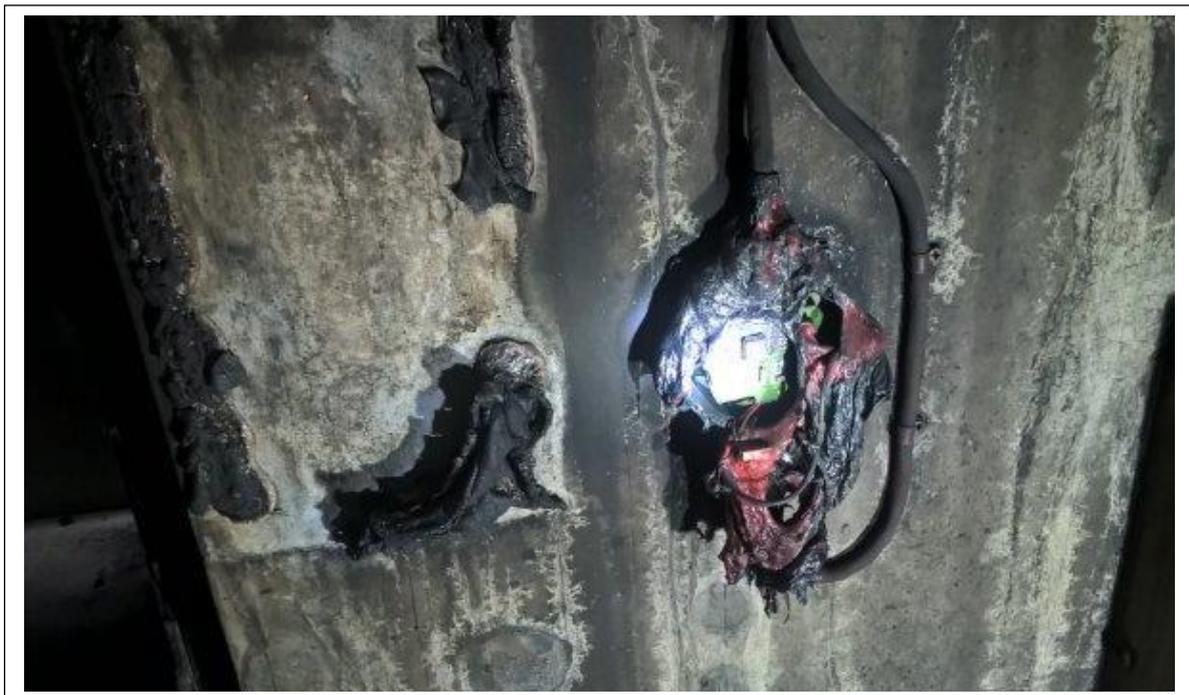
The fire alarm was first actuated at 16:43:49, alarm panel indicating call point 64, level 3, adjacent to escape stairwell 3.

Figure 3.4.2: Photograph of Alarm Panel, 1st Actuation



However, it was not possible to visually identify this call point, due to fire damage.

Figure 3.4.3: Photograph of Damaged Call Point on Level 3, Outside Stairwell 3



The second actuation was at 16:51:53, alarm panel indicating multi-sensor 53. The fire alarm panel indicates lift lobby, level 3.

Figure 3.4.4: Photograph of Alarm Panel, 1st Actuation



However, the photograph below was taken in the lift lobby area of stairwell 2, level 3 and clearly shows the number 56, once the products of combustion had been removed from the identity label.

Figure 3.4.5: Photograph of Multi-sensor in Lift Lobby, Stairwell 2, Level 3



Notwithstanding, it is reasonable to assume that both these locations indicated on the panel are accurate, as the alarm panel indication of a call point on level 3, outside stairwell 3, was the same location that both LCC staff and a member of the public said that they had actuated the break glass point. Secondly, the lift lobby door at stairwell 2, level 3 was sited close to the fire. This door was repeatedly opened by members of the public and staff, allowing the products of combustion into the lobby area, actuating the multi-sensor.

Further investigation and scrutiny of the original fire alarm schematics showed that the call point and detector labelling matched their siting within the building. The zones indicated on the panel actuations matched both the zonal plan in the office and the zones of alarm actuation (where staff and members of the public stated that they had pushed the break glass).

Upon inspection, call point 64 was found to be located in stairwell 4, level 2 and multi-sensor 53 was located in stairwell 2, level 1. Both these locations matched the fire alarm schematic.

This would indicate that the detector and call point addresses had been incorrectly inputted into the alarm system during installation, or at a later stage.

The protected stairwells have dry risers, automatic openable vents with manual overrides, automatic detection on all levels refuge points with communications and manual call points are sited adjacent to final exits.

Figure 3.4.6 Active Protection Measures, ground floor, Stairwell 3

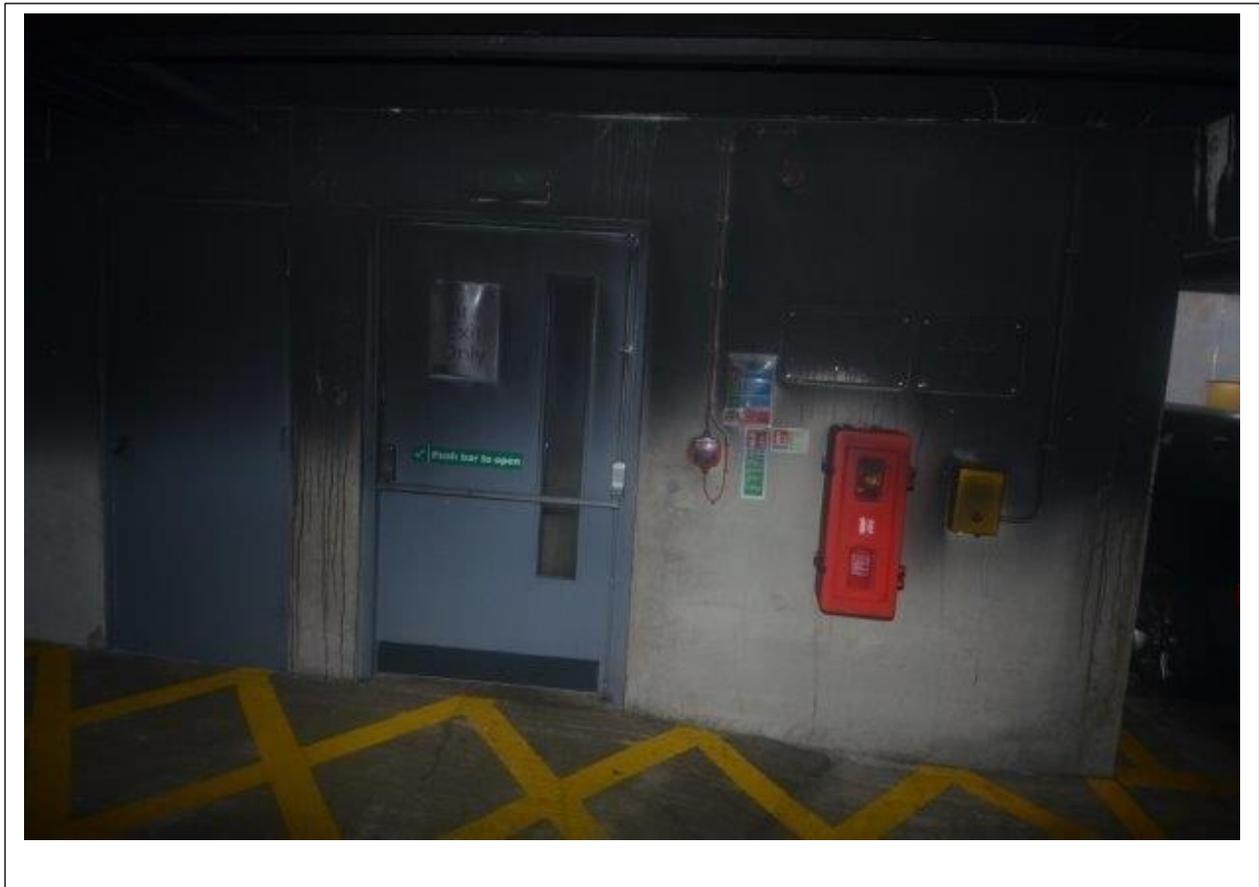


The car park and all escape routes are provided with emergency lighting, conforming to BS5266 and emergency signage conforming to BS5499.

The building comprises four stairwells. Stairwells 1 and 4 are two hour firefighting shafts, conforming to BS5588-5. Stairwells 2 and 3 are ninety minute protected stairwells. Stairwells 1 & 2 are served by passenger lifts. None of the stairwells are served by firefighting lifts.

Fire extinguishers are located adjacent to call points on all levels and additional firefighting equipment and a fire event team were provided by WH Management during the event. The remit of the event firefighting team within the car park did not extend beyond the stabled area on the ground floor.

Figure 3.4.7 Fire point and exit, Level 1 Stairwell 4



Stairwells 3 and 4 are only available on actuation of the fire alarm. The push bar doors are locked by magnetic devices, linked to the alarm panel. These stairwells are not accessible from outside the car park, for security reasons. Members of the public complained of difficulty in opening the emergency escape door to stairwell 3, level 3.

Figure 3.4.8 Remnants of Fire point, Level 3 Stairwell 3



Images 3.4.9 and 3.4.10 are good examples of the effectiveness of the passive fire protection measures in place and how well they performed, despite the severity and intensity of the fire.

Figure 3.4.9 Stairwell 2 Level 2 exit from parking area

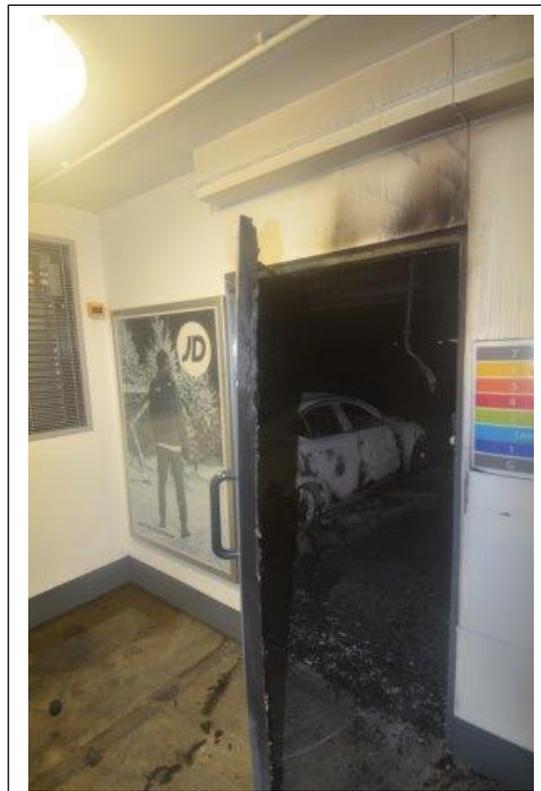


Figure 3.4.10 Stairwell 3 Level 2 exit from parking area



Observations and recommendations

1. LCC are advised to undertake an audit of fire escape doors at all parking locations, to check compliance to BS5839-3 and BS7273-4.
2. Correctly labelled addressable detectors and call points clearly help the responsible persons and Fire and Rescue Services to reduce the time taken to identify the specific location of alarm actuation. A delay to locating a fire can lead to an escalated incident and potentially more severe fire.
3. Where CCTV is used as part of a fire strategy for detecting a fire, it should fulfil the requirements of BS EN 6276 and BS8418 and have adequate numbers of staff to monitor it. If this is not achievable, then alternative and/or additional detection should be considered.

3.5 Firefighting Access and Facilities

The gross floor combined area exceeds 24,000m² and consequently requires 100% perimeter access for pumping appliances and high rise appliances. The apartments constructed on the south and east sides, restrict 50% of the access area, consequently reducing firefighter appliance and aerial appliance access to 50% of the building. As a result MF&RS insisted on firefighting shafts so that a fire could be fought internally, in a safe environment (see **3.4 Fire Protection Measures p.36**).

The following images show the severely restricted firefighter appliance access due to the proximity of the serviced apartment building on the southern side of the car park. This negative impact was identified during building regulations submissions and MF&RS insisted on protected stairwells to mitigate this deficiency and accommodate internal firefighting, reaching all levels.

Figure 3.5.1: Firefighting Access on southern elevation

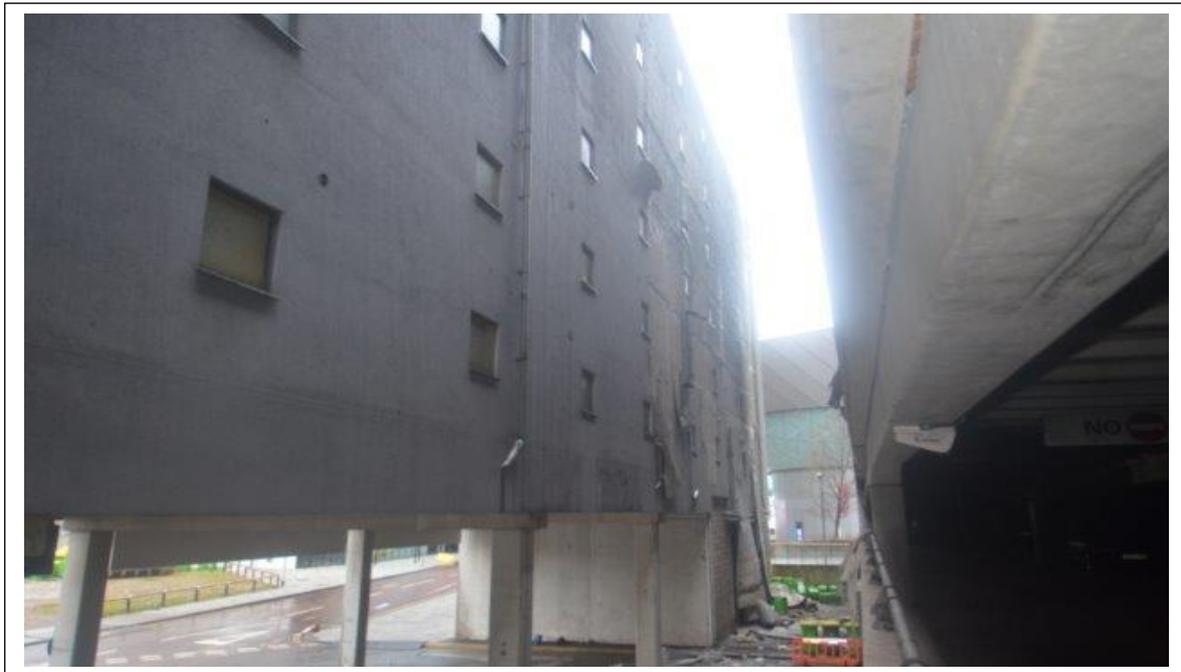


Figure 3.5.2: Firefighting Access on southern elevation, viewed from western elevation



Figure 3.5.3: Firefighting Access on the eastern elevation, viewed from easterly direction



Observations and recommendations

1. Aerial appliance access proved very difficult at this incident and the grilles across the open sides hindered external firefighting. Access and facilities for firefighters at car parks should be reviewed.

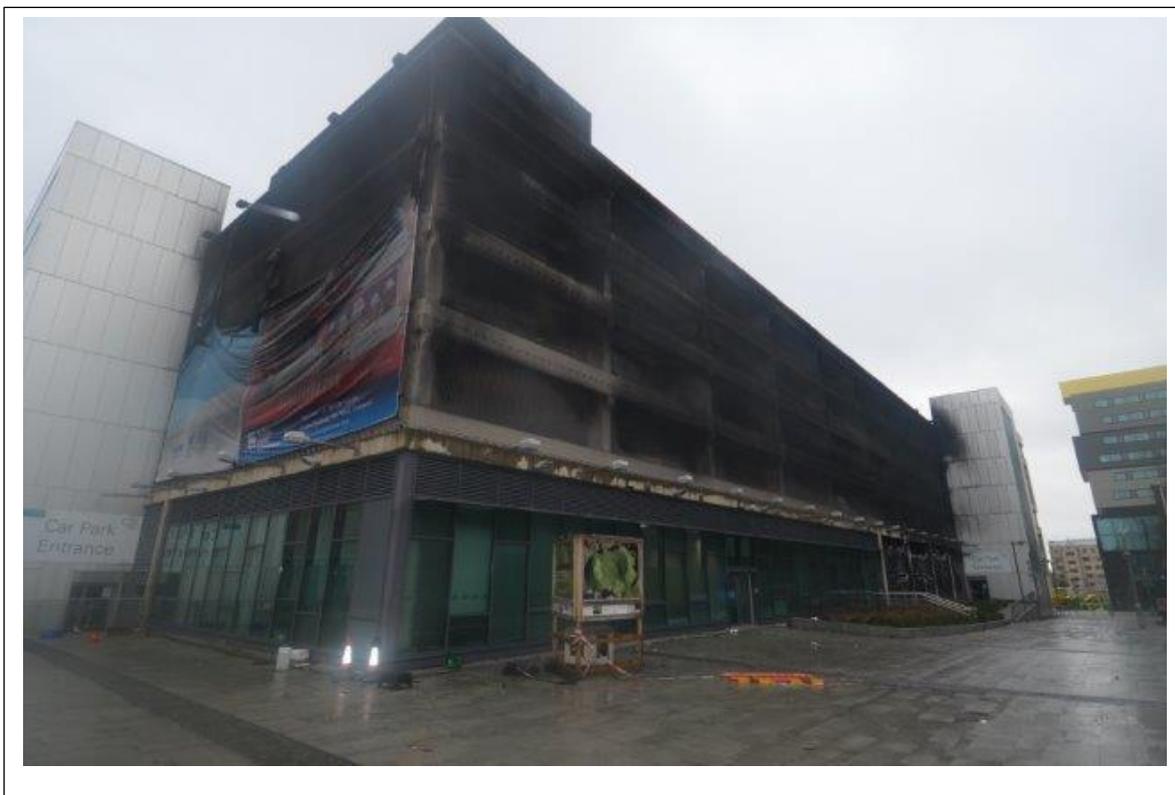
4. NATURAL VENTILATION

Approved Document B, Volume 2, (Buildings other than dwelling houses), **Section 11.3b** states that, in order for the car park to be defined as open-sided:

- “each storey should be naturally ventilated by permanent openings at each car parking level, having an aggregate vent area not less than 1/20th of the floor area at that level, of which at least half (1/40th) should be equally provided between two opposing walls;”

Post incident, MF&RS and LCCLABC undertook a thorough and robust examination of the car park, to ascertain whether the cross ventilation was compliant with ADB, Vol.2 and whether advertising hoardings attached to two locations on the northern elevation had any potential negative effect on compliance. A comprehensive survey of differing aperture areas was undertaken, involving a mobile elevating work platform and laser measuring, due to the unstable nature of the floors following the fire.

Figure 4.1: Fire damaged advertising hoardings



Initial calculations from plan drawings of the building showed that the building had been constructed to plan and that the natural ventilation requirements had been achieved. However, both parties wanted a definitive answer and LCCLABC should be commended for this. The calculations submitted to MF&RS by LCCLABC are very similar to the calculations performed by MF&RS and both show compliance to the regulations set out in ADB Vol.2.

These calculations differ because MF&RS measured distances from as-built drawings, whereas LCCLABC used laser measuring on site for actual opening sizes.

MF&RS took into account an approximate 8% reduction in ventilation caused by the advertising in their calculations and the building still complied with ventilation requirements under ADB Vol.2.

Figure 4.2: Internal view of grille and advertising on level 2



As can be seen from the above photographs (**Figs. 4.1 & 4.2**), the apertures between columns are covered by grilles. These 'Tigris Woven Mesh Panels' cover the apertures from level 3 to level 6 on the northern and western elevations. The free area of these mesh panels is 65 %, according to GKD UK, the PC-Tigris data sheet. This was taken into account by both LCCLABC and MF&RS in their calculations.

5. HUMAN BEHAVIOUR TO FIRE

Human Behaviour in Fire is the study of human response when exposed to fire in buildings. It includes an understanding of people’s awareness, beliefs, attitudes, motivations, decisions, behaviours and coping strategies and the factors that influence them.

In the case of the Kings Dock fire, human behaviour and reaction to the fire may have led to fire development prior to MF&RS arrival and may have caused initial attending crews and incident commanders to have been distracted from commencing an immediate weighted attack on the fire on level 3. Considering the number of witnesses to the fire in its initial stages and their ability to dial 999 (mobile phone technology), very few calls were received by MF&RS Fire Control in the early stages of the incident and this would appear to indicate that members of the public displayed reactions to fire that go against all fire situation training and advice.

CCTV footage shows several pedestrians and persons in vehicles witnessing the fire but not making an emergency call. Some decided to drive down to ground level and report the incident to LCC staff, whilst others did nothing. One particular driver stopped their vehicle in the roadway for 30 seconds, immediately next to the vehicle of origin when it was well alight and then proceeded to park their vehicle on the ramp from level 3 to level 4, without raising the alarm.

The CCTV images below (**Figure 5.1.1**) was taken just before first 999 call. None of these witnesses called 999 or raised the alarm and the image overleaf (**Figure 5.1.2**) captures the event approximately 3 minutes prior to 999 call.

Figure 5.1.1: CCTV still frame



Figure 5.1.2: CCTV still frame



Only five 999 calls were received by MF&RS prior to first attendance (between 16:42hrs and 16:45hrs). No further 999 calls were made until 17:25hrs.

An “Event Firefighting Team” was in attendance by 16:45hrs. They parked outside the main entrance to the car park, in a vehicle which had blue flashing lights and “fire & rescue” livery. This may have led members of the public to believe that MF&RS were in attendance and reduced number of 999 calls.

Figure 5.1.3: WH Management Emergency Response vehicles



MF&RS, LCC, ACCL and WH Management staff all cited members of the public not following instruction to evacuate, distracting staff from performing their duties, and interfering with prescribed fire strategies that had been agreed between the responsible parties. Although the vast majority of members of the public's actions and inputs were undoubtedly well-intentioned, the WH Management Post Incident Report contains the following statement:

“During the briefing stage, a member of the public had forced her way into the stable area and started to open stable doors. This caused panic with horses and younger grooms in what had been a calm and prepared area. She was asked to leave twice by WH and event organisers who on the third warning escorted her out of a side entrance. Her actions were irresponsible, dangerous and placed not only herself but also others at risk.”

The first social media post (complete with photo of the vehicle of origin on fire) was posted by 16:50hrs and this was followed by a 'live stream' on social media by 16:57hrs. This would appear to reinforce a growing trend of members of the public placing more importance on capturing emergency events, disasters, RTCs, assaults etc. for uploading to a social media platform, rather than follow the basic principles of fire safety advice of leaving by the nearest available exit; raising the alarm and letting the emergency services deal with the incident.

Notwithstanding the above, it should be noted that two student nurses who made the initial 999 call, did exactly what FRS advises (raise the alarm, leave the premises and stay out). They had entered the car park and were proceeding to drive up the levels when they noticed the fire. They called 999, drove down to ground level and informed LCC staff and then drove out of the car park.

Observations and recommendations

1. Event organisers should seriously consider the limitations of private emergency response teams.
2. Private response teams should make every attempt, as far as is reasonably practicable, to ensure that their personnel, equipment and vehicles are not mistaken for emergency services. The requirement for response under blue lights by such teams is seriously questionable.
3. MF&RS would advocate more public information as to what their actions should be upon discovering a fire and the potential positive and negative effects of members of public recording and streaming live emergency incidents and the impact this has on the emergency services and any potential victims.

6. RELATED INCIDENTS

Fleming Way, Wiltshire, 29/01/18

Multi-storey car park, attached to local shopping centre, three crews dispatched to tackle a vehicle fire on the third floor, suspected to have been deliberately ignited.

Topp Way, Bolton, 20/01/18

Multi-storey car park, single vehicle fire within the multi-storey car park. Firefighters using one main jet on scene for 1 hour, recorded as an accidental fire.

Paris, France, 10/01/18

Fire in underground car park, 1 Firefighter fatality (heart attack), 120 Firefighters attended.

Jecheon, South Korea, 20/12/17

Fire in a ground floor car park spread to the floors above in an eight storey building. 29 people were killed.

Boomtown Festival Fire, Hampshire, 12/8/16

Open car park on a straw stubble field. 92 vehicles involved in fire.

Southwater, Telford, Shropshire, 20/6/16

Multi-storey car park, fire involving several vehicles causing damage to wiring, electrical fittings and surrounding structures on the third floor. 3 appliances dispatched, using BA and one main jet brought the fire under control within 2 hours.

Cheltenham Rd, Harrogate, 4/12/15

Multi-storey car park, vehicle fire on 5th floor, 4 appliances dispatched and one aerial ladder platform due to the position of the fire. Crews used 1 dry powder and 1 carbon dioxide extinguisher to resolve the incident.

Isle of Wight, Newport town centre, 17/7/15

Multi-storey car park, one car involved, crews hauled up a hose reel to extinguish the vehicle, fire investigation concluded as accidental ignition.

Willow Place Shopping Centre, Corby, Teeside, 30/12/14

Multi-storey car park building, several vehicles involved, damage to the car park structure and several retail outlets. 6 appliances attended, 30 firefighters worked for four hours to extinguish the fire. 4 youths aged between 14 and 20 charged with arson in connection with the incident.

Place Vendome, Paris, 2012

Underground car park, 40 high performance and luxury vehicles lost in fire, declared as accidental ignition due to electrical fault.

Ivry-sur-Seine, France, 2009

Multi-storey car park, 200 vehicles involved in fire, fifteen appliances engaged, use of aerial appliances as water towers.

Foregate Shopping Centre, Kilmarnock 26/12/08

Multi-storey car park, fire on the third level with heat and smoke travel up to the fourth and fifth levels. 2 BA teams deployed, a total of 11 vehicles damaged, fire investigators found the cause to be accidental.

Monica Wills House, Bristol, England, 2006

Multi-storey car park, fire involving 22 vehicles, one fatality due to smoke inhalation from occupancy above the parking facility.

Gretchenbach, Switzerland, 2004

Underground multi-storey car park, fire involving up to one hundred vehicles, 7 firefighters killed during firefighting operations.

REFERENCES

1. Ministry of Housing, Communities and Local Government, [Fire safety: Approved Document B](#), Building Regulations 2010
2. [BRE, Fire spread in car parks BD2552](#), December 2010
3. [The Regulatory Reform \(Fire Safety\) Order 2005](#)
4. [British Parking Association website](#), accessed 26/01/18
5. The Institution of Civil Engineers, [Recommendations for the Inspection, Maintenance and Management of Car Park Structures](#), 2002
6. The Institution of Structural Engineers, [Design recommendations for multi-storey and underground car parks](#), Fourth Edition, March 2011
7. [Structural-Safety, SCOSS Topic Paper, Fires in Multi-Storey Car Parks](#), February 2018
8. Ministry of Technology and Fire Offices' Committee Joint Research Organisation, Fire and Car Park Buildings, Fire Note 10, E.G. Butcher, G.J. Langdon-Thomas and G.K. Bedford 1968
9. Municipal Engineering in Australia, BHP Fire Tests Prove the Value of Sprinkler Systems, Volume 14, Issue 4 pp.3-13, Thomas, I., Bennetts, I., September 1987
10. [UNECE Regulation 34](#) Technical Prescriptions for Wheeled Vehicles
11. [PC-Tigris Data Sheet](#) GKD UK

GLOSSARY OF TERMS

ACCL: ARENA and CONFERENCE CENTRE LIVERPOOL

ADB: APPROVED DOCUMENT B

BA: BREATHING APPARATUS

BRE: BUILDING RESEARCH ESTABLISHMENT

BS: BRITISH STANDARD

CCTV: CLOSED CIRCUIT TELEVISION

DCLG: DEPARTMENT of COMMUNITIES and LOCAL GOVERNMENT

FRA: FIRE RISK ASSESSMENT

H&S: HEALTH and SAFETY

IIT: INCIDENT INVESTIGATION TEAM

LCC: LIVERPOOL CITY COUNCIL

LCCLABC: LIVERPOOL CITY COUNCIL LOCAL AUTHORITY BUILDING CONTROL

LIHSBE: LIVERPOOL INTERNATIONAL HORSE SHOW BOLESWORTH EVENTS

MF&RS: MERSEYSIDE FIRE and RESCUE AUTHORITY

OCS: OUTSOURCED CLIENT SOLUTIONS UK LTD.

OSS: ONLINE SAFETY SOLUTIONS

RR(FS)O 2005: REGULATORY REFORM(FIRE SAFETY) ORDER 2005

UKFRS: UK FIRE and RESCUE SERVICE

UNECE: UNITED NATIONS ECONOMIC COMMISSION for EUROPE

Appendix 1 – Detailed Timeline

Time	Date	Details
16:29	31.12.17	Internal car park CCTV - first signs of fire (smoke) from the vehicle
16:33	31.12.17	Internal CCTV - steady stream of smoke from vehicle
16:37	31.12.17	Internal CCTV – initial signs of flame from vehicle
16:37	31.12.17	External CCTV – first signs of smoke in Plaza area
16:40	31.12.17	External CCTV – pans to 3 rd floor and shows developing fire
16:42	31.12.17	First call to the Fire Service (999 call from member of public)
16:43:	31.12.17	First fire alarm actuation (break glass call point)
16:43	31.12.17	Two appliances mobilised
16:44	31.12.17	First call received from LCC at venue.
16:45	31.12.17	Female seen taking photo that is later shown on social media
16:45	31.12.17	Event firefighting team arrive at main entrance, under blue lights
16:50	31.12.17	MF&RS 1 st Appliance attendance at main entrance
16:51	31.12.17	MF&RS 2 nd Appliance attendance at main entrance
16:51	31.12.17	Second fire alarm actuation (multi-sensor in stairwell 2)
16:56	31.12.17	Assistance message – “Make pumps 3”
16:56	31.12.17	External firefighting begins
16:57	31.12.17	Fire alarm Panel re-actuation (break glass and multi-sensor)
17:01	31.12.17	Assistance message “Make pumps 6”
17:08	31.12.17	First BA team (Alpha 1) committed from stairwell 2 into level 3 (Sector 2)
17:09	31.12.17	Second BA Team (Alpha 2) committed from stairwell 2 into level 3
17:31	31.12.17	Assistance message – “Make pumps 8”
17:31	31.12.17	BA crews report multiple vehicles involved and re-ignition of extinguished vehicles
17:35	31.12.17	Third BA crew (Alpha 3) committed from stairwell 2 into level 3. BA crews report running fuel fires, explosions and “waterfall” of fire coming from level above
17:40	31.12.17	BA crews report up to 30 vehicles involved and running fuel fire between rows of cars
17:41	31.12.17	Assistance message – “Make pumps 12”
17:52	31.12.17	Internal CCTV – first signs of flame from level 4, in location away from ramps and above initial fire on level 3
18:07	31.12.17	First BA team (Bravo 1) committed from stairwell 1 to level 3 (Sector 3). Report clear view of fire due to wind conditions. Fire confined to two rows of vehicles, away from ramps
18:20 - 18:25	31.12.17	All BA crews withdrawn from sector 2 due to untenable fire conditions
18:22	31.12.17	Incident Investigation Team (IIT) in attendance
18:28	31.12.17	Second BA team (Bravo 2) committed from stairwell 1 into level 4. Report a well-developed and rapidly escalating fire.
18:38	31.12.17	Emergency evacuation of all teams due to major fire event on level 4 and concerns over firefighter safety

Appendix 2 - Alterations Notice

1. Name:
- Premises: **Liverpool Arena & Convention Centre**
Address: Monarchs Quay, Liverpool, L3 4FP

2. I, **Fire Safety Manager, Liverpool**, on behalf of Merseyside Fire and Rescue Authority, hereby give you notice that the Fire and Rescue Authority are of the opinion that, under Article 29(1)(b) of the above Order, any change made to the premises, or the use to which they are put, may constitute a serious risk to relevant persons (See notes) due to the reliance on fire engineering features designed into the building and the high degree of management required to ensure the maintenance of a fire safe premises.

3. The Fire and Rescue Authority hereby direct that if you, as a responsible person, (See notes) intend making any of the following –
 - (a) a change to the premises, including the fire safety strategy;
 - (b) a change to the services, fittings or equipment in or on the premises;
 - (c) an increase in the quantities of dangerous substances which are in or on the premises, or
 - (d) a change to the use of the premises;

you, as the responsible person, must notify the Fire and Rescue Authority of the proposed changes.

The Fire and Rescue Authority also direct that in addition to the notification referred to above, that as a responsible person you must -

- (a) take all reasonable steps to notify the terms of this notice to any other person, or persons, who have to any extent control of the premises, insofar as the requirements in articles 8 to 22 of the Regulatory Reform (Fire Safety) Order 2005, or in regulations made under Article 24, relates to matters under his, or their, control;

- (b) carry out or review the risk assessment and record the significant findings, including the measures which have been taken or will be taken and identify any group of persons identified by the risk assessment as being especially at risk;

- (c) record the arrangements as are appropriate, having regard to the size of his undertaking and the nature of its activities, for the effective planning, organisation, control, monitoring and review of the preventative and protective measures, and

- (d) before making any changes referred to in the above paragraph, send to the Fire and Rescue Authority a copy of the risk assessment and summary of the changes proposed to be made to the existing general fire precautions.