REPORT ON THE INVESTIGATION INTO THE FIRE ON BOARD THE CLIPPER SHIP - CUTTY SARK, KING WILLIAM WALK, GREENWICH, LONDON SE10 ON MONDAY 21ST MAY 2007

Working together for a safer London

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Summary.

At 4.47am on the 21st May 2007, the world's sole surviving tea clipper ship – 'Cutty Sark' was engulfed in fire. The following is a summary of the full investigation report relating to this incident.

The physical evidence and CCTV footage of the fire show that it probably originated towards the stern of the ship on the lower deck, in the area of the aft stairway. On the basis of the witness evidence, it is considered unlikely that the fire was caused by hot work or by carelessly discarded smokers' materials, due to the extended period of time between the last known activities on the ship and the outbreak of flaming fire. There is no evidence to suggest that the fire was caused deliberately.

There was no CCTV camera in use on the site at the time of the fire. The analysis of the CCTV footage in the areas external to the site suggests that it is unlikely that an intruder accessed the site at around the time of the fire.

A number of potential electrical causes of the fire have been considered. Only resistance heating at terminations in plastic junction boxes that supplied fluorescent lights, and overheating of a motor in an industrial vacuum cleaner were considered plausible causes of the fire. In view of the severity of the damage to the Cutty Sark, it was not possible to conclusively establish the cause of the fire. However, tests carried out on the same model of industrial vacuum cleaner as that used on the ship showed that the unit could ignite if operated for an extended period of time with the suction hose blocked.

There was no physical evidence to show that the industrial vacuum cleaner on board the Cutty Sark had been operating at the time of the fire, and the witness evidence in this regard is somewhat conflicting. However, the last person to use the unit stated that it was left switched 'on', and nobody else described switching it 'off'. Given the identified susceptibility of the industrial vacuum cleaner to cause fire under certain conditions, and provided the unit had been left switched 'on' this would present the most likely cause of the fire.

1.0 INTRODUCTION

1.1 At 4.47am on the 21st May 2007, the world's sole surviving tea clipper ship – 'Cutty Sark' was engulfed in fire. This report outlines the events of that morning, and details the subsequent investigation into this incident.

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2.0 BACKGROUND

2.1 History

2.1.1 The Cutty Sark was originally launched in 1869. Since 1954, the ship had been located in a dedicated 'dry dock' in Greenwich, beside the River Thames.

2.1.2 A structural survey in 1998 highlighted advanced corrosion of the wrought iron frame, and suggested that if nothing were done to conserve the structure of the ship then it would become unsafe within approximately ten years. The ship was in the process of a significant restoration project to address these corrosion problems.

2.1.3 Cutty Sark Enterprises managed the project on behalf of the owners - The Cutty Sark Trust. Several areas for restoration and improvement work were identified and included:

- Treating the ironwork with a combination of electrolysis and mechanical cleaning, to preserve as much original fabric as possible and strengthening the weakened frames.
- Replacing the keel, main deck and sheathing.
- Replacing the props and shores with a new support system to give an even support to the hull.
- Removing the offices and workshops from the ship and removing the 1950's false deck, replacing it with 'lily pad' decks with a collapsible auditorium.
- Improving internal access to the ship by replacing the 1950's stairway in the

aft hatchway with a lift and replacing the steep stairway in the forward hatch with a new stairway.

• Covering the ship at waterline level with a canopy to give weather protection to the hull and improve security.

• Replacing the existing entrance with a lift/stairway taking visitors onto the main deck.

• Opening up the dry berth to the public by installing lifts and ramps and raising the ship by 1½ metres.

• Creating toilets and catering facilities in a unit within the dry berth wall.

2.1.4 The project was scheduled to last from October 2006 - 2008. From April 2007-September 2008 there was to be a temporary exhibition adjacent to the ship – referred to as the 'Pavilion'. This included a live web-camera where visitors were given the opportunity to live-view the restoration project.

2.2 Construction of the Cutty Sark – Pre conservation project

2.2.1 The ship comprised of oak and rock elm hull planking attached to an iron frame. There were three decks: a main upper deck, a tween deck, and a lower deck. The lower planks were constructed of pine and Douglas fir, the tween deck consisted of pine, and the main deck planks were teak. Two stairways provided access between the decks. These were situated towards the bow and stern of the ship.

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3.0 CONSERVATION PROJECT

3.1 Responsibilities

3.1.1 Heery International Limited were employed as the construction managers for the Cutty Sark conservation project, and Heery International Limited sub-contracted Munnelly Support Services Limited to provide 24-hour site security. The restoration project required the installation and maintenance of temporary electricity supplies for lighting and electrical equipment, and this was sub-

contracted by Heery International Limited to Crosby Electrical Services Limited.

3.2 Condition of the Cutty Sark – May 2007.

3.2.1 Fortunately, as part of the conservation project, the masts, rigging, and the vast majority of the hull planking had been removed prior to the fire. They were removed as part of the conservation project, and these items were in storage at a secure location.

3.2.2 A temporary steel and wooden roof structure had been erected on board the ship, and scaffolding had been erected around the hull of the vessel to provide workers with access to those areas. The scaffolding frame was covered with a white sheeting material (as detailed in paragraph 6.4.1.2). Plywood decking had been installed to replace the voids left by the removal of the original decking, and plywood inner hulls were in place in certain areas of the lower and tween deck.

3.3 Ship access

3.3.1 Three walkways provided access to the scaffolding from the pier of the dry dock. These were located at the bow, stern, and midway along the starboard side of the ship. The tween deck could be accessed from the scaffolding via the iron hull frame. It could also be accessed via the pier of the dry dock through the original public entrance, midway along the port side of the vessel.

3.4 The Cutty Sark site

3.4.1 The Cutty Sark was situated in King William Walk, Greenwich, London, SE10. The bow faced the River Thames, with the starboard facing towards King William Walk. The port side faced an open pedestrian area above an underground car park. The boundary of the site consisted of wooden hoarding along the east, west and north boundaries, and a stone wall along the southern boundary. Metal shipping containers were situated inside the northern boundary. These were utilised as offices.

3.4.2 The Pavilion area was situated outside the site boundary hoarding, towards the southwest of the site.

3.5 Site access

3.5.1 The main entrance was situated in King William Walk towards the southeast of the site. This entrance consisted of a large wooden gate, which naturally led to a security hut situated near the southeast corner of the dry dock. Two other wooden gates were positioned along the west boundary hoarding. A further access site was via one of the northern boundary container offices, which was fitted with a swipe-card entry system. A further similar swipe-card system was in operation inside the security hut. This was used to register an individual entering or leaving the site, commonly referred to as ‘clocking in’.

3.6 Electricity supply to the site

3.6.1 The Cutty Sark was provided with a three-phase service head, rated at 230/400 volts, located in a distribution board on the port side of the tween deck, adjacent to the port side entrance to the ship. The distribution board was fitted with three-phase fused switches which had supplied the fixed wiring on board the ship when it had been open to the public. The fixed electrical systems on board the ship had been isolated at the distribution board prior to the commencement of the conservation project. Only one of the switches in the distribution board was reportedly not isolated, as this supplied pumping equipment located in the dry dock, outside the ship.

3.6.2 Crosby Electrical Services Limited connected a temporary supply cable to the distribution board, immediately downstream of the service head and metering equipment. This temporary supply powered a three-phase main distribution unit (MDU) located off the port side of the ship, which provided electricity to all the temporary electrical equipment on the site. This port side MDU directly supplied nine transformers located on the decks of the ship, three electrical socket outlets located on the tween deck, two 10 kVA three-phase transformers positioned external to, and near the bow of the ship, a fire alarm

panel and two other MDU's. The electrical socket outlets on the tween deck had reportedly been used to supply a radial arm saw, circular saw and band saw respectively. The two other MDU's supplied the office buildings, the security hut, an adjacent air compressor and two 10 kVA three-phase transformers located at the pier of the dry dock near the stern of the ship.

3.6.3 Of the nine transformers located on the ship, six were three-phase 400:110 Volt transformers rated at 10 kVA. Three of these were located near the forward stairway, one per deck, whilst the other three were located near the aft stairway, also one per deck. The remaining three transformers on the ship were single-phase 230:110 Volt transformers rated at 5 kVA, and were located around the middle of the ship, again one per deck.

3.6.4 Crosby Electrical Services Limited supplied the fixed lighting on and around the ship, but did not supply any portable or task lighting. The lower deck and tween deck were fitted with fluorescent lights that were supplied with electricity from the transformers on the ship. These were permanently switched on.

3.7 Security

3.7.1 Site security was provided on a 24 - hour basis, by Munnelly Support Services Limited. During the day shift (07:00 hrs - 19:00 hrs), one security guard was present, and this was increased to two guards for the night shift (19:00 hrs - 07:00 hrs). During the night shift, one security guard was responsible for the Pavilion, the other being responsible for the construction site. At a meeting between Munnelly Support Services Limited, and a Heery International representative, it was apparently clarified that the night shift should perform a patrol every hour around the Cutty Sark, both inside and outside the site boundary. This was to be recorded in a log/occurrence book and confirmed by a telephone call to an automated call centre.

3.8 Fire detection and protection systems

3.8.1 A temporary fire detection system had been installed by Crosby Electrical Services Limited. The system consisted of heat detectors located on the tween and lower decks, alarm sounders in the ship, and three alarm sounder/

beacons devices around the exterior of the ship. The control panel was situated at the pier of the dry dock, near the port side ship entrance, and the electricity was supplied from the port side main distribution unit (MDU). There was no sprinkler system operating on board the ship, although there were some pipes remaining in the bilges from the sprinkler system that had been decommissioned to enable the restoration work to take place.

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4.0 THE CUTTY SARK FIRE – MONDAY 21st MAY 2007

4.1 Discovery of the fire

4.1.1 The London Fire Brigade were called to the Cutty Sark at 04:47:56 hrs on Monday 21st May 2007. The call was made by one of the two security guards on duty at the Cutty Sark site from his mobile telephone. The time of the discovery of the fire is corroborated by CCTV images covering the port side of the ship. These images show flames first visible at 4.47.49 hrs. The CCTV cameras are some considerable distance from the ship, but the images appear to indicate that almost the entire ship was engulfed in flames within three minutes of the initial visible flames.

4.2 Attendance of the London Fire Brigade

4.2.1 The London Fire Brigade arrived on the scene within 6 minutes of the initial call. The initial request however, was to attend a fire at the University of Greenwich, King William Walk, London SE10. Two pumps were assigned to the incident (call signs E221 and E222) and a hydraulic platform (call sign E224). The attendance of a hydraulic platform is standard procedure for any call to the University, and these three units were all despatched from Greenwich Fire Station.

4.2.2 Upon the arrival of the London Fire Brigade, the Watch Manager noted that the entire ship was ablaze, albeit the flames were more intense towards the stern. At 04:53 hrs, he sent a message to his control room to increase the

number of pumps at the scene to six. Further crews subsequently arrived from East Greenwich, Deptford and Lee Road Fire Stations.

4.2.3 The Watch Manager made enquiries with the security guards as to the existence of any gas cylinders within the site. The guards were unable to provide the information required, and the Watch Manager requested the attendance of the Cutty Sark Operations Manager as soon as possible, and that person arrived shortly afterwards. According to Munnelly Support Services, the guards would have been unaware of the existence of gas canisters on the site.

4.2.4 The Watch Manager noted that there was a diesel-powered generator operating, but it was unclear to him what equipment this unit was supplying. The 'emergency lighting' on the scaffolding around the ship was illuminated.

4.2.5 Gas cylinders were indeed present on the site, in two cages near the starboard side of the Cutty Sark. The fire brigade removed these to a safe area outside the boundary hoarding, and then continued to fight the fire.

4.2.6 The Watch Manager handed the scene command over to a senior fire officer at 05:28 hrs. By this time, the fire was already under control. A few minutes later, only burning embers in the lower deck remained.

5.0 INITIAL POLICE INVESTIGATION AND STRATEGY

5.1 Scene

5.1.1 Police initially arrived at the scene at about 04:51 hrs. They were tasked by the London Fire Brigade with co-ordinating a 200-metre exclusion zone, ensuring the closure of the nearby pedestrian tunnel, and evacuating nearby residential properties in Cutty Sark Gardens. Site access was restricted to those persons specifically required by the London Fire Brigade.

5.1.2 Once the fire was under control, the initial fire and Police investigation commenced. The Police investigation began with officers from Greenwich Borough Criminal Investigation Department (CID). Almost immediately, it became apparent that there were aspects of the case which would clearly require further detailed investigation. These involved the security guards employed at the site, some of the initial witness accounts and the initial fire investigation.

5.2 Security

5.2.1 Immediate concerns were expressed at the accounts given by the two night-duty security guards. Their explanations were vague and inconsistent. It was soon discovered that page 93 had been removed from the log/occurrence book for night of 20th/21st May 2007. This page was subsequently found in the waste paper bin in the security hut. The removed page indicated that a series of false entries had been entered up to and including 7am on 21st May 2007. All routine patrols had been shown as correctly completed with no incidents reported. The final entry at 7am on 21st May 2007 reads: 'Booked off duty. All is in order'.

5.2.2 Both Security guards were interviewed on 21st May 2007, and witness statements were obtained from them. The guard responsible for patrolling the Pavilion stated that page 93 had been removed by a colleague earlier in the day, after a drink was spilt onto it. In a further statement taken later that day, the security guard admitted that the occurrence book had been falsified to allow his night-duty colleague to leave work early - at 5am, as he was feeling unwell. After the fire, page 93 had been removed in an attempt to conceal the falsified entries. The other guard – responsible for patrolling the inner site boundary, made no mention of feeling unwell, nor intending to leave work early. He explained that it was his colleague's responsibility to complete the occurrence book, and that he had no knowledge of the circumstances of the missing page 93, although he was aware that it had been removed.

5.3 Initial witness accounts

5.3.1 Several witnesses were identified at the scene and via the national and local press. Newspaper reports from eyewitnesses suggesting an explosion at the time of the fire, and reports of a silver car leaving the scene heightened the public perception that this was a case of arson.

5.4 Initial fire investigation

5.4.1 The initial fire investigation commenced on 21st May 2007. This began with an external inspection to determine how access could be safely gained aboard the ship, and included representatives from the Forensic Science Service Fire Investigation Unit, Police, Dr J. H. Burgoyne & Partners LLP (on behalf of the Cutty Sark Insurers: Royal and Sun Alliance) and the London Fire Brigade.

5.4.2 The following day - 22nd May 2007, an internal inspection was made of the ship and some of the associated electrical equipment. The fire damage was considerable, and the result of the initial examination was inconclusive in terms of causation. It was agreed however, that the fire had started on the lower deck towards the rear of the ship, in the area of the aft stairway, although the actual stairway had been totally destroyed by the fire. This opinion was based on the pattern and extent of burning within the ship. Whilst there was some witness evidence that flames were seen at an early stage towards the forward end of the ship, this is not supported by CCTV footage of the aft half of the ship, which shows smoke and flames first in the area above the aft stairway, and flames later towards the area of the loading hatch. The loading hatch was situated on the upper deck, in the centre of the Cutty Sark, between the forward and aft stairways.

5.4.3 In addition to those mentioned at paragraph 5.4.1 above, representatives from Hawkins & Associates Limited were also present on 22nd May 2007. Hawkins & Associates Limited had been instructed by Cunningham Lindsey - Loss Adjusters of London, who were appointed by AIG - the insurers of Heery International Ltd.

5.5 Investigative strategy

5.5.1 Towards the end of May 2007, it was becoming clear that the extent of the Police and fire investigation would be considerable. Several lines of enquiry had been identified with a view to ascertaining the cause of the fire, and this was assessed as being beyond the resource capabilities of Greenwich Borough Police at that time, taking into account their responsibilities to community policing.

5.5.2 On 1st June 2007, the investigation was transferred to the Homicide and Serious Crime Command based at Lewisham Police Station. The Senior Investigating Officer appointed was DCI David Garwood.

5.5.3 DCI Garwood devised the investigative strategy which was divided into two elements - 'Causation' and 'Criminal Investigation'.

5.5.4 <u>Causation</u>

5.5.4.1 Police sought the advice of the National Policing Improvements Agency to identify an expert with the specialist knowledge to survey and review the electrical systems on board the Cutty Sark. Dr J. H. Burgoyne & Partners LLP were recommended as having the necessary expertise and Ian Griffiths was duly appointed. Dr J. H. Burgoyne & Partners LLP were tasked, alongside Watch Manager Nick Carey of the London Fire Brigade Fire Investigation Unit, to utilise their expertise to assist in developing the following investigative strands, and answering the following questions:

- Secure the remains of the lighting and electrical systems on board the Cutty Sark to preserve potential evidence.

- Review the schematics of all electrical systems installed within the Cutty Sark in order to establish:
  i) Was the original electrical design safe?
  ii) How many systems were contained on the Cutty Sark?

- Compare electrical specification with those accepted for the renovation project. Were there any modifications, authorised or otherwise?

- Compare electrical specification with the damaged system on board the Cutty Sark – had any components been modified or downgraded? Did they conform to the original specification?

- Examine the recovered wiring, electrical equipment and components and light fittings - were any of these defective?

5.5.5 Criminal investigation

5.5.5.1 The following lines of enquiry were identified with a view to proving or disproving any criminal act relating to the Cutty Sark fire.

5.5.5.2 Approximately 250 hours of CCTV footage has been recovered by Police during this investigation. This included:

- Greenwich and Tower Hamlets Borough Council CCTV.
- Footage from the Greenwich foot tunnel – linking Greenwich with the Isle of Dogs, under the River Thames.
- Other privately owned CCTV systems.

5.5.5.3 The task of viewing and evaluating this evidence was outsourced to PAR Associates (Police Associates Register). They were initially tasked with identifying the geographical areas covered by the various CCTV cameras to highlight any areas of vulnerability where access to the Cutty Sark could be gained undetected. Once this was complete they were tasked with examining the CCTV footage to identify any suspicious activity in the vicinity of the Cutty Sark, with particular emphasis on tracking the movements of individuals seen near the ship.

5.5.5.4 House-to-house enquiry parameters were set to identify potential witnesses. This task involved visiting approximately 500 individual residences, and included properties on both the South and North side of the River Thames.

5.5.5.5 The interviewing of all staff concerned with the restoration project was seen as a priority. This task involved interviewing approximately seventy individual persons, and included individuals employed as labourers, skilled workers, supervisors and management.

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6.0 PHASE 1 POLICE AND FIRE INVESTIGATION – Causation Element

6.1 Previous fire contingency planning.

6.1.1 The restoration project was bound by a sixty-six page 'Construction Health and Safety Plan' dated October 2006, and an additional thirty-five page 'Fire Safety Plan'. Heery International provided Police with a copy of the Fire Safety Plan. This document indicated that a particular Heery International project manager had overall responsibility for fire safety. The document also stipulated that a Fire Safety Co-ordinator should have been responsible for implementing weekly checks of fire fighting equipment and testing of fire detection and alarm systems, the results of which should have been recorded.

6.1.2 Due to the obvious risk of fire on the site, the fire plan incorporated a 'Hot Working Regime'. The purpose of this regime was to ensure that all 'hot work' was properly authorised and undertaken in accordance with strict procedures. Hot Working includes any welding, cutting, grinding and use of any other equipment or operation likely to generate sparks capable of causing fire. Specified procedures were to be followed for such work including confirming an individual's competence to undertake hot work, and the issue of a 'Hot Works Permit' prior to commencement of the task. The project manager and one other named supervisor were the only persons authorised to issue such permits. One hour after completion of any 'hot work', the area was to be inspected to ensure that it was free of any smouldering.

6.2 Adherence to the Fire Safety Plan

6.2.1 Fire Brigade supervision.

6.2.1.1 The London Fire Brigade was supplied with a copy of the 'Fire Safety Plan'. In January or February 2007 the Fire Brigade attended the site for the purpose of Fire Brigade planning. At that time, the London Fire Brigade identified some 'housekeeping issues'. These concerned the location of potentially explosive cylinders around the site, the use of a gas heater on the site (but off the ship), the location of oily rags near the heater, and maintaining clear escape routes. However, the general state of tidiness with regards sawdust was considered satisfactory. All of the points raised by the London Fire Brigade were subsequently rectified except for the failure to comply with a request to supply the London Fire Brigade with a list of chemicals stored at the site.

6.2.2 Hot working

6.2.2.1 A Construction and Safety Consultant employed by Cutty Sark Enterprises undertook weekly safety inspections at the site, and completed reports on his findings. Police were supplied with reports dated in March, April and May 2007. On several occasions during March 2007, welding practices were criticised for failure to utilise fire blankets to prevent sparks falling into the ship. Excessive sawdust was also noted near cutting machinery. According to the Construction and Safety Consultant however, these procedures had improved in the weeks leading up to fire, and the use of a 'firewatcher' (human observer) during welding sessions reduced the risk of fire considerably.

6.2.2.2 Police obtained 66 'hot work permits' held at the site by Heery International Limited. These were dated from 28th November 2006 to Friday 18th May 2007, and were only valid for the day of issue.

6.2.2.3 Deficiencies were identified in the systems on site relating to hot work. Of the 66 permits examined, 56 were not signed as complete by the contractor, whilst 52 were not signed by Heery in the appropriate section to indicate that the area of work had been checked for smouldering one hour after completion. In many of the permits, a Heery supervisor had signed the permit at the end of

the working day, but in the section designated for checks made during the course of the work. However, 30 of the permits lacked any signature to indicate that the work area had been checked by Heery, either during the work or afterwards. An instance of welding was also apparent where no permit had been issued.

6.2.2.4 The last permit to be issued prior to the fire was permit number '68' dated Friday 18th May 2007. The permit was for the use of a welder on the 'port side shaws [sic]' between 08:00 hrs and 16:00 hrs. The permit was issued by a supervisor from Heery International Limited. The permit was signed in the area designated for ‘inspections during the work’, at a time of ‘5pm'. The permit was not signed as complete by the contractor and was not signed in the last section designated for supervision one hour after completion of the work. The supervisor who completed this document indicated that the reference to ‘5pm’ should have been entered in the ‘one hour after completion of the work’ section. There were no other permits dated 18th May 2007.

6.2.2.5 Given the deficiencies identified in relation to the operation of the hot work permit system, the hot work records cannot be relied upon as evidence of when the last hot work was carried out.

6.2.3 <u>Fire alarm tests</u>

6.2.3.1 Crosby Electrical Services would undertake quarterly visual inspections of the fire alarm system. They were not required to carry out any functional testing of the fire alarm system and were not asked to do so by Heery International.

6.2.3.2 Several restoration site employees were questioned in respect of fire alarm tests at the site. One employee stated that he had worked on the site since November 2006, and had heard the fire alarms sound only “a couple of times”. A senior project manager was aware of signs on the site which indicated the time of a weekly fire alarm test but could not recall hearing such a test.

6.3.3.3 The only inspection by the Construction and Safety Consultant (referred to in paragraph 6.2.2.1) which was conducted on a Friday was on 11th May 2007.

The remainder were conducted on Thursdays or Wednesdays. On 11th May 2007, he noted in his report – 'no fire alarm test 10:30 today'.

6.3.3.4 A fire safety report was examined which indicated that a test of the alarm system was conducted on 1st May 2007. This appears to be the last known confirmation that the fire alarm system was working correctly.

6.2.4 Fire Security

6.2.4.1 The 'Fire Safety Plan' incorporated a comprehensive policy on fire safety, and consisted of nine key 'objectives'. These related generally to fire prevention, detection, alarm systems, emergency procedures, arson prevention and training.

6.2.4.2 Roles were defined for 'Overall Fire safety Management', 'Fire Safety Co-ordinator' and 'Fire Marshalls (contractors)' The first two roles named the individuals responsible, however the Fire Marshalls role reads 'TBC' (to be confirmed). According to the plan, five Fire Marshalls should have been appointed, but there are no records to indicate who was subsequently tasked with this role.

6.2.4.3 Responsibilities were defined for the Fire Safety Co-ordinator and Fire Marshalls. The Fire Safety Co-ordinator was responsible for, amongst other things, monitoring compliance with the hot working regime, weekly checks of fire fighting equipment, and weekly fire inspections – the results of which were to be recorded in a 'Project Safety Diary'. Fire Marshall responsibilities included daily monitoring of site storage, fire fighting equipment, fire escapes and reporting any defects or failures to the Fire Safety Co-ordinator.

6.2.4.4 The Project Safety Diary has been examined for the period 17th November 2006 to 21st May 2007. The diary does not specifically relate to fire safety matters, and includes several other health and safety related subjects. It is clear that weekly fire inspections were not recorded as required in the Fire Safety Plan. The first recorded 'Fire Safety Inspection' was entered on 1st March 2007. No details are recorded beside this entry, only that it was *'carried*

out'. The next inspection recorded was dated 10th April 2007, although this entry did specify details of the inspection, and actions subsequently taken.

6.2.4.5 Section 9 of the Fire Safety Plan refers to 'Protection against arson'. The penultimate paragraph reads *'At the end of each working day, a fire check will be undertaken throughout the building by security and an appointed Fire Marshall prior to the site closing. During the night a fire check will be made by security'.* There are no records to indicate who the Fire Marshalls were, or that these procedures were ever adhered to. It is understood that the security staff were not permitted aboard the Cutty Sark for health and safety reasons, and as such, it is difficult to accept that this procedure could ever be followed precisely according to the Fire Safety Plan.

6.3 Witness evidence

6.3.1 <u>London Fire Brigade witness evidence</u>

6.3.1.1 On 12th June 2007, Police interviewed the members of the London Fire Brigade who attended the Cutty Sark fire scene on 21st May 2007. Ian Griffiths from Dr J. H. Burgoyne & Partners LLP was present, as was the representative from Hawkins & Associates Limited.

6.3.2 <u>Fire alarm sounders</u>

6.3.2.1 The Fire Brigade witness accounts vary considerably in relation to the activation of the Cutty Sark fire alarm sounders during the fire on 21st May 2007. It is clear that the enormity of the situation played some part in this, as did the apparent sounding of a fire alarm at the Cutty Sark Pavilion – probably activated by burning embers from the Cutty Sark itself. This was supported by recent fire damage to the roof area of the Pavilion.

6.3.2.2 The Station Manager heard a fire alarm sounding, but was unable to clarify the origin of the alarm sounders he heard, although he does say that he believed the sound was emanating from an area away from the ship itself. He also

noted that the sound was louder on the port side of the ship. He believed that the alarm may have been from the Pavilion.

6.3.2.3 The Crew Manager heard an alarm at some stage, although he could not identify the position of the sounders. He did not hear an alarm upon his initial arrival.

6.3.2.4 One of the fire-fighters did not notice a fire alarm upon his arrival, nor whilst engaged in fighting the fire. When the flames died down however, he heard an alarm which he believed emanated from the area of the Pavilion.

6.3.2.5 Another fire-fighter was in the process of operating a water jet towards the bow / midships area when he heard an alarm activate. He recalls this clearly, as he thought it strange for the alarm to activate with the fire so far advanced. He believes that the alarm activated at least an hour into the incident.

6.3.2.6 The Station Officer was the on-call senior officer on the morning of the 21st May 2007. Upon his arrival at 5.28am, he heard alarm sounders. They were not emanating from the ship, but from the Pavilion. He also noticed that burning embers had damaged small areas of the Pavilion.

6.3.2.7 Several other fire-fighters who attended the scene were unable to recall any alarms sounding at all.

6.3.2.8 Following the fire, a representative from Crosby Electrical Services Ltd attended the site to isolate the electricity supply. He arrived at the site at about 09:30 hrs on 21st May 2007, and noted that the lights at the site were 'off'. Once on site he tested the electricity supply at the incoming side of the MDU on the port side of the ship, and he noted that this was 'dead'. Nevertheless, he isolated one of the circuit breakers in the MDU such that it could no longer provide power to the site. He could not recall whether one of the circuit breakers had already 'tripped'. He was asked to silence alarms that were sounding. He was unsure where the alarm sounds were coming from. He examined the alarm panel associated with the ship, and noted that the panel was sounding 'locally'. It was indicating both 'fault and 'fire' in two zones. He disconnected the sounder circuits from the alarm panel, but did not notice any

change in the alarms that he was hearing. He was then asked to silence the Pavilion fire alarm system. He removed a fuse from the supply to the fire alarm panel in the Pavilion and removed the wires connected to the battery, which silenced the system.

6.3.3 General working conditions and practices

6.3.3.1 Police have interviewed the vast majority of persons employed at the Cutty Sark restoration site. This included both skilled and unskilled labourers, contractors, site supervisors and management – approximately seventy individuals in total.

6.3.3.2 A number of employees described the method by which debris was cleaned from the ship. There were black plastic bins on each deck, which were emptied when full. Labourers swept the decks clear and collected the rubbish in the plastic bins. It was not clear that these were always emptied at the end of every day, although one employee maintained that he swept all three decks regularly between the hours of 09:00 hrs and 16:00 hrs on Friday 18th May 2007.

6.3.3.3 There was a distinct lack of clarity concerning responsibility for removal of debris, and overall supervision of debris removal. A typical example was a supervisor who “assumed” that a ‘Planet 200’ industrial vacuum cleaner would be emptied when full. No individual appeared to be specifically responsible for doing so.

6.3.3.4 Labourers were generally responsible for cleaning work areas, however some skilled workers cleared debris themselves at the conclusion of their shift, while others relied on the labourers to complete this task. Instances were reported of workers arriving for work on board the ship, and finding debris present from the previous day.

6.3.3.5 Part of the restoration project involved the breaking and subsequent removal of a concrete base below the lower deck area. Some workers described commencing the first concrete breaking shift in the lower deck area at 07:00 hrs to find debris still present from the day before.

6.3.3.6 Portable appliance testing (PAT) had been carried out in March 2007. Records of PAT testing dated 19th April 2006, 5th December 2006 and 6th March 2007 were held by Cutty Sark Enterprises, and these records were examined. There was no record of PAT testing relating to the Planet 200 industrial vacuum cleaner.

6.3.3.7 Deficiencies were identified in the use of some electrical equipment on board the ship. An example was a site worker who described a method of connecting electrical power tools into the lighting system when no plug sockets were available.

6.3.3.8 There was an overall impression that electrical equipment was often left ‘plugged in’ at the close of business, and this practice was described by several site workers. A week before the fire, one site worker reported that the industrial vacuum cleaner had been left operating overnight, as it was still running when he arrived for work.

6.3.3.9 Witness evidence from the site Stores Manager indicated that a number of Dewalt drills were removed from the ship due to their batteries overheating during use.

6.3.3.10 The Project Manager of Cutty Sark Enterprises stated that the lighting on the ship was supplied from the transformers and, as far as he was aware, was left energised at all times. He was also aware of instances of the security guards being found asleep, or worse still, not present on site at all on some occasions. These breaches were not reported to Munnelly Support Services.

6.3.3.11 One labourer stated that a portable light on the tween deck forward of the entrance door was faulty, and would “go off if knocked”. Nobody else who provided statements to the Police recalled there being such a faulty light in that area.

6.3.3.12 A shipwright also reported a flickering lighting ring, which he said was tied to the shores supporting the ship. The transformer supplying this lighting was on the lower deck, in the midships area, and the problem had been apparent for

about 3 weeks prior to the fire. According to this witness, the lights would “flicker on and off” about two or three times a day, and more often than not, “correct itself”. If the light failed to stabilise, he would “wiggle” the plug at the transformer, which seemed to correct the fault. He assumed that the fault was a loose connection, and the matter was not reported to anyone.

6.3.4 The Planet 200 industrial vacuum cleaner

6.3.4.1 The Planet 200 industrial vacuum cleaner was purchased from a UK-based supplier - PWM (Sales) Limited, in June 2006. The unit was manufactured in Italy by Soteco. It was required on the Cutty Sark site to remove dust from the concrete breaking area beneath the lower deck. According to the Cutty Sark Project Manager, the Planet 200 vacuum cleaner was initially selected for purchase on the basis that:

- It had a sufficiently large capacity,
- It was believed that the unit could be left operating all day, and
- It was fitted with thermal ‘cut-out’ protection.

According to a supervisor, staff were “encouraged to unplug” the unit from the transformer when not in use, “however, this was not enforced”.

6.3.4.2 A problem with the vacuum cleaner filter mounting was identified in October 2006, which was allowing dust into the motor compartment. A subsequent repair was conducted by PWM Limited, whereby two of the three motors were replaced. The repairer suggested the use of ‘jubilee clip’ to retain the filter in place, but according to the Project Manager, this was never fitted, as the filter appeared to be held securely, following the repair.

6.3.5 Project work on Friday 18th May 2007.

6.3.5.1 A number of workers describe removing boxed 'spirketting' timbers from the tween deck on Friday 18th May 2007, whilst others describe detaching planking from the hull adjacent to the keel and just below the level of the top deck on the port side of the ship. One worker stated that angle grinding of 'Muntz' bolts might have taken place to remove the hull planking just below the level of the top deck, towards the rear of the ship, but no sparks were generated by this activity and no hot work permit was required.

6.3.5.2 A number of labourers used pneumatic and electric hammer drills to break up concrete ballast from the aft end of the ship, and removed the rubble that was produced from the lower deck to the tween deck, and then off the ship. The statements given to the Police indicate that the labourers who dug out the concrete wore disposable suits, which they placed in a plastic bin on the lower deck before leaving the ship. This bin was to be emptied when it was full.

6.3.5.3 All the site workers who were employed breaking concrete in the lower hold were identified and interviewed. Generally, two workers completed the concrete breaking in two-hour shifts, from O7:00 hrs until about 16:00 hrs.

6.3.5.4 The last shift of concrete breaking was performed from around 13:00 hrs and finished at around 15:30 hrs. One of the two workers who performed this final shift stated that there were no other workers on the lower deck that afternoon.

6.3.5.5 These two workmen were interviewed by fire investigators prior to being interviewed by Police. One of the workers stated that he could not recall if an industrial vacuum cleaner, used to extract dust from the area where concrete breaking took place, was operating during his shift that day.

6.3.5.6 The other revealed that he had never used the vacuum cleaner, never saw anyone turn it 'on' or 'off', and whilst there was noise in that area he assumed this was associated with the air supplies to the breathing equipment. Police interviewed this worker on 3rd July 2007. With regards to the vacuum cleaner, he stated that he knew it was switched ‘on’ when he was concreting on Friday 18th May 2007, and was also aware that it was still powered ‘on’ when he left this area. He also said that he has never switched the vacuum cleaner off as he has never been instructed to do so. He “assumed” that a supervisor would switch the machinery off at the end of the working day. This worker left the lower deck area shortly after his colleague and as such, was the last person known to be working in that area of the ship prior to the fire.

6.3.5.7 Of all the persons interviewed, no person describes deactivating the vacuum cleaner on Friday 18th May 2007. The Project Manager recalls a final walk-through of the ship late on the Friday afternoon, but stated that although he

did not recollect inspecting the vacuum cleaner itself, he “would have been very aware if the motors were left running because of the “jet aeroplane-like” noise it made.

6.4 Fire damage inspection

6.4.1 The Fire Damage

6.4.1.1 The ship had sustained extensive and severe burning damage. All of the planking that formed the main deck, the tween deck and the lower deck was charred, and very little remained of the plywood that had reportedly been used to cover the gaps in the decks where planking had been removed.

6.4.1.2 The dry dock area and the external parts of the hull planking that remained attached to the iron frames at a low level in the dry dock were largely free from fire damage. However, at a higher level, in the area of the tween deck and the main deck, where the hull planking had been removed, the scaffolding had been affected by fire and wooden shores which supported the sides of the ship at the main deck level were charred at the ends which made contact with the ship. The scaffolding was covered with sheeting on which the following text was printed: 'Monarflex Scaffband FR - Conforms to BS8093 & BS7955 for scaffold sheeting. LPS 1215 Flammability requirements. BS5867 Part 2. BS 476 Part 12. Ignition Source C'. The sheeting remained intact in areas near the bow and stern of the ship respectively, but had been destroyed by fire in the intermediate areas. Similar sheeting had extended onto the temporary roof structure, although little of this remained after the fire.

6.4.1.3 The bilges were largely free from fire damage.

6.4.1.4 The most severe fire damage was present in the area of the aft stairway. The decking of the tween deck had burned through in the area around the staircase, and there were no identifiable remains of the aft stairs. Longitudinal metal plating which was connected to the top of the horizontal section of the iron frames had buckled in this area.

6.4.2 Combustible items found the ship

6.4.2.1 The Police found the burnt remains of a plastic bin containing sawdust. This was recovered from the tween deck in the centre of the ship, close to a circular saw and a band saw. The diameter of the base of the bin measured approximately 30 centimetres. The police also took samples of caulking from between the timber that formed the top deck. Ad hoc ignition tests showed that the material ignited easily when it was not compacted. When compacted, as it was found on the ship, it was not readily ignitable, but could potentially sustain a smouldering fire.

6.4.2.2 The witness evidence indicated that there had been a bin at the aft end of the lower deck that was used to dispose of white coveralls that were worn by those who were breaking concrete on the ship. The coveralls used on the site were tested by the Forensic Science Service, and found to melt rather than smoulder.

6.4.3 The Electricity Distribution Equipment.

6.4.3.1 Records of the electrical installation and maintenance were obtained. These indicated that Crosby Electrical Services Limited had been at the Cutty Sark site six weeks prior to the fire to undertake a three-monthly check of the electricity supply systems. Police obtained an ‘Electrical Installation Certificate’ relating to the ship and offices electricity supply equipment, dated 6th March 2007, less than three months prior to the fire, and a ‘Periodic Inspection Report’ dated 25th April 2007, just under four weeks prior to the fire, for circuits supplied from an 'electrolysis cabin’. Police also obtained ‘Plant Test Sheets’ relating to safety checks undertaken on the distribution boards, residual current devices and transformers used at the site.

6.4.3.2 The main distribution board on the ship was severely fire damaged. The three-phase service head was in the lower right corner of the distribution board. The ceramic parts of the fuses had become detached from the end caps, such that it was not possible to confirm whether the fuses had operated. The electricity supplied by the service head to the site was metered using current transformers, which were in a metal housing mounted on the right side of the

distribution board, and a meter which was below the current transformers in another metal housing. Three-phase conductors were routed from the outgoing side of the service head to the current transformers, via a short length of steel trunking. Further conductors were routed from the outgoing side of the current transformers, back through the steel trunking, to termination blocks in the top section of the distribution board. An adjacent neutral termination block was connected directly to the service head. The termination blocks in the top section of the distribution board were connected to fused switches within the distribution board, and to an outgoing cable which, it is understood, was the temporary electricity supply cable installed by Crosby Electrical Services Limited. Following examination of the circuitry within the distribution board, the only evidence of electrical arcing damage identified was on the phase conductors in the steel trunking and on the adjacent parts of the steel trunking. There was no evidence of any resistance heating faults at any of the terminations of the circuitry just described.

6.4.3.3 The remains of electricity distribution equipment was also examined. This was removed by Police from the area adjacent to the main distribution board. The equipment comprised two relatively small three-phase distribution boards, a three-phase RCD, a number of switches and steel trunking. There was no evidence of electrical arcing damage, and there was no evidence of a resistance heating fault.

6.4.3.4 The MDU located off the port side of the ship, which was supplied from the main distribution board on the ship, was also examined. At the time of the inspection, a 250 Amp circuit breaker was in the 'off' position, whilst a 160 Amp circuit breaker within the distribution board was in the 'tripped' position, this being distinct from the 'off' or 'isolated' position. The 160 Amp circuit breaker, as well as providing overcurrent protection, was controlled by an RCD situated within the MDU. The RCD was adjustable in terms of the level of fault current required to trip the circuit breaker, and the time delay before tripping. Both settings were at the lowest (most sensitive) setting, these being 0.1 Amps (on a scale of 0.1 Amps to 1 Amps) and 0 seconds respectively. The MDU contained a mixture of single-phase and three-phase miniature circuit breakers (MCB's) rated at between 20 Amps and 63 Amps, which supplied the items described in paragraph 3.6.2 above. At the time of the inspection on

21st May 2007, one three-phase MCB was in the 'off' position, but there were no outgoing conductors connected to it. All of the remaining MCB's were in the 'on' position.

6.4.3.5 The MDU located at the aft end of the ship, which supplied two transformers, the security hut, and the adjacent air compressor, contained four MCB's rated at 32 Amps and two single-phase MCB's rated at 40 Amps. One of the three-phase MCB's was not in use. Of the remaining MCB's, only the 32 Amp three-phase MCB which protected the compressor circuit was in the 'off' position.

6.4.3.6 The nine transformers on the ship had all sustained severe fire damage. The transformers were all housed in steel cubic containers raised from the floor by steel feet, and fitted with miniature circuit breakers. The Police recovered all of the transformers. Owing to the severe fire damage sustained by all of the transformers, it was not possible to determine if any of the MCB's fitted in them had operated. Examination revealed no evidence of electrical arcing damage or of a causative electrical fault within the transformers. The three-phase transformers located near the forward and aft stairways were similar to the three-phase transformers located off the ship, and it is likely that they had provided similar over-current protection. The transformers located off the ship each contained nine MCB's, one on the transformer input, rated at 16 Amps, and one for each of the eight output circuits. Of the eight output circuits, two were protected by 32 Amp type 'C' MCB's, whilst the remaining six were protected by either 16 Amp or 20 Amp type 'C' MCB's. The output circuits were supplied from four 16 Amp electrical socket outlets, two 32 Amp electrical socket outlets, and two fixed wiring points.

6.4.3.7 Based on the labelling on the port side MDU, the cabling that supplied the three three-phase transformers near the bow of the ship was protected by one type 'D' MCB rated at 32 Amps. Examination of these three transformers showed that there were two 4-core steel wire armoured (SWA) cables terminated in the transformers on the main and tween decks, and one 4-core SWA cable terminated in the transformer on the lower deck, indicating that the supply cabling was looped from one transformer to the next. A similar arrangement existed at the three three-phase transformers towards the stern of the ship, which were also protected by one type 'D' MCB rated at 32 Amps.

Based on the labelling on the port side MDU, two type 'C' MCB's rated at 32 Amps protected the supply cabling to the three single-phase transformers near the centre of the ship. One of the MCB's was associated with the main deck single-phase transformer, whilst the other MCB was associated with the remaining tween deck and lower deck single-phase transformers. Examination of these two transformers showed that there had been two cables connected to the transformer on the tween deck, indicating that the supply had been looped from the tween deck transformer to the lower deck transformer.

6.4.3.8 Police removed from the ship, various sections of the SWA cable used to supply the transformers, totalling approximately 80 metres of 3-core SWA cable and some 76 metres of 4-core SWA cable. This was in addition to a 13-metre-length of 4-core SWA cable, which had supplied the lower deck aft transformer. There were many areas across the ship, where the copper conductors had melted as a result of heat from the fire. No evidence of electrical arcing activity was found on the conductors, although such evidence could subsequently have been masked by melting of the conductors during the fire.

6.4.4 <u>The Fire Alarm System</u>

6.4.4.1 The fire alarm panel was labelled 'Bardic by Honeywell Zircon 4 Zones'. A handwritten label on the panel which read Zone 1 Callpoints & detectors lower deck and Zone 2 Callpoints & detectors middle deck. Although there was a nearby communications device, it was not related to the fire alarm system, the panel for which was not connected to any external communication cables. Therefore, the system provided only local alarms.

6.4.4.2 Four signal cables were connected to the alarm panel, two used for detector circuits, and two used for sounder circuits. Three were routed directly onto the ship near the port side entrance. The fourth cable was routed around the ship on the external scaffold, in an anticlockwise direction when viewed from above, and was connected to three sounder/beacon devices.

6.4.4.3 The remains of a number of heat detectors and manual break-glass call points were found on the lower deck. There was a break-glass call point just forward

of the aft stairway, and the nearest heat detector was just forward of the break-glass call point.

6.4.4.4 The fire alarm panel supplied two sounder circuits, each protected by a 1 Amp fuse. The 1 Amp fuse for ‘Sounder Circuit 1' had operated, whilst that for ‘Sounder Circuit 2’ was intact. ‘Sounder Circuit 1’ was connected to one of the cables which entered the ship, whilst ‘Sounder Circuit 2’ was connected to the cable which was routed around the ship on the external scaffold. The two remaining signal cables routed onto the ship were connected to two detector circuit inputs. At the time of the inspection, the live conductors for each of the sounder circuits had been disconnected. The panel also contained a 24 Volt auxiliary supply circuit which was protected by a 250 milliAmp fuse.

6.4.4.5 When the battery was reconnected the to the alarm panel, many of the fault lights illuminated, although it was noted that the 'disabled’ light did not do so.

6.4.4.6 The battery voltage was measured at 12.5 Volts, and the voltage supplied by the auxiliary supply circuit was measured at 24.9 Volts. The external sounders were connected to the auxiliary supply circuit, which resulted in all three of the sounder/beacons operating. This demonstrated that the battery, the cabling that supplied the sounder/beacons, as well as the sounder/beacons themselves, were functional.

6.4.4.7 With the fire alarm panel in its normal resting state (i.e. not in alarm) the voltage at the ‘Sounder Circuit 2’ measured 5.5 Volts. As the fuse for the ‘Sounder Circuit 1’ had operated, a similar measurement was not made for that circuit.

6.4.4.8 A manual break-glass call point from the ship was placed across the Zone 1 input, causing the fire alarm panel to go into an alarm state. However, the sounder circuit outputs both measured 0 Volts, such that sounders could not operate.

6.4.4.9 Honeywell provided a circuit diagram of the alarm panel, including the circuitry relating to the sounders. The sounders were activated by using a double-pole-double-throw relay. When a fire was detected, current passed through the

relay coil, which caused two switches within the sounder relay to change position. When activated in this way, current passed through the ‘positive' switch, through the parallel sounder circuits, including the two sounder circuit fuses, and through the 'negative' switch in the relay. During testing of the panel it was established that when the relay was energised the negative switch operated as expected, but the positive switch failed to change position. In this condition, none of the sounders would operate when the panel was in an alarm state. The relay was subsequently tested and it was determined that when the relay was energised the positive switch left one contact, but did not reach the second contact. X-Rays of the relay in the de-energised and energised states failed to determine the precise nature of the failure.

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7.0 PHASE 2 POLICE AND FIRE INVESTIGATION – Causation Element

7.1 An overview of the electrical appliances

7.1.1 The lower deck in the area of the aft staircase was excavated during the initial part of the investigation. The items in that area are most relevant to the investigation, and are described in detail in subsequent paragraphs. The Police retained the following items from other parts of the ship:

- The radial arm saw, circular saw and band saw located on the tween deck.
- Eight severely fire-damaged extension reels.
- A fire-damaged submersible pump from the forward end of the top deck.
- A fire-damaged pump found in the bilge near the bow, with an extension lead.
- A task light.
- A compressor.
- Halogen lights used on the ship prior to the conservation project.
- A camera.
- A printed circuit board and an associated transformer.
- A hand drill from the lower deck near the bow.

All of the items were examined in the laboratory, but no evidence of significance was identified.

7.1.2 Given the severity of the fire damage in the area of the aft staircase, and in particular the damage to the decking of the tween deck, the lower deck in the area of the staircase was excavated at an early stage of the investigation. This area contained a three-phase transformer fitted with six electrical socket outlets, similar to the undamaged units located off the ship. Plugs had been inserted into the four 16 Amp electrical socket outlets and into one of the 32 Amp electrical socket outlets.

7.1.3 One 16 Amp electrical socket outlet supplied a largely undamaged electric hammer drill located in the bilge at the stern of the ship, where the concrete breaking had been taking place, and another 16 Amp electrical socket outlet supplied an unused extension lead located just forward of the transformer.

7.1.4 The other three cables connected to the transformer had severed. One of the severed cables connected to a 16 Amp electrical socket outlet was routed directly behind the transformer, and was severed close to the transformer. It is possible that this had supplied an extension lead located on the bottom of the dry dock, the flex of which trailed up into the lower deck in the area forward of the transformer. The other severed cable connected to a 16 Amp electrical socket outlet was routed towards the port side of the ship and then towards the area in which concrete breaking had been taking place. It is possible that this had been used for lighting or, at some stage, for a second electric drill located in the bilges where concrete breaking had taken place, although this drill had not been connected to a power source at the time of the fire, as demonstrated by damage patterns to it’s plug.

7.1.5 The cable connected to the 32 Amp electrical socket outlet was routed from the transformer directly towards the stern, along the edge of the stairway, where it was severed. The only item of equipment in that area of the ship that would have been supplied from a 32A electrical socket outlet was a 'Planet 200’ vacuum cleaner manufactured by Soteco of Italy.

7.1.6 The only other electrical equipment found in the area was a fan (see Photograph 4 – page 36), the cable for which was coiled around the appliance, such that it is clear this was not connected to a power supply at the time of the fire, and a small electric drill, the plug for which had not been inserted into an electrical socket outlet at the time of the fire.

7.1.7 The remains of seven fluorescent lights were found around the area of the aft stairway. Due to the severe damage sustained by the lights and their cabling, it was not possible to determine which transformer, or transformers, had supplied the lights with electricity. Two fluorescent lights were found in the bilges where concrete breaking had been taking place, two fluorescent strip lights were found on the adjacent part of the decking (see Photograph 4 – page 36), one fluorescent light was just forward of the transformer, another fluorescent light was in a similar location on the port side of the decking, whilst the final remaining light in that area of the ship was upright against the starboard side of the ship. The remains of these seven lights were recovered for examination.

7.2 The lighting

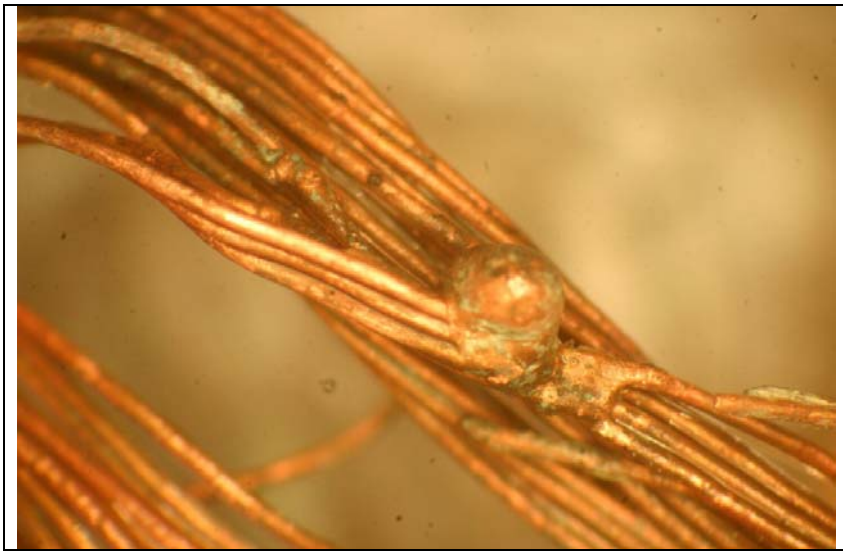
7.2.1 The area where the concrete breaking had taken place was largely free from fire damage at a low level. One of the fluorescent lights in that area was only moderately damaged, unlike all the other lights on the ship, of which little combustible material remained. The light comprised a yellow plastic casing and a plastic diffuser, with electrical components mounted on a metal gear tray, such that the components were between the gear tray and the yellow casing. The light contained a ballast manufactured by Ding Sheng labelled 'Bef no. 905-3 SB 5B.905', and a Capacitor marked 'RC-250-18 l8pF. A similar undamaged light which was taken from the site hoarding, was fitted with a ballast and capacitor of the same make and specification, and appeared to be the same type of light fitting. The light contained a starter which was labelled 'CNONC S2 36-58W. The lights external to the ship were each connected to an external plastic junction box, and the remains of a similar junction box were amongst the remains of the moderately damaged light from the concrete breaking area. It is understood that the lights were supplied with external

junction boxes in order that the lights could be installed without opening the light casing.

7.2.2 The remains of a number of electrical terminations associated with the fire-damaged fluorescent lights and their junction boxes were found in the area around the aft stairway. Parts of the circuitry had sustained very severe fire damage, such that parts of various termination blocks had melted and parts of the conductors had melted and oxidised. A severed section of flex cable, approximately 2.2 metres in length, was found at the aft end of the decking in the area of lighting terminations, and it appeared that the cable had formed part of a lighting circuit. Two of the conductors had melted locally such that the conductors were welded to one another (see Photographs 1 and 2). The adjacent parts of the conductor were not brittle or severely oxidised, and had not melted, on the basis of which, it was interpreted that the localised area of melting was as a result of electrical arcing.

Photograph 1.

Arcing damage to fluorescent lighting conductors recovered from the aft of the lower deck area. (see microscopic view of this damage in Photograph 2)



Photograph 2.

Microscopic view of arcing damage to fluorescent lighting conductors recovered from the aft of the lower deck area.

7.2.3 The ballasts from the seven fluorescent lights found around the aft stairway were examined, and localised damage to the winding of one ballast was identified. The ballast winding comprised a conductor looped around a laminated core. The winding had melted locally, affecting two adjacent loops of the winding, and two adjacent loops were notched.

7.3 Lighting equipment fire tests

7.3.1 Fire tests were performed at the Forensic Science Service laboratory using a light fitting and an associated junction box removed from the hoarding around the site, and thought to be the same as the lights used inside the ship.

7.3.2 Initially, the flame of a disposable lighter, and later the flame of a candle, was applied to the external surface of the yellow casing. The flame was applied at different locations for increasingly long periods of time, up to a maximum of three minutes. During the tests of a short duration, the plastic did not appear to be involved in the combustion process. Black smoke was generated after approximately one minute of flame application, but when the flame was removed the plastic did not continue to support combustion. Only during the longest test of three minutes, did the plastic material support combustion after the flame was removed, but only for two or three seconds, before self-extinguishing.

7.3.3 The external surface of the plastic diffuser was tested in a similar manner, and similar results were obtained.

7.3.4 Tests were also performed with a flame applied to the internal surfaces of the casing and the diffuser. The external surface of the plastic diffuser began melting after a flame application of 2 minutes and 40 seconds, and the flame penetrated the diffuser after 2 minutes and 45 seconds. The flame was removed after three minutes and the diffuser continued to burn for twenty seconds before self-extinguishing. The plastic casing was tested in a similar manner. The external surface began to blister after approximately 30 seconds, and smoke was generated after 1 minute and 20 seconds. After 2 minutes and 45 seconds there was some extension of the flame, but when the flame was removed after 3 minutes and 30 seconds, the casing self-extinguished, and the flame had not penetrated the casing. Subsequently, the test was repeated for a longer duration, and the flame penetrated the casing after approximately six minutes. The test was stopped after 10 minutes, and the casing self-extinguished.

7.3.5 The ignition properties of electrical components within the fluorescent light casing, namely the termination block, capacitor and starter, were also tested by using the flame of a candle. The body of the starter was subjected to flame impingement for up to three minutes, but always self-extinguished on the removal of the flame. When testing the body of the capacitor, combustion was supported briefly after the removal of the flame, but the material quickly self-extinguished. The termination block at the head of the capacitor sustained flame for twenty-five seconds after the removal of a flame that had been applied for three minutes, before self-extinguishing.

7.3.6 The plastic junction box supplied with the lights was found to ignite and spread flame within 30 seconds of the application of the flame. When the flame was removed, the junction box continued to burn until it was extinguished. The termination block within the junction box was insulated with plastic, which was ignitable with the flame, and which sustained combustion for approximately 15 seconds after the flame was removed.

7.4 The Planet 200 vacuum cleaner

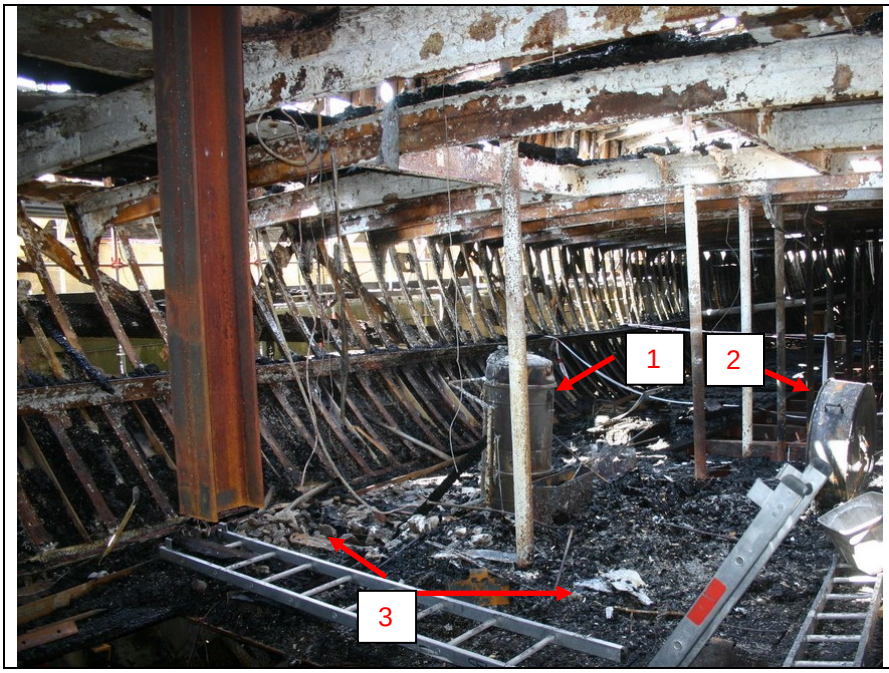
7.4.1 The only remains of a plug that could have been used to supply the Planet 200 vacuum cleaner were those inserted into the electrical socket outlet of the nearby transformer. The vacuum cleaner was the only item of equipment near the aft lower deck transformer that required a 32 Amp electrical socket outlet. The remains of the flex connected to the plug that had been inserted into the 32 Amp electrical socket outlet were examined in a laboratory. The copper was severely heat affected, such that it had become brittle, and was in various sections. One such section had melted at various locations along its length. Most of the melting appeared to have resulted from heat from the fire, due to the gross nature of the melting and oxidation of the conductors. One area of melting was less oxidised, and affected two adjacent conductors such that detailed consideration was given as to whether the damage had resulted from electrical arcing between the conductors. There was an area of melting near to, but separate from, the area of melting at the parted ends of the conductor, and an additional area of melting with oxidation slightly further from the parted ends.

Photograph 3

View of lower deck- pre fire, showing plywood inner hull (1), and The Planet 200 vacuum cleaner (2) and the aft stairway (3).

Photograph courtesy of Cutty Sark Trust

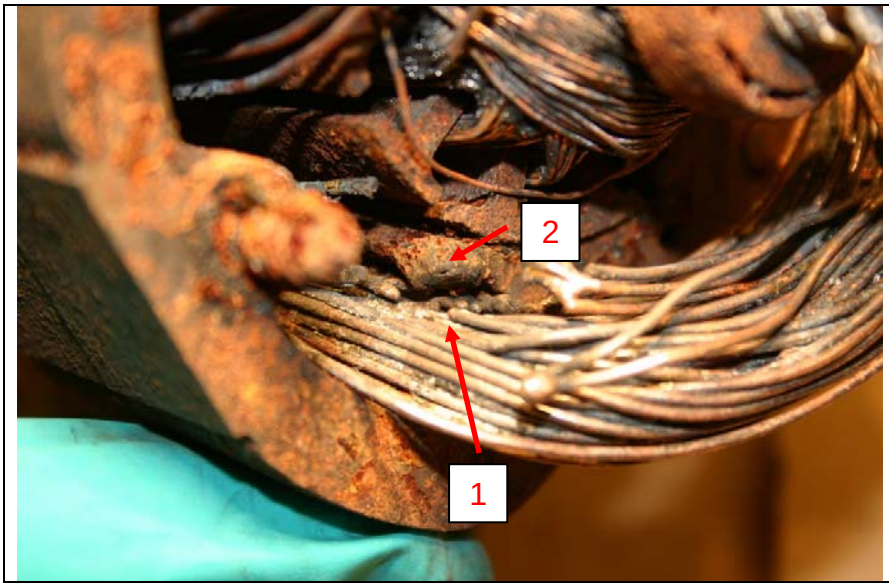
7.4.2 The vacuum cleaner had sustained very severe fire damage. The body of the appliance contained a metal shaft with a filter support, but there were no remains of any filter cloth. There was no significant accumulation of concrete, but there was some material in the base of the appliance similar in appearance to the burnt remains of a thermoset plastic, on top of which there appeared to be re-solidified aluminium. There were no other significant



Photograph 4.

View from the lower deck facing towards the area of the aft stairs, showing the Planet 200 vacuum cleaner (1), the unused fan (2) and the location of the remains of two fluorescent lights (3)

quantities of combustible material remaining. The electrical circuitry from the unit was examined in a laboratory. The unit contained three motors and associated switches. There were no combustible parts remaining, such that it was not possible to determine the position of the switches at the time of the fire. Each motor had two stator windings. Parts of the windings of one of the motors had melted. The steel laminations had melted adjacent to the area of the winding that was most grossly melted (see Photograph 5).



Photograph 5.

View of the melting (1) at the motor winding and the steel laminated core (2)

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8.0 PHASE 3 POLICE AND FIRE INVESTIGATION – Causation Element

8.1 Examination of a new Planet 200 vacuum cleaner

8.1.1 A new Planet 200 vacuum cleaner, identical to that used on the ship, was purchased. The unit was manufactured by Soteco in Italy, and had a manufacturer's label that read 'Planet 200, 110-115V, 2400W, 2800W max'. The unit was supplied by PWM Distribution and was labelled 'PWM Surface Preparation Products'. A second label read 'Model TV200, Serial No. 030408-01, 110V, 2800W, PWM (Sales) Ltd. A manual supplied with the unit stated that the appliance was built in conformity with the rules set by the 'EEC 89/392 Machine Directive, and that the machine 'has been designed for the suction of dust, scraps and liquid'. The manual included technical data for the 230 Volt version of the unit and a circuit diagram. A loose sheet of technical data relevant to the 110 Volt version of the unit purchased was inserted into the manual.

8.1.2 The vacuum cleaner contained a 'vacuum gauge' that provided the operator with an indication as to the condition of the filter. As the filter became blocked, the needle of the gauge was designed to move from a green zone to a red

zone. The manual stated that when the gauge moved into the red zone the filter should be cleaned. A red light was also designed to illuminate when the filter required cleaning. Cleaning of the filter was achieved by shaking the filter using a shaft that protruded through the top of the machine.

8.1.3 The vacuum cleaner was designed to operate in a maximum ambient temperature of 40 degrees Centigrade.

8.1.4 According to the manual provided with the vacuum cleaner, it was *'provided with a thermic device that protects the vital parts from possible overheat or anomalous functioning. Usually the thermic device that protects the vacuum cleaner intervenes for the following reasons:*

- excessive obstruction of the filter

- lack of filter maintenance

- obstruction of the suction hose

- electrical failures of one or more motors

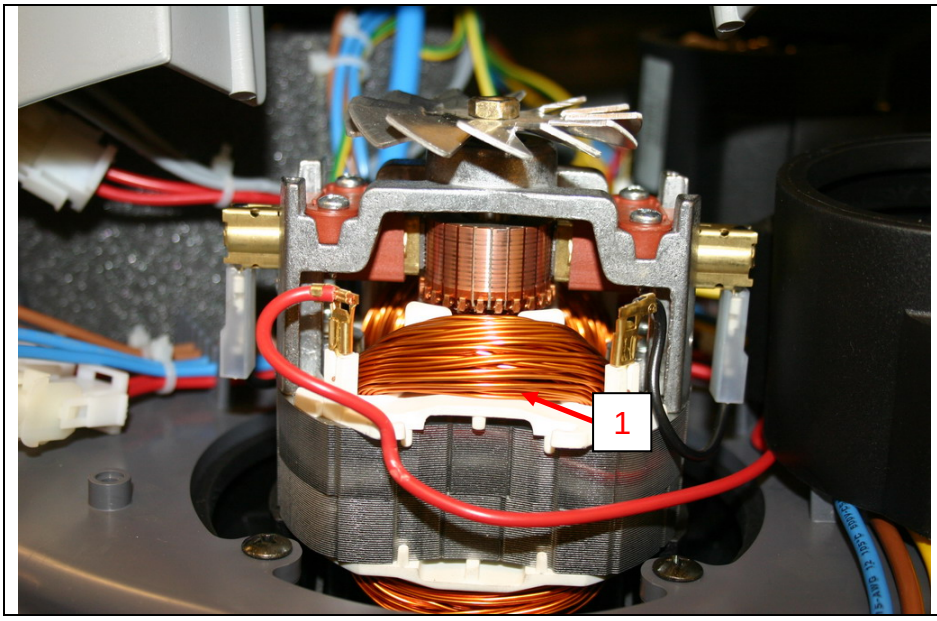
The thermic device must not be eliminated or short-circuited for any reason. Modifications to the electrical connection of the vacuum cleaner can cause serious injuries, even death, to the operator and irreparable damages to the vacuum cleaner itself.'

8.1.5 Initial examination of the unit showed that there was no thermal cut out (or 'thermic device') fitted. Enquiries with the supplier revealed that the circuit diagram in the manual provided with the unit did not apply to the 110 Volt version of the appliance, which was not designed to incorporate a thermal cut out. A circuit diagram for the 110 Volt version was obtained from the suppliers of the unit, and this showed no thermal cut out device was used.

8.1.6 The new appliance was disassembled in order to examine the electrical circuitry and the materials of construction. The appliance used three single-phase two-stage motors to drive three fans. The electrical circuitry matched that shown in the circuit diagram provided for the 110 Volt version of the appliance. The motors, fans and all of the associated electrical circuitry, were contained within the head of the unit which could be removed from the stainless steel collection tank by releasing three clamps. The head comprised four main parts, a steel top dome, a light grey plastic cover, a dark grey plastic

support and a stainless steel base. Removal of the top steel dome revealed parts of the electrical circuitry and the light grey cover. Removal of the light grey plastic cover revealed the motors and the remaining parts of the electrical circuitry. The motors were attached to the dark grey plastic support. Removal of the stainless steel base revealed the underside of the dark grey plastic support and the fans. The fan outlets were positioned between the underside of the dark grey plastic support and the top of the stainless steel base, and the air from the fans discharged through openings between these two components around the circumference of the appliance. The top of the motors incorporated cooling fans, which drew air down through circular openings in the light grey plastic cover above the motors. Openings around the circumference of the light grey plastic cover allowed the ventilation air to enter and exit the unit.

8.1.7 The underside of the steel dome was lined with a dark grey foamed plastic, and circular discs of similar material covered the circular openings in the top of the light grey cover. The material was also used to circumferentially line external parts of the light grey cover. The motors each had a black plastic cover, which was surrounded by more of the dark grey foamed plastic, and a ring of black plastic surrounded the ventilation fans. The foamed plastic was also present between the underside of the dark grey plastic support and the stainless steel base. This area also contained three segments of a cream coloured foamed plastic, which were between the fan housings. Removal of the black covers on the motors revealed a white plastic at the motor windings (see Photograph 6).



Photograph 6.

View of a new Planet 200 vacuum cleaner motor, with black plastic casing removed showing new motor windings (1)

8.1.8 Ad hoc ignition tests were performed on small samples of the plastics and the grey foamed plastic used in the appliance. Samples of the following were tested:

- a web formed in the dark grey support
- a web formed in the light grey cover
- the white plastic at the motor winding
- the black plastic motor cover
- the grey foamed plastic from around the light grey plastic cover
- the black plastic ring around the motor ventilation fan

Attempts were made to ignite the samples by using a naked flame. The light grey plastic, the dark grey plastic and the black plastic ring from around the motor ventilation fan all ignited readily and continued to support combustion when the flame was removed. The grey foamed plastic ignited readily, but burned for a short time before self-extinguishing. The white plastic at the motor windings and the black plastic motor covers degraded, but did not support combustion once the flame was removed.

8.1.9 Two additional samples of materials from the appliance were analysed in more detail by the Fire Science Department of Bureau Veritas in London. One sample was of the dark grey foamed plastic that surrounded the motors, whilst the other was of the cream coloured foamed plastic adjacent to the fan housings. Both samples were determined to be thermoplastic materials, and produced odours characteristic of polyurethane foam. Whilst the grey foamed plastic was found to be difficult to ignite, the cream foamed plastic ignited easily and continued to burn and spread flame, producing molten flaming drips.

8.2 Preliminary testing of a new Planet 200 vacuum cleaner

8.2.1 On 20th and 21st May 2008, tests were undertaken on the new Planet 200 vacuum cleaner. The purpose of the tests was to determine the temperatures inside the unit at various locations during its operation. Temperatures were measured with the unit operating normally, and with partial and complete blockages in the filter and/or the suction hose. Finally the unit was partially disassembled and tests performed with one of the motors locked, and with a

torque applied to one of the motors. Type-K thermocouples were used to measure temperatures, which were logged using a data logger. The vacuum cleaner was supplied with electricity from a 60 kVA generator, via a Defender 3.3 kVA 240/110 Volt transformer and a 32 Amp type 'B' miniature circuit breaker.

8.2.2 Three thermocouples were placed inside the unit at the following locations:

- close to one of the motor windings,
- inside the steel dome (above the light grey plastic cover), and
- in the dust collection area, just below the stainless steel base of the head of the unit.

A thermocouple was also placed external to the unit to measure the ambient temperature in the test room.

8.2.3 First the unit was operated with no hose attached, such that the unit was operating against as little restriction as possible. The temperatures increased after the unit was switched on. The unit was operated for approximately half an hour, during which time the highest temperature obtained was 36 degrees Centigrade close to the motor winding. The temperatures were still increasing at the end of the test, at a small rate. When the unit was switched 'off' the temperatures near the motor winding, and above the light grey cover, increased rapidly. The highest temperature was near to the motor winding, where over 50 degrees Centigrade was recorded.

8.2.4 The second test was performed with a 50 mm diameter hose, of 10 metres length. The unit was operated again for approximately half an hour. The results were similar to the first test, with modest increases in temperatures during the test, and rapid increases in temperatures near the motor winding and above the light grey cover when the unit was switched 'off'. There was also an increase in the temperature measured below the stainless steel base of the head when the unit was switched 'off'. The highest temperature again occurred near the motor winding, which reached over 60 degrees Centigrade.

8.2.5 During the third test, the hose was used to suck up broken concrete, in order to try and simulate normal usage, and to partially block the filter. This first part of the test lasted approximately 20 minutes. Subsequently, the hose was

completely blocked by securing a plastic covering over the end of the hose, and the unit left to operate for just under one hour. During the first part of the test the temperature measured below the stainless steel base of the head fluctuated, increasing rapidly when the unit was blocked, and reducing rapidly when any such blockage was released. The maximum temperature measured there was 46 degrees Centigrade. The other temperatures, measured in the area of the motors, did not fluctuate in this way, and the maximum temperature recorded in that area was below 40 degrees Centigrade, near the motor windings. Subsequently, with the hose end completely blocked the temperature measured below the stainless steel base increased steadily, and reached around 98 degrees Centigrade after forty minutes. The other temperatures did not increase significantly during that period. Subsequently, the temperature measured below the stainless steel base was almost constant. When the unit was switched 'off', as in previous tests, the temperatures near the motor winding and above the grey plastic cover increased rapidly, this time the temperature measured near the motor winding reached almost 80 degrees Centigrade. The temperature measured beneath the stainless steel base reduced rapidly after the unit was switched 'off'. After the test the unit was disassembled, which showed that part of the cream coloured foamed plastic between the fans had discoloured.

8.2.6 During the fourth test, only one motor was switched 'on'. The rotor of the motor was held stationary by securing the associated fan to its housing. When the unit was switched on there was a rapid increase in the temperature measured near the motor winding. After approximately 70 seconds, the measured current increased rapidly to over 80 Amps, at which point the transformer's over-temperature protection operated, and the temperatures measured near the motor winding subsequently reduced. The light grey plastic cover directly above the locked motor was heat affected, and parts of the black plastic casing around the locked motor had softened. The motor windings of the locked motor were severely heat damaged.

8.2.7 During the fifth test an attempt was made to apply a torque to another of the motors by attaching a short shaft to the underside of the fan and clamping the shaft. During the test another motor was operated normally. Due to difficulties encountered in applying the torque, it was not possible to apply a constant

torque, however a fluctuating torque was applied to the motor, such that a fluctuating current was measured. Similar affects were observed as in the previous tests, in that when the motors were switched 'off' after the initial stages of this test, the temperature measured near the motor windings increased rapidly. The temperature measured near the motor that had been subject to loading increased to over 80 degrees Centigrade after the unit was switched 'off'. A different clamp arrangement was then used more successfully to load the motor, such that the motor almost stalled. The temperature measured near the motor windings when the motor almost stalled reached 330 degrees Centigrade. Subsequently, the motor stopped and the current rose rapidly, with temperatures reaching 294 degrees Centigrade before the transformer's thermal trip operated. Examination of the unit after the test showed a similar degradation of the light grey plastic cover above the motor than in the previous test. The black plastic casing was damaged where it had come into contact with the ventilation fan, and seemingly stopped the motor from rotating. The black plastic casing had sustained more severe damage that in the previous test, and the conductors appeared to have been overloaded such that the insulation had melted.

8.2.8 A further test was performed using the one remaining motor, with the hose blocked, as in the third test. The temperatures were significantly lower than those measured during test 3 when all three motors were operational.

8.3 Supplementary testing of a new Planet 200 vacuum cleaner

8.3.1 On 1st July 2008, further tests were undertaken on another new Planet 200 vacuum cleaner. The electricity supply for these tests was provided by a 10 kVA 400/110 Volt transformer, as was used on the Cutty Sark site. The output of the transformer used to supply the extract unit was protected by a type 'C' MCB rated at 32 Amps. The transformer was supplied with electricity from a 60 kVA generator, which supplied an input to the transformer of 467 Volts. The output from the transformer was measured at 126 Volts before any load was supplied from it, and dropped to 123 Volts when the unit was switched ‘on'.

8.3.2 The tests were to monitor over a longer duration the effects of a hose blockage within the unit. In order to avoid disturbing the head of the unit, no thermocouples were placed at the motor windings, which would have required the head to have been disassembled. Thermocouples were placed above the light grey cover, and beneath the stainless steel base of the head of the unit. Two thermocouples were placed in the latter location, one as before, a few inches inside the collection area, and the other at the circumference of the base, such that it was clamped between the base and the stainless steel collection canister. During these tests the current and voltage at the transformer were measured. The temperature data, as in the previous test, was logged using a data logger which was synchronised with a computer. The current and voltage data logged independently using two data loggers. The data loggers used to measure the current and voltage were synchronised with another laptop computer and the time difference between the computers noted in order that the data could be correlated. The tests were recorded using a video camera.

8.3.3 The unit was operated with all three motors switched 'on'. The temperatures measured increased in the initial stages of the test. After approximately half an hour the ambient temperature and the temperature measured above the light grey cover were 36 degrees Centigrade and 38 degrees Centigrade respectively, whilst the temperature measured below the stainless steel base had reached approximately 80 degrees Centigrade. The temperature there remained between 80 and 90 degrees Centigrade for the subsequent 20 minutes. Halfway through the 20-minute period, the unit generated unusual noises, and the current increased. At the end of the 20-minute period, some 50 minutes after the start of the test, the current increased rapidly and the 32 Amp MCB at the transformer operated. After the unit stopped operating the temperature measured below the stainless steel base increased to 97 degrees Centigrade, whilst the temperature measured above the light grey plastic cover increased rapidly to approximately 60 degrees Centigrade. The unit was then re-energised by resetting the MCB. The unit then continued to operate, with a lower current than previously (11 Amps compared to 16 Amps), indicating that one of the three motors had failed. The unit then continued for over three hours. Over that period of time the ambient temperature rose from 39 degrees Centigrade to 44 degrees Centigrade. The temperature measured

above the light grey plastic cover was consistently several degrees higher than the ambient temperature. The temperature below the stainless steel base increased during the period from approximately 80 degrees Centigrade to approximately 90 degrees Centigrade.

8.3.4 Four hours and twenty minutes after the unit was first switched on, there was a change in the pitch of the sound made by the unit, and a grinding noise was heard. Thereafter, the current began to increase and fluctuate. The noise stopped about a minute later, suggesting that the noisy motor had stopped rotating. There was a jump in current at this stage to over 30 Amps. Smoke was first visible in the video of the test less than twenty seconds later, venting from large openings beneath the light grey plastic cover, where the ventilation fan of the motor that was still running would direct smoke. The current remained over 30 Amps, and the smoke became thicker. A few seconds later the current increased to 130 Amps for a short period, before dropping to approximately 60 Amps, and less than 10 seconds later dropping again to approximately 2 Amps. At that stage the unit went silent, but no electrical protection had operated. Subsequently the temperature measured above the light grey cover increased very rapidly, peaking at 315 degrees Centigrade. Just over two minutes after the initial alteration in the sound of the motor, the motor abruptly made a brief noise, and the 32 Amp MCB at the transformer operated, isolating the electrical supply to the unit. This very brief operation of the unit caused smoke to quickly vent from the large openings beneath the light grey cover, as the motor ventilation fan forced the smoke through the normal ventilation air path. The 32 Amp MCB was reset almost immediately. The subsequent operation of the unit caused the temperature measured above the light grey cover to decrease more rapidly than it had been previously, falling to 87 degrees Centigrade before the unit was switched 'off' manually using the MCB (17 seconds after it had been reset). Once the unit was isolated the temperature measured above the light grey cover increased rapidly again, reaching a peak of 278 degrees Centigrade after a further 5 seconds, before decreasing. The temperature fell to a minimum of 150 degrees Centigrade before starting to increase again. Flames were seen inside the unit in the area of the motors, just over three minutes after the unit was switched off at the MCB.

8.3.5 The flames appeared first at the right side of the unit when viewed from the front. Small pieces of burning material fell to the floor and continued to burn approximately four minutes after flames were first observed (see Photograph 7 - taken 3 minutes after flames were first observed). After fifteen minutes of burning, a substantial portion of the plastic parts of the appliance were involved in the fire, and flames extended above the top of the unit. After approximately 27 minutes of burning, the front of the steel dome had dropped down towards the steel body of the appliance, as much of the plastic parts had been consumed by the fire (see Photograph 8). After 38 minutes of burning, larger quantities of burning material fell to the floor, subsequently causing the hose to ignite. After approximately one hour the unit was still burning, but the size of the flames at the head had decreased in size.

Photograph 7.

The Planet 200 vacuum cleaner, approximately 3 minutes after flames were first observed.

Photograph 8.

The Planet 200 vacuum cleaner approximately 27 minutes after flames were first observed. Much of the plastic support within the unit has been consumed by the fire, resulting in the front of the steel dome (1) dropping down towards the debris collection canister (2)

8.3.6 The unit was disassembled following the testing. The internal parts of the appliance beneath the stainless steel base, including the cloth filter, were largely undamaged, and the motors were burnt. The motor at the rear of the unit was severely fire damaged and the stator windings of the motor had both melted. The motor located at the front right hand side of the unit, in the area where flames were first seen during the testing, was also burnt. The associated fan was damaged and the nut that had secured it was missing. There was melting at both stator windings, at three locations. The casing of the brushes had melted where they appeared to have been in contact with the commutator, the corresponding parts of which had also melted.

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9.0 POLICE AND FIRE INVESTIGATION – Criminal Investigation Element

9.1 Overview

9.1.1 During Phases 1 and 2 of the 'Causation' element to this investigation, Police also concentrated on the 'Criminal investigation' element. This aspect of the investigation sought to prove or disprove any criminal offences relating to the fire, and if so proved, to identify the offender(s) and instigate criminal proceedings if appropriate.

9.2 Security guards

9.2.1 Clearly, the initial reports given by the two security guards were of great significance. The two accounts were both inconsistent and irrational.

9.2.2 On 2nd and 3rd August 2007, Police further interviewed both security guards as 'significant' witnesses. This process involved audio-recording the interviews in order that there was a full record of everything the witness said. At the time of

these interviews, the security guards were no longer employed by Munnelly Support Services.

9.2.3 As a result of these further interviews, both security guards made further written statements. The guard responsible for patrolling the inner site boundary maintained the majority of his original account. He did however admit that the two of them would patrol alternately (contrary to their instructions to patrol individually), once every hour until midnight, then once every two hours thereafter (contrary to their instructions to patrol every hour), until 7am.

9.2.4 The other guard altered his explanation dramatically when interviewed. He accepted that their security patrols had not been completed as required. He stated that it was his task to patrol the Pavilion, whilst the other guard patrolled the Cutty Sark inner site perimeter (excluding the ship). Contrary to instructions to patrol every hour until 10pm, then every two hours thereafter, no patrols were completed by this guard after 9pm that evening. Instead, he went to the cafeteria (which was closed) where he sat alone, reading his bible and “dozing” off to sleep. He admitted falling asleep once during the night of 20th/21st May 2007, probably he thought, before midnight. At about 4am, shortly after a telephone call from the 'Munnelly control room', he returned to the security hut where he met with his colleague. The colleague said he was going to brush his teeth and left the security hut. Whilst his colleague was gone, he commenced a patrol of the Pavilion. Shortly after this at about 4.10am, his colleague returned, stating that he could smell burning plastic.

9.2.5 Both guards searched the area outside and inside the site boundary hoarding, initially seeming to exclude the ship itself as a potential source of a fire. Eventually, one guard climbed onto the scaffolding surrounding the Cutty Sark, where he too, could now smell the burning. Within a couple of minutes, huge flames erupted from the lower deck through to the middle deck, together with a siren-type alarm which activated simultaneously.

9.2.6 The final accounts of the two guards remain inconsistent. In addition to the significant contradiction concerning details of patrolling that evening, there are

clear inconsistencies regarding the exact position of each guard when the burning smell was first noticed.

9.2.7 The London Fire Brigade were called by the Pavilion guard at 4.47am on 21st May 2007. Subsequent calls were made to his control room (Munnelly Support Services), and two members of the Cutty Sark conservation project.

9.3 Site entries during the weekend prior to the fire

9.3.1 From the site security ‘swipe entry’ system, a record was obtained which indicated all entries to, and exits from, the site during the weekend prior to the fire. The log showed that ten security cards were swiped at the site during that period.

9.3.2 Excluding the two security guards (who both swiped their entry onto the site at 06:59 hrs), four persons attended the site on Saturday 19th May 2007. The Construction Manager stated that he had been on site on the Saturday from about 08:10 hrs (security card swiped at 8:21 hrs), to supervise two Cutty Sark personnel who removed two props (shores) from the starboard side of the ship towards the stern. The Construction Manager did not write a 'Hot Work Permit’ for this work, as the props were removed manually without the need for hot work.

9.3.3 A welder/fabricator stated that he was on site between 07:00 hrs and 09:30 hrs (security card swiped at 07:17 hrs) removing two shores in the dry dock area, using a power hammer. His assistant said that he had been on site from 08:00 hrs until 12:00 hrs on Saturday (security card swiped at 7:41 hrs).

9.3.4 The Conservation Team Manager had been on site on Saturday 19th May 2007 in order to switch off electrolysis equipment located on the main deck of the ship towards the bow (security card swiped at 15:06 hrs). This person gained access to the ship from stairs that ran from external scaffolding at the forward end of the ship on the port side, into the tween deck. From there, a stairway near the bow was used to access the main deck. A plug that supplied the electrolysis equipment from a transformer located just aft of the stairs on the main deck was removed. The electrolysis equipment was located just

forward of the stairs. Nothing unusual was noticed at that time. Following a visit to the Pavilion, the Conservation Team Manager left the site (card swiped indicating exit at 17:31 hrs).

9.3.5 On Sunday 20th May 2007, the Pavilion security guard was due to commence work at 17:00 hrs, whilst the site security guard was due to commence at 19:00 hrs. The security log records indicate that on 20th May 2007 the Pavilion guard's card was swiped 'in' at 17:14 hrs and again at 19:08 hrs. The site security guard swiped 'in' at 19:08 hrs.

9.3.6 Excluding the two security guards, three other persons legitimately attended the site on Sunday 20th May 2007 (see also paragraph 9.4.3). Two of these individuals were Pavilion staff, and the third was employed both at the construction site, and the Pavilion. Several entry/exit swipes were made during the course of the day to access the toilets on site, there being no such facilities at the Pavilion. Only one entry was made onto the site specifically to carry out work there, and that was at 16:48 hrs when the diesel generator was filled.

9.4 Witnesses

9.4.1 Following the fire, several members of the public contacted police directly with information which they believed may be relevant to the enquiry. Further witnesses were identified as a result of house-to-house enquires, 'Crimestoppers' and press articles concerning the Cutty Sark fire. Some eyewitnesses were vital in establishing the sequence of events, while others highlighted potential suspects who may have been responsible for an arson attack.

9.4.2 Initial press articles highlighted the sighting of 'silver car' that was seen leaving the scene at about the time of the fire. The source of this information was traced and interviewed by police. At about 4.40 am on 21st May 2007, the witness was in the underground car park located to the west of the Cutty Sark site. Approximately 10 minutes later a male entered the car park and drove away in a distinctive silver car. At that time there were only two cars parked in the car park, and the witness supplied a full description of the other car,

including the manufacturer's details. Subsequently, at approximately 4.55am, the witness left the car park to find the Cutty Sark alight. The owner of the silver car was traced by police and interviewed. The driver's identity was confirmed by his description, the description, make and model of his vehicle, and the fact that he was able to exactly describe the vehicle he parked beside, in the underground car park. The driver provided a written statement detailing his movements that morning, and a further witness confirmed his account. The driver's actions were innocent and legitimate, and he was eliminated from the enquiry.

9.4.3 A potentially significant line of enquiry arose as a result of a member of the public who witnessed a male climbing the Cutty Sark site boundary hoarding on Sunday 20th May 2007, a day before the fire. This 'potential suspect' was traced by police and interviewed. It transpired that he was a carpenter employed on the restoration project. He attended the site on the Sunday to retrieve some carpentry tools which he required elsewhere. Having unsuccessfully attempted, for some 20 minutes, to attract the attention of a site security guard, he was left with no option but to climb the hoarding and retrieve his tools. He entered the tween deck of the ship on the starboard side, and accessed the lower deck by using the stairway located towards the bow of the ship. He retrieved his tools from a tool vault in the forward area of the lower deck, before leaving the ship by retracing his steps. Whilst at the site, he saw no security staff at all, and he therefore exited the site the same way that he entered. Whilst in the site, he noticed the sound of machinery running towards the rear of the Cutty Sark, but was unsure whether this sound was coming from on or off the ship. Although the witness is uncertain, and may be correct that equipment was indeed running on board the ship, It should be noted that a diesel-powered generator was located inside the site boundary towards the stern of the Cutty Sark, which supplied electricity to the Pavilion

9.5 CCTV evidence

9.5.1 CCTV evidence was vital in establishing the full sequence of events, and the identification of any potential suspects. The task of viewing and evaluating this evidence was completed by PAR Associates (Police Associates Register) in

accordance with an agreed strategy formulated by the DCI Garwood (see paragraph 5.5.5.3). To avoid compromising the effectiveness of CCTV systems in the vicinity of the Cutty Sark, the specific locations of CCTV cameras and any areas of vulnerability due to the absence of CCTV coverage will not be documented in this report.

9.5.2 In relation to the sequence of events, the first visual indication of a fire is at 04:47:00 hrs. The camera on which these images are seen is some considerable distance from the Cutty Sark. Below, is a summary of the events that followed:

04:47:00 hrs - What appears to be white smoke is visible in the area approximately above the aft stairway.

04:47:47 hrs - The first clear image of smoke, which is black, above the area of the aft stairway.

04:47:49 hrs - The first flames are visible, which are in the same area as the first observed smoke. The flames then rapidly spread and are also visible just to the left of the opening in the temporary roof for the aft stairway (possibly and indication of flames at a lower level).

04:47:59 hrs - The hoarding lights go 'off'.

04:48:10 hrs - Large quantities of black smoke in the area of the aft stairway, but also in the area of the loading hatch.

04:49:39 hrs - Flames are at a lower level in the area of the aft stairway.

04:49:50 hrs - A large eruption of flames begins at the aft stairway area, and flames become visible towards the left of the image, in the area of the loading hatch.

04:50:35 hrs - Very large flames are in the area of the aft stairs, and flames are erupting in the area of the loading hatch.

04:51:12 hrs - Flames erupt further.

04:51:31 hrs - The ship is engulfed in flames.

9.5.3 In relation to identification of potential suspects, PAR Associates applied a procedure to monitor the movements of individuals between the various CCTV camera views to establish:

- The direction individuals had come from,
- The direction in which they were going,
- Their exact movements whilst in the vicinity of the Cutty Sark and
- Identify any visible suspicious activity.

9.5.4 Several individuals were identified in the vicinity of the Cutty Sark in the hours leading up to the fire. Fortunately the area was quiet due to the time of night, and it was possible to establish their movements through the various CCTV camera views. Only one person is seen in the vicinity of the Cutty Sark site, and this was shortly before the fire started. The conclusion is, that this person is one of the two security guards from the Cutty Sark site. That conclusion is based on the movements of the individual, his apparent state of confusion, and the fact that one of the guards left the site at that time to try and ascertain the source of the ‘plastic burning smell’.

9.5.5 In terms of the CCTV coverage and the opportunity to avoid detection, there is a very limited area of vulnerability due to the absence of cameras, however the approaches to and from the general area of the Cutty Sark are reasonable enough to indicate that the chance of anyone being able to reach the Cutty Sark undetected by any of the cameras, is unlikely.

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10.0 DISCUSSION

10.1 The Origin of the Fire

10.1.1 The pattern of fire damage suggested that the fire originated in the area of the aft stairway on the lower deck, resulting in the very severe damage sustained by the tween decking and the adjacent metalwork. It has been considered whether this area of more severe damage could have resulted from a combination of the fire load in that area, in particular the large aft stairway, and the nature of the fire fighting, which reportedly was initially focused on preventing the spread of fire towards the bow of the ship, thereby permitting the fire to burn for longer towards the stern of the ship. Whilst these factors could have allowed more severe damage to occur in the area concerned, and some witnesses describe seeing smoke and flames first towards the forward end of the ship, it is still considered most likely that the fire originated on the lower deck in the area of the aft staircase for the following reasons:

a) The evidence of electrical arcing damage, on what appeared to be lighting conductors at the aft end of the lower deck, most probably occurred when the fire destroyed the insulation that protected the conductors. Therefore, when that cable was damaged by fire, the electrical protection afforded to the ships electrical system as a whole had not yet operated. However, the system as a whole most probably became isolated when the hoarding lights, which were supplied from a transformer external to the ship, went 'off', just one minute after smoke was first visible in the CCTV footage. Accordingly, the electrical arcing damage indicates that the lower deck in the area of the aft stairway was involved in the fire at this somewhat early stage of the fire.

b) The CCTV footage, whilst only covering the aft half of the ship in the early stages of the fire, shows smoke and flames in the area above the aft stairway, before smoke and flames are visible in the area of the loading hatch.

10.2 The Cause of the Fire

10.2.1 There are a number of potential causes of the fire worth considering, namely an electrical fault, hot work, carelessly discarded smokers' materials and a deliberate act.

10.2.2 In relation to the possibility that a smouldering fire was initiated by hot work, it is worth noting that based on the currently available information, the last such work was undertaken on Friday 18th May 2007, some 60 hours before the fire was discovered in the early hours of Monday 21st May 2007. Similarly, in respect of the possibility that a smouldering fire was caused by carelessly discarded smokers' materials, the last person to have been on the ship in the area where the fire most likely originated, left there on Friday 18th May 2007. If this information is correct, a smouldering fire started in this way would have to be sustained for a period of some 60 hours before undergoing transition to a flaming fire.

10.2.3 Not all combustible materials will smoulder. Only porous materials that form a solid carbonaceous char when heated are capable of sustaining smouldering combustion. Suitable materials that are commonly found include corrugated cardboard, cotton fabrics and sawdust. Transition to flame is favoured by a change in ventilation conditions, such as when a smoulder embedded in a mass of material reaches an outer surface, after the smoulder is transferred to adjacent combustibles or the exposed smouldering area reaches a critical size. In the case of a smouldering fire within a waste paper basket, transition to flaming typically occurs within an hour. However, much longer periods of smouldering, such as that required in this consideration, can occur where suitable combustible material, such as sawdust, is stored in bulk, such that there is a restricted supply of air to the region of combustion, and the smouldering spreads slowly through the bulk of the material before breaking out at the surface. A smouldering fire initiated on Friday 18th May 2007 could only have resulted in the fire that broke out on Monday 21st May 2007 if these conditions were met.

10.2.4 A number of black plastic waste bins were used on the ship. If one of these had been filled with sawdust, and an ignition source placed deep within the bulk of the material, there would exist the potential for a long duration smouldering fire. Tests have been undertaken[1] which indicate that a container filled with sawdust to a depth of approximately forty centimetres above the ignition source could potentially support smouldering combustion for the period of some 60 hours under consideration. It was reported that there had been a plastic container on the lower deck near the aft stairway, into which disposable coveralls had been placed. Even if disposable coveralls had been made from cotton fibres, it is considered very unlikely that a collection of disposable coveralls in a bin would have created a sufficiently dense and uniform medium to support a smouldering fire for such a prolonged period as would be necessary in this case. Furthermore, samples of the coveralls used were found to be constructed from a synthetic material that does not smoulder. Nevertheless, if large quantities of other material, such as sawdust, had been placed in such a container, then the possibility of a long smoulder would provide a potential cause of the fire. Whilst a container of sawdust was found on the tween deck in the area of the woodworking equipment, no remains of any bulk material or an associated container were found in the area where the fire probably started. Whilst it is possible that all the remains of such material were destroyed by the fire, it is likely in that scenario, that there would have been some identifiable localised severe damage where the fire had originated. Therefore, and on the basis of the witness evidence, it is considered unlikely that the fire was caused by hot work or by carelessly discarded smokers' materials.

10.2.5 With regards to the potential that the fire was caused by a deliberate act, there was no evidence of this. A deliberate act by way of an object being thrown from outside the perimeter hoarding onto the ship has been excluded. This is based on the area where the fire is believed to have originated - deep within the ship on the lower deck area, and the fact that ship was surrounded by a protective sheeting along the outer scaffolding frame. It is considered an unrealistic proposition that an object thrown from the street could potentially

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[1] Palmer, K.N. (1957), comb. and Flame, 1,129-52.

cause a fire in the lower deck area. Whilst there was no CCTV camera in use on the site itself at the time of the fire, and the site boundary was not entirely in the view of CCTV cameras, the analysis performed by P.A.R. Associates of the CCTV footage in the areas external to the site has led them to conclude that it is unlikely that an intruder accessed the site at around the time of the fire. Whilst CCTV evidence alone cannot conclusively exclude an intruder, the CCTV coverage on the approaches to and from the general area of the Cutty Sark are reasonable enough to indicate that the chance of anyone being able to reach the site undetected by any of the cameras, is very unlikely.

10.2.6 In relation to potential electrical causes of the fire, the only equipment in use at the time of the fire were the fluorescent lights connected to the 110 Volt transformers, potentially other task lighting if this was left switched 'on', and potentially the Planet 200 vacuum cleaner if that had been left switched 'on'.

10.2.7 No remains of any task lights were found in the area of the aft stairs on the lower deck, or indeed on the tween deck.

10.2.8 The localised damage to the ballast winding of one of the fluorescent lights found in the area of the aft stairway is difficult to explain as a result of fire attack, but the limited nature of the damage and the resistance to ignition of the light casing tends to suggest that this cannot be considered positive evidence of a causative electrical fault. Given the design of the fluorescent lights and their resistance to ignition, it is considered that the fluorescent lights do not present a likely cause of the fire. Nevertheless, whilst no positive evidence was found in this regard, the possibility remains that the fire resulted from a resistance heating fault at an external connection in the junction boxes, which were found to ignite readily by exposure to a small flame.

10.2.9 The melting of the motor winding in the Planet 200 vacuum cleaner is difficult to explain as a result of fire attack, and does not appear to have been caused by alloying. Its appearance and location deep within the motor winding indicate that the melting was caused by a failure of the motor winding, and this is supported by the similar appearance of the damage produced at the motors that failed during the testing of the second new Planet 200 vacuum cleaner.

Therefore, the physical evidence indicates that one of the motors in the Planet 200 vacuum cleaner in use on the ship, failed at some stage.

10.2.10 It is not clear when the motor in the vacuum cleaner used on the ship failed. As the unit contained three separately switched motors, this damage could have occurred at some stage before the fire, causing the motor to fail, but allowing the machine to continue operating satisfactorily with just two motors, as occurred during the testing of the second new appliance. If this were the case however, the motor failure would appear to have gone unnoticed by everyone who worked in that area. Overall, there was no conclusive physical evidence to show that the unit had been operating at the time of the fire. It is important to consider whether there was any evidence of electrical arcing damage on the flex that supplied the vacuum cleaner, as this would indicate that the fire originated outside the unit, rather than within it. Whilst there was localised melting at two adjacent parts of the conductors of the supply flex, given the severe heat damage and melting sustained at other parts of the cable, and in particular the very similar melting close to, but separate from the two adjacent parts of melting, it is not considered that this provides positive evidence of electrical arcing damage.

10.2.11 The testing that led to the outbreak of fire in the second new Planet 200 vacuum cleaner imposed harsh conditions on the unit. In particular, it should be noted that the voltage supplied to the machine during the testing was 123 Volts. UK mains voltage, nominally 230 Volts, is required to be between 216 and 253 Volts. Accordingly, 110 Volt equipment might be expected to operate at between 103 Volts and 121 Volts. Therefore, the mains voltage supplied to the unit during the test was just beyond the upper limit of the voltage that the design might have been expected to operate at. In addition, the ambient temperature in the test room just exceeded the design limit of 40 degrees Centigrade, and the suction hose was completely blocked, creating the worst possible ventilation conditions for the unit. Lastly, after smoke was observed venting from the unit, the MCB 'tripped', but was reset for a few seconds, which would not be expected to occur in normal use.

10.2.12 With regards to the latter factor, when the MCB 'tripped', the temperature in the head of the unit increased very rapidly immediately after the unit stopped,

and then started to fall. Subsequently, the brief operation of the unit after the MCB had been reset accelerated the reduction in the temperature measured in the head of the unit. When the MCB was switched 'off' a few seconds later, the temperature in the head of the unit behaved in a similar way to when the MCB 'tripped', but peaked at a lower temperature than that which had been earlier attained. It is considered that the data collected indicates that the brief operation of the unit after the MCB had tripped did not cause an increase in the temperatures within the unit by comparison with the temperature attained immediately after the MCB tripped. Given the temperature data and the smoke that vented from the unit before the MCB was reset, it is likely that there was already a fire within the head of the unit before the MCB was reset.

10.2.13 Simulating a blockage in the filter or the suction hose were reasonable conditions to impose. It is foreseeable that the unit might be operated with a blockage. Indeed, the manual that was supplied with the unit indicated that operation of the 'thermic device' in the 240 Volt model might occur if there was an obstruction in the hose or if the filter was blocked.

10.2.14 Whilst the supply voltage during the tests was marginally higher than it was likely to have been on site, and the ambient temperature was somewhat high, the testing showed that the vacuum cleaner was not protected sufficiently to prevent the failure of a motor and the possibility of a fire as a consequence of the suction hose becoming blocked. The evidence that one of the motors, from the unit on the ship, had failed lends support to the proposition that the unit from the ship had been operating under similar conditions to those of the test, or perhaps operating under less arduous conditions for a longer duration. However, it should be noted that the damage to the commutator and the brushes found in the motor that was first involved in the fire during the tests was absent on the motors from the vacuum cleaner that had been on the ship. Nevertheless, given the identified susceptibility of the unit to cause fire under certain conditions that could have prevailed on the ship, and its location in the area where the fire most likely started, if the unit had been left switched 'on', it would present the most likely cause of the fire. It was not possible to determine from the physical evidence if the unit was switched 'on' at the time of the fire, and as such the investigation is reliant solely on the witness evidence in this regard. The witness evidence is somewhat conflicting, but the

last person to use the unit stated that it was left switched 'on', and nobody else described switching it 'off'.

10.3 Hot Work on the Site

10.3.1 Deficiencies were identified in the systems of work on site relating to hot work. Firstly, a site worker stated he undertook welding along the starboard side of the ship on Friday 18th May 2007 that was covered by a hot work permit. While the available records contained a permit for such work on the port side of the ship on that day, the only permit pertaining to such work on the starboard side of the ship was for the previous day. Secondly, of the permits issued in the months preceding the fire, almost half were not signed by a supervisor to indicate that checks had been made of the relevant area after the work had been completed. Such checks are widely recognised as being important to reduce the likelihood of a smouldering fire developing unnoticed. Given the deficiencies identified in relation to the operation of the hot work permit system, the hot work records cannot be relied upon as evidence of when the last hot work was carried out, and the investigation relies upon witness recollection in this regard.

10.4 Security at the Site

10.4.1 Deficiencies were identified in the actions of the security staff at the site on the day of the fire, in that a security log was apparently falsely written prior to the completion of the relevant shift, in order that one of the two security guards on duty would be able to leave early. Furthermore, one of the security guards admitted to failing to perform the patrols and/or maintain a presence in the Pavilion. Inconsistencies in the accounts of the security guards were reported by both the Fire Brigade investigators and the Police, and one of the guards admitted lying in two of his statements. There are inconsistencies in the information set out in the final statements of the two security guards. In view of this, the accounts of the two security guards cannot be relied upon as an accurate description of the level of observation and security on the site during the night of 20th/21st May 2007.

10.4.2 If the witness evidence is correct, on the weekend before the fire, the site was not guarded for a period of time when one of the Cutty Sark employees had to access the site by climbing over the hoarding to retrieve tools.

10.4.3 Whilst the site was protected by hoarding, it was possible for an agile person to access the site, and the ship, without great difficulty, and without the security guards being aware of it.

10.5 The Fire Alarm System

10.5.1 The witness evidence of the Fire Officers who attended the fire, and of the Crosby engineer who attended to silence the alarms, suggest that either the temporary fire alarm system associated with the ship did not cause the sounders to operate, or the sounders only operated for a short period. One of the security guards, bearing in mind their unreliability, did not mention the fire alarm operating, but the second guard stated, in his third statement, that the fire alarm activated after he saw flames. This issue is somewhat confused by the undoubted operation of the nearby Pavilion fire alarm system. Nevertheless, if the fire started underneath the aft stairs on the lower deck, such that hot combustion products were deflected by the stairs towards the rear, it is feasible that the alarm system would not activate until the fire was well developed, as the nearest heat detector was well forward of the stairs, and the open structure of the ship would not lend itself to the rapid operation of the heat detectors.

10.5.2 At the time of the inspection, the cabling and sounders external to the ship were functional, but when an alarm condition was simulated, the system did not provide the required output voltage to power the sounders. This was because of a fault in a relay in the alarm panel.

10.5.3 A sounder circuit fuse within the alarm panel had operated, and this could only have blown if the relay was at some stage functional, such that current could flow through it and the fuse. It is not clear when the fuse operated, but with the fuse blown a 'fault' buzzer and light would have activated at the panel to alert the user. Either the fuse operated at some stage prior to the fire, and such fault alarms were ignored, or the fuse operated and the relay failed during the

fire. The fuse operation could well have occurred during the fire as a result of fire attack on the sounder circuit cables or the sounders themselves. The other sounder circuit, with its intact fuse, could have drawn current through the relay until the relay's positive switch failed, most likely initiated by the short circuit currents.

10.5.4 Having regard to the points discussed in the preceding two paragraphs, there was no positive physical evidence to show that the fire alarm system had been defective before the fire.

10.5.5 Crosby Electrical Services Limited did not perform any functional tests after the alarm system was handed over. However, it is typical in many buildings for a fire alarm system to be tested by the user on a weekly basis. There were signs at the site which specified the day and time of a weekly fire alarm test, and the requirement for such tests were set out in the Fire Safety document. However, based on the witness evidence, such weekly tests were not regularly undertaken in the months leading to the fire.

10.5.6 The CCTV footage of the fire shows that the ship was fully engulfed in flames within five minutes of the first signs of smoke emanating from the ship. Whilst the CCTV footage does not show the extent to which the fire may already have developed in the lower parts of the ship when smoke was first visible, the fire nevertheless developed very rapidly as a result of the well ventilated open timber construction presented by the ship. It is not clear whether the extent of fire damage would have been significantly affected by any failure of the fire alarm system to operate, given that a flaming fire would have to have become established before the heat detection would have activated and given the large surface area of timber and effective ventilation that were conducive to rapid fire development.

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11.0 CONCLUSIONS

11.1 The physical evidence and CCTV footage of the fire show that it probably originated towards the stern of the ship on the lower deck, in the area of the aft stairway.

11.2 On the basis of the witness evidence, it is considered unlikely that the fire was caused by hot work or by carelessly discarded smokers' materials, due to the extended period of time between the last known activities on the ship and the outbreak of flaming fire.

11.3 The analysis performed by P.A.R. Associates of the CCTV footage in the areas external to the site has led them to conclude that it is unlikely that an intruder accessed the site at around the time of the fire.

11.4 Deficiencies were identified in adhering to the provisions of the Cutty Sark restoration project ‘Fire Plan’. These deficiencies related to the hot work regime, fire alarm testing, fire security and the role of the Fire Safety Co-ordinator.

11.5 Deficiencies were identified in the actions of the security staff at the site on the day of the fire.

11.6 The witness evidence suggested that either the temporary fire alarm system associated with the ship did not cause the sounders to operate, or the sounders only operated for a short period. Regular weekly fire alarm system tests, required by the site Fire Safety Plan, were not undertaken, but there was no physical evidence to show that the fire alarm system had been defective at the time of the fire.

11.7 A number of potential electrical causes of the fire have been considered. Two of these present plausible causes of the fire, namely resistance heating at terminations in plastic junction boxes that supplied fluorescent lights, and overheating of a motor in a Planet 200 vacuum cleaner. There was no physical evidence to show conclusively that either had caused the fire.

11.8 Tests carried out on the same model of industrial vacuum cleaner showed that the unit could ignite if operated for an extended period of time with the suction hose blocked.

11.9 One of the three motors used in the Planet 200 vacuum cleaner on the ship had failed. It is not clear whether the failure occurred at some stage prior to the fire, or whether the failure was associated with the outbreak of fire. The evidence of a motor failure provides an indication that the vacuum cleaner could have been operated under similar conditions to that of the test that resulted in the outbreak of fire.

11.10 There was no physical evidence to show that the Planet 200 vacuum cleaner had been operating at the time of the fire. The witness evidence is somewhat conflicting, but the last person to use the unit stated that it was left switched 'on', and nobody else described switching it 'off'.

11.11 The investigation into the fire on board the Cutty Sark on Monday 21st May 2007, has found no evidence that the ship was subjected to an arson attack. It is the view of the enquiry that the cause of the fire was accidental. Having considered all the information available, it is believed that the most likely cause of the fire was the failure of an industrial vacuum cleaner that had inadvertently been left switched on over the weekend of the 19th – 20th May 2007. The Health and Safety Executive have been informed of the concerns surrounding the safety of this type of vacuum cleaner, and the Health and Safety Executive have formally notified the importer and Italian manufacturer of the equipment of their obligations under UK Health and Safety legislation. Inspectors from the Health and Safety Executive also visited the site this summer to make a routine inspection during which advice on fire precautions was given to the principal contractor.

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