ACCIDENT REPORT

Report on the investigation of

the fire on the main vehicle deck of

Commodore Clipper

while on passage to Portsmouth

16 June 2010

MAIB
MARINE ACCIDENT INVESTIGATION BRANCH

LESS SERIOUS MARINE CASUALTY　REPORT NO 24/2011　NOVEMBER 2011

Pursuant to Regulation 6 of Chapter XI -1 of the International Convention for the Safety of Life at Sea (SOLAS) and the Code of the International Standards and Practices for a Safety Investigation into a Marine Casualty (Casualty Investigation Code) (Resolution MSC.255 (84)), the MAIB has investigated this accident with the co-operation and assistance of the Bahamas Maritime Authority. Their contribution to this investigation is acknowledged and greatly appreciated.

Extract from
The United Kingdom Merchant Shipping
(Accident Reporting and Investigation)
Regulations 2005 – Regulation 5:

"The sole objective of the investigation of an accident under the Merchant Shipping (Accident Reporting and Investigation) Regulations 2005 shall be the prevention of future accidents through the ascertainment of its causes and circumstances. It shall not be the purpose of an investigation to determine liability nor, except so far as is necessary to achieve its objective, to apportion blame."

NOTE

This report is not written with litigation in mind and, pursuant to Regulation 13(9) of the Merchant Shipping (Accident Reporting and Investigation) Regulations 2005, shall be inadmissible in any judicial proceedings whose purpose, or one of whose purposes is to attribute or apportion liability or blame.

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GLOSSARY OF ABBREVIATIONS AND ACRONYMS

ABB	Asea Brown Boveri
ALP	Aerial Ladder Platform
ARCC	Aeronautical Rescue Co-ordination Centre
BA	Breathing Apparatus
BMA	Bahamas Maritime Authority
BST	British Summer Time
CCTV	Closed Circuit Television
CGLO	Coastguard Liaison Officer
CHA	Competent Harbour Authority
CMS	Condor Marine Services
CPSO	Counter Pollution and Salvage Officer
DAO	Duty Area Officer
DNV	Det Norske Veritas
DOD	Duty Operations Director
DPA	Designated Person Ashore
DQHM	Duty Queen's Harbour Master
ECR	Engine Control Room
EEBD	Emergency Escape Breathing Device
FLM	Fire Liaison Manager
HFRS	Hampshire Fire and Rescue Service
HMCG	Her Majesty's Coastguard
Hz	Hertz
IDC	Insulation Displacement Connector
IEC	International Electrotechnical Commission
IMO	[The] International Maritime Organization
IP	Ingress Protection [rating]
ISM	International Safety Management [Code]
kW	kilowatt
MCA	Maritime and Coastguard Agency

MIRG	Marine Incident Response Group
MOD	Ministry of Defence
MOU	Memoranda of Understanding
MSC	Maritime Safety Committee
OOW	Officer of the Watch
OSB	Outer Spit Buoy
PEC	Pilotage Exemption Certificate
PIP	Portsmouth International Port
PMSC	Port Marine Safety Code
QHM	Queen's Harbour Master
RAF	Royal Air Force
SAR	Search and Rescue
SHA	Statutory Harbour Authority
SLF	IMO Sub-Committee on Stability and Load Lines and Fishing Vessels Safety
SOLAS	International Convention on Safety of Life at Sea
SOLFIRE	Solent and Southampton Water Marine Emergency Plan
SOSREP	Secretary of State's Representative
STCW	International Convention on Standards of Training, Certification and Watchkeeping for Seafarers
VCG	Vertical Centre of Gravity
VDR	Voyage Data Recorder
VHF	Very High Frequency

Times: All times used in this report are local (UTC+1) unless otherwise stated. Timings taken from automated ship and coastguard systems are all corrected to match voyage data recorder time

SYNOPSIS

At 0242 (BST) on 16 June 2010, a fire was detected on the main vehicle deck of the Bahamas registered ro-ro ferry *Commodore Clipper.* The vessel was on passage from Jersey to Portsmouth and the vehicle deck was loaded with many freight trailers. The crew identified that an unaccompanied refrigerated trailer unit, powered from the ship's electrical supply, had caught fire.

The crew contained the fire using the vehicle deck water drenching system and boundary cooling from above, but were not able to extinguish it. Fire damage to unprotected cables and pipework in the main vehicle deck caused extensive disruption to systems, affecting the vessel's ability to manoeuvre and contain the fire. Fire-fighting efforts had to be suspended as cargo debris blocked vehicle deck drains, causing water from the fire-fighting effort to accumulate and reduce the vessel's stability.

Although *Commodore Clipper* was close to Portsmouth harbour, berthing was significantly delayed through ineffective co-ordination between shore agencies and because of equipment defects. Once alongside, the high density of cargo and constraints in the design of the vessel limited access to both fight the fire and to disembark the passengers. As a consequence, freight trailers had to be towed off the vessel before the fire could be extinguished. The last of the 62 passengers disembarked from the vessel nearly 20 hours after the fire started.

The investigation identified that the fire started due to overheating in an electrical cable that provided power from the ship to one of the refrigerated trailer units. The materials used both in the curtain-sides and the cargo packaging burnt readily.

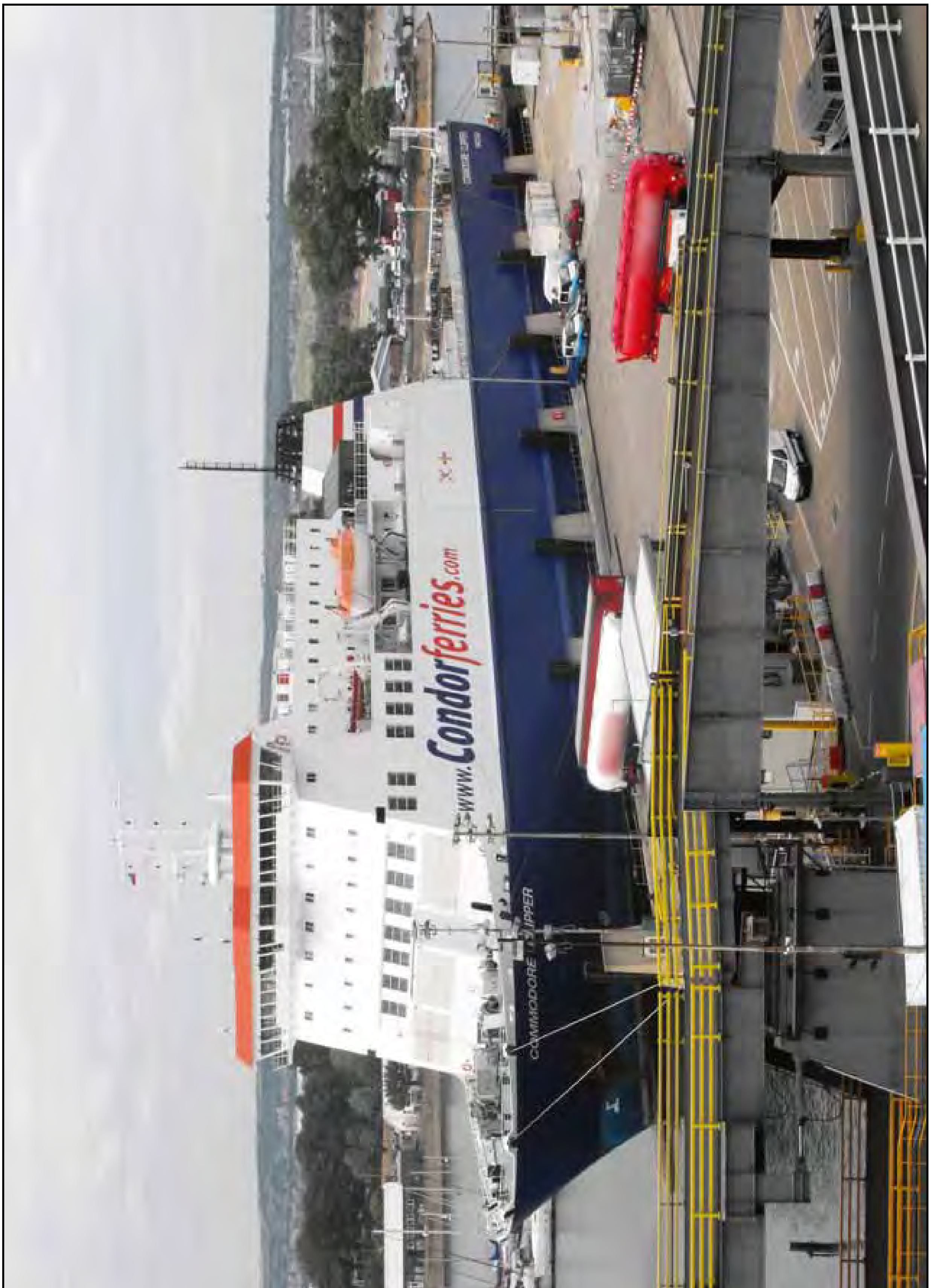
The vessel managers and port authorities have taken a range of actions during the investigation which should reduce the likelihood of a similar accident recurring, and improve their ability to respond to future emergencies. The Maritime and Coastguard Agency (MCA) has undertaken to implement a number of recommendations resulting from an internal review of its response to the incident.

The MAIB has made recommendations to the MCA and the Port Marine Safety Code (PMSC) steering group regarding the response to, and management of similar incidents in the future.

The Chief Inspector of the MAIB has written to the Secretary General of the International Maritime Organization (IMO) requesting that this report and the reports of the investigations into the fires on board *Al Salaam Boccacio 98*, *Und Adriyatik*, *Lisco Gloria* and *Pearl of Scandinavia*, are reviewed with the aim of identifying improvements that can be made to the fire protection standards applied to ro-ro passenger vessels constructed before 1 July 2010 to enhance their survivability and safe return to port in the event of a vehicle deck fire.

The Bahamas Maritime Authority (BMA) has agreed to make a submission to the International Maritime Organization on providing improved stability information to masters of vessels and to work with the MCA on a joint submission regarding pedestrian access to ro-ro ferries.

The MAIB issued a safety bulletin in July 2010 identifying the risk of power supply cables to refrigerated trailers overheating, and has published a flyer to raise awareness of the safety issues in the ferry and port management sectors of the industry.



Commodore Clipper

SECTION 1 - FACTUAL INFORMATION

1.1 PARTICULARS OF *COMMODORE CLIPPER* AND ACCIDENT

SHIP PARTICULARS

Flag	Bahamas
Classification society	Det Norske Veritas (DNV)
IMO number	9201750
Type	Ro-ro passenger
Registered owner	Condor Limited
Manager(s)	Condor Marine Services
Construction	Steel
Length overall	129.14m
Registered length	118.7m
Gross tonnage	14000
Minimum safe manning	13
Authorised cargo	Not applicable

VOYAGE PARTICULARS

Port of departure	St Helier, Jersey
Port of arrival	Portsmouth, UK
Type of voyage	Short international voyage
Cargo information	Cars and road freight trailers
Manning	39 crew

MARINE CASUALTY INFORMATION

Date and time	16 June 2010, 0242
Type of marine casualty or incident	Less Serious Marine Casualty
Location of incident	50° 18.87 N, 001° 29.76 W
Place on board	Deck 3, special category space
Injuries/fatalities	None
Damage/environmental impact	Material damage to the vessel
Ship operation	On passage
Voyage segment	Mid water
External & internal environment	Dark, good weather conditions
Persons on board	62 passengers and 39 crew

1.2 BACKGROUND

Commodore Clipper provided a passenger and vehicle freight service linking St. Peter Port, Guernsey and St. Helier, Jersey in the Channel Islands with Portsmouth. One round trip of all three ports was completed in each 24-hour period from Monday to Saturday. At the time of the accident, *Commodore Clipper* was on the overnight leg, from St. Helier to Portsmouth. The vessel was certified to carry 500 passengers, but 62 were on board at the time. The vehicle decks were almost full to capacity, mainly with unaccompanied road freight trailers.

1.3 EVENTS LEADING UP TO THE FIRE

1.3.1 Cargo operations in Jersey

On 15 June 2010, *Commodore Clipper* sailed from St. Peter Port at 1747 and arrived at St. Helier at 1940. The main season for exporting Jersey Royal potatoes was reaching its end; 24 of the 77 trailers that were loaded on board were refrigerated units, carrying pre-packaged potatoes for delivery straight to supermarkets. There were too many refrigerated trailers to allow them all to be loaded on the upper vehicle deck (deck 5), which was in the open air and would have allowed their diesel-powered fridge units to be run. Consequently, those refrigerated trailers that could be powered from the ship's electrical system were loaded onto the main vehicle deck (deck 3). These trailers were connected to power sockets on deck 3 by staff working for the haulage company, using cables provided on board *Commodore Clipper*.

1.3.2 Departure from Jersey and return passage

Cargo operations and ship stability calculations were completed and *Commodore Clipper* departed from St. Helier at 2145. The weather was fair, the ship made good progress to Portsmouth and was able to reduce to a more economical speed. Crew conducted fire and security checks of the accommodation through the night hours. The Officer of the Watch (OOW) and lookout maintained a periodic check on the vehicle decks from the bridge, by monitoring the closed circuit television (CCTV) and fire detection systems.

Masters, deck officers and managers had identified that the vessel's repetitive daily schedule did not provide bridge watchkeepers with the best opportunities to rest if traditional watch handover times were kept. Accordingly, the two second officers handed over the bridge watch at 0230. Navigational traffic was light and there were no indications of any problems on board. At about 0240, the off-going second officer made his way from the bridge to the mess room. He did not notice anything untoward or smell any smoke as he passed through the accommodation.

1.4 FIRE

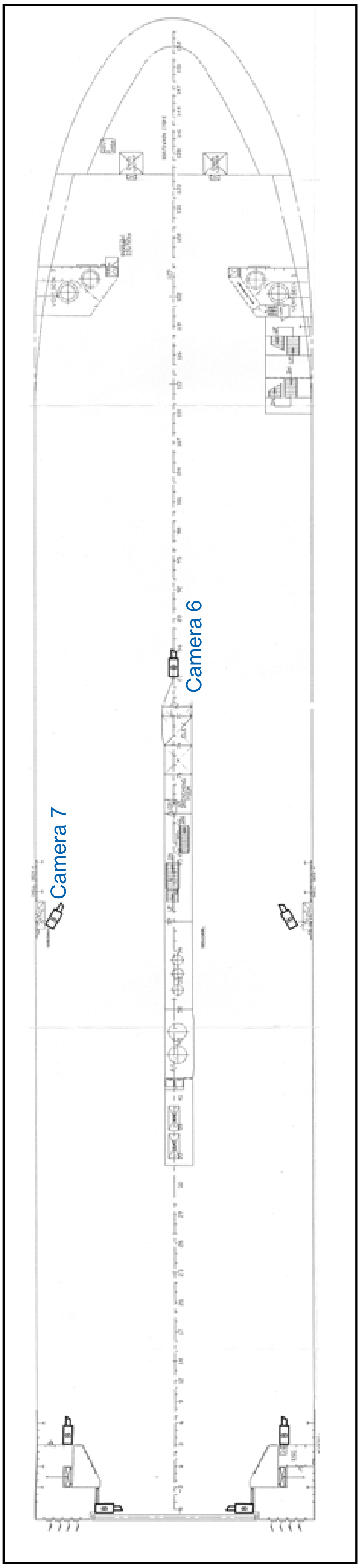
1.4.1 Early fire development

At 0237, the picture recorded by CCTV camera 7 on the port side of the main vehicle deck started to get hazy **(Figure 1)**. The vehicle deck lighting began to appear more diffused and the picture gradually faded grey. Shortly afterwards a machinery control alarm showed an earth fault at the bus-tie breaker linking the two parts of the main 400V electrical distribution system. The third engineer, on duty in the engine control room, also heard the noise of the breaker opening. Two minutes later, at 0241, the image recorded on CCTV camera 6, at the centreline of the main vehicle deck **(Figure 2)**, began to darken.

Figure 1

Sequence of images recorded by CCTV camera no.7 from 0237 BST (CCTV timings are in UTC)

Figure 2



Layout of CCTV cameras on the main vehicle deck

1.4.2 Initial response

The ship's fire detection system had control stations on both the bridge and in the engine control room (ECR). The system had no particular history of spurious, nuisance alarms, and company procedures allowed either the OOW or duty engineer to respond to an alarm and co-ordinate the initial response. The alarm activated in both locations at 0242:36, indicating that sensor D24 on the port side at the midships section of the vehicle deck had detected smoke. Sensors on either side of D24 activated within the next 30 seconds **(Figure 3)**. The third engineer had gone to the auxiliary engine room and he returned to the ECR to investigate the alarm. He silenced the alarm and contacted the second officer on the bridge by telephone, to report the alarm. At 0243, the second officer instructed the lookout to take a portable very high frequency (VHF) radio and go and check the main vehicle deck to confirm if there was a fire.

The third engineer had not smelled any smoke and suspected that the alarm might be due to a faulty component in the detection system. After calling the bridge, he telephoned the electrical fitter and asked him to investigate if there was a fault with the fire detection system. The third engineer continued to silence the alarm a further six times during the next three minutes before resetting the system at 0245:42.

After the fire detection system had been reset, the sensors reactivated and the fire alarm sounded again. The second officer silenced the alarm on the bridge at 0246:20 and reset the system from his control station immediately afterwards. By the time the fire detection system had reactivated, 10 different sensors on the port side of the main vehicle deck, ranging from the original location midships, all the way aft to the stern ramp, had detected smoke.

1.4.3 Confirmation

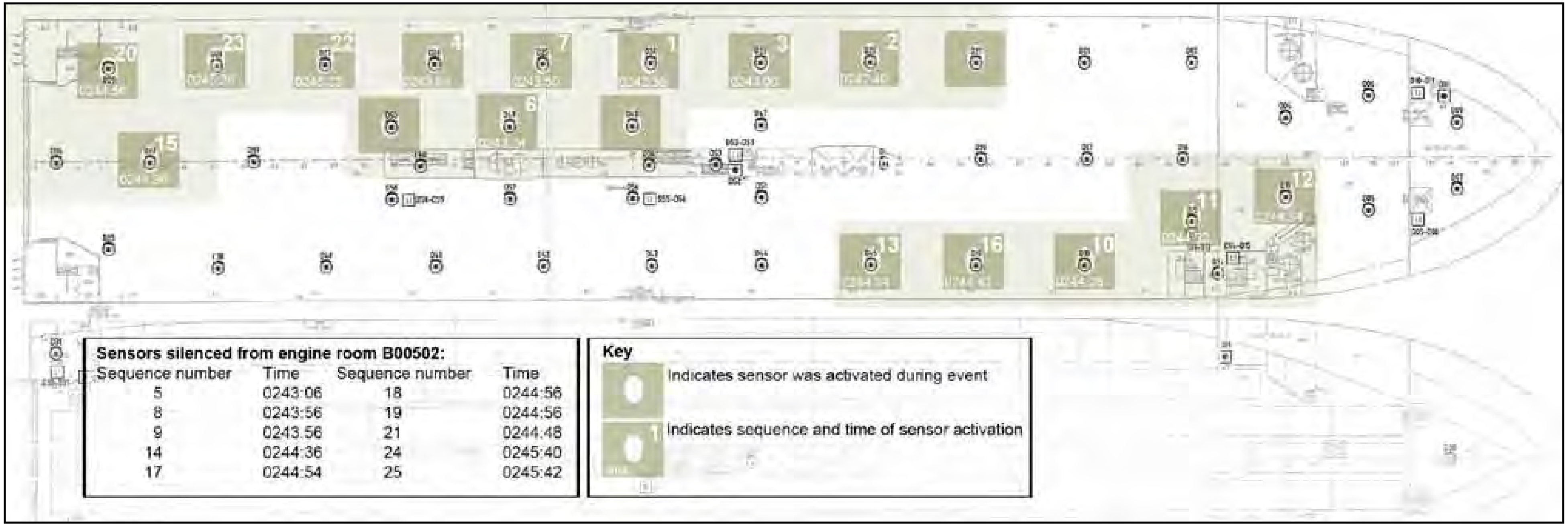
The lookout knew that the portable radio that he was assigned was not reliable, and was concerned that he might become injured or trapped near the fire and not be able to summon help. After leaving the bridge, rather than go straight to the main vehicle deck he went to the passenger restaurant on deck 7 and met the two night stewards. They could smell smoke in the area, and the lookout returned to the bridge at 0248. Meanwhile, the second officer was talking to the third engineer in the ECR using the bridge telephone. It was possible to determine, from listening to the second officer's side of the conversation on the voyage data recorder (VDR), that the two officers had concluded that the likely cause of the fire alarm was a problem with the detection system. The third engineer subsequently telephoned the chief engineer to report that there was a problem with the fire detection system and that it could not be reset.

The fire detection system ceased to function at 0249:12; 6 minutes and 54 seconds after the first alarm. During this period, 16 sensors detected smoke, activating a combined total of 81 times. The system had been silenced 11 times and reset 7 times by the combined inputs from the bridge and ECR control stations.

The lookout reported to the second officer that he had smelled smoke in the accommodation area, but that he had only been as far as the restaurant. The second officer told him to go to the main vehicle deck; the lookout left the bridge at about 0250. Over the next 7 minutes, the second officer received 8 distorted and unreadable calls on his portable VHF radio, all of which he thought were likely to have been from the lookout.

Throughout this period, the electrical fitter had been attempting to gain access to the main vehicle deck to check the fire detection sensors. He was beaten back by smoke, and went to the ECR instead. The electrical fitter reported the smoke to the third engineer, and the two men isolated the electrical power supplies to the refrigerated trailer units on the main vehicle deck. The third engineer also started an auxiliary generator to take the electrical load from the shaft generator.

Figure 3



Schematic diagram of the initial smoke detector activation and alarm silencing sequence

Recordings from all the CCTV cameras on the main vehicle deck showed increasingly heavy smoke; visibility was lost by 0254. The second officer reported that he looked at the CCTV pictures of the main vehicle deck, but did not see any indication of a fire. Machinery alarm records indicated that the ventilation fans on both the main and upper vehicle decks were stopped at about 0255. However, the system had an in-built delay of 5 minutes between the fans stopping and the machinery alarm being activated. Consequently, the vehicle deck fans would have stopped at about 0250 and this was closely followed by a second earth fault being recorded at the bus-tie breaker. The dampers on the ventilation inlets were arranged to shut automatically but pre-dated the requirement for their position to be indicated remotely.

At about 0258, the machinery control system recorded '*fail'* alarms on both steering gear no.1 (port) and steering gear no.2 (starboard). There was no apparent fault with the steering; the machinery records showed that the alarms were accepted shortly afterwards and they did not recur.

1.4.4 General emergency stations

The chief engineer had been asleep in his cabin on deck 9 when the third engineer reported the activation of the fire detection system and his conclusion that it was a false alarm. The chief engineer decided to go to the closest fire detection system control station on the bridge to try and find out what was wrong. He smelled smoke as soon as he opened his cabin door, and went straight to the bridge. The second officer on watch reported that many fire detection sensors on the main vehicle deck had been activated, but that he was not sure why. The chief engineer concluded the most likely reason was that there was a fire, rather than a fault with the fire detection system. At 0259:20, the lookout called the second officer by telephone and confirmed that there was a fire on the main vehicle deck. The chief engineer activated the crew alert signal at 0301 and then, concerned that the situation was serious and developing rapidly, activated the general emergency signal immediately afterwards. At the same time, the second officer telephoned the master and chief officer in their cabins and told them there was a fire on the main vehicle deck.

The chief engineer turned the switch on the bridge to ensure that the vehicle deck ventilation fans had been shut down. He then started the vehicle deck drenching system[1] in section 4, the immediate location of the fire **(Figure 4)**. At about 0306, main vehicle deck water leakage alarms were triggered, indicating that water from the drenchers had started to drain overboard from the compartment.

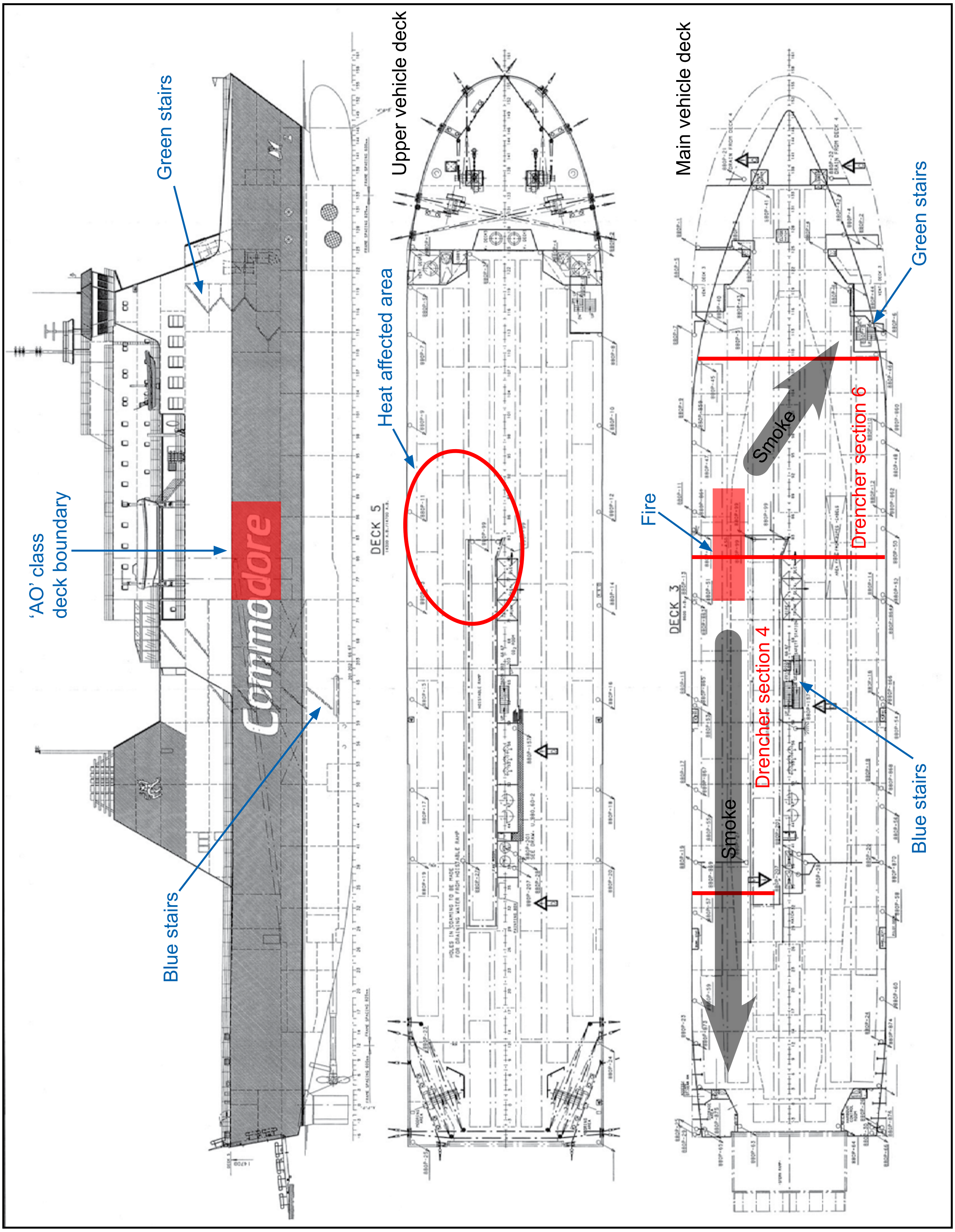
1.4.5 Muster stations

The master and chief officer arrived on the bridge soon after the alarm was sounded, and were briefed by the chief engineer. The master made an announcement on the public address system for all the passengers to muster at the assembly stations, and the fire screen doors were shut. The chief engineer activated the drenchers in section 6 in addition to section 4 and left the bridge to go to his muster point at the safety station on deck 3. The chief officer went to his muster point at the safety station on deck 9.

Hotel staff checked each cabin in turn and directed the passengers to the assembly stations at either the restaurant on deck 7 or the bar on deck 8, where they were issued with lifejackets.

Crew in emergency team 1 mustered at the safety station on deck 9 and began to put on fire-fighting suits and breathing apparatus (BA). Smoke from the main vehicle deck had gathered in the central stairwell, and crew in emergency team 2, who were

[1] An approved manually operated fixed pressure water spraying system was fitted in the main vehicle deck as required by SOLAS Chapter II-2, Regulation 20 and resolution A.123(V). This was known on board as the vehicle deck drenching system.



General arrangement of *Commodore Clipper* and location of the fire assigned to muster at the safety station on deck 3, were unable to get through. They mustered at the fire locker on deck 7 and subsequently joined up with emergency team 1. The chief engineer, realising that no-one else was coming to join him, left the safety station on deck 3 and went to the ECR to check on the main machinery and confirm that electrical power to the refrigerated trailer units had been turned off.

The lookout had used an emergency escape breathing device (EEBD) to enter the vehicle deck from both the starboard forward and centreline access doors in order to confirm the location of the fire. After telephoning the second officer, he returned to the bridge and reported to the master that one of the unaccompanied trailers, on the port side at about the midships position, was on fire.

At 0307, *Commodore Clipper*'s master called Solent Coastguard[2] on VHF channel 16. His transmission was mixed with other radio traffic and Solent Coastguard asked him to call again on VHF channel 67. When the master made contact, he reported that the ship had a fire on board and that the crew were investigating. No distress or urgency message prefixes were used. Two minutes later, Solent Coastguard called back requesting the number of people on board and other information about the incident. The second officer provided these details and asked for the emergency services to meet the ship on its arrival in Portsmouth. At 0313, the coastguard activated its search and rescue (SAR) plans and made preparations to notify the Marine Incident Response Group (MIRG) in case firefighters from Hampshire Fire and Rescue Service (HFRS) needed to be sent out to *Commodore Clipper*.

All the passengers had now mustered in either the restaurant on deck 7 or the bar on deck 8. A stairwell, known on board as the “green stairs”, led all the way up from the starboard forward corner of the main vehicle deck (deck 3) to the restaurant. Smoke from the vehicle deck had drifted up the green stairs and had begun to make the atmosphere in the restaurant unpleasant. The crew decided to direct the passengers who were in the restaurant to move to the bar via a door onto the upper deck and some external stairs. All the passengers were accounted for and mustered together in the bar. Although not all the crew were able to reach their designated muster points, they were accounted for quickly and no injuries were reported.

Condor Marine Services' (CMS) Designated Person Ashore (DPA) was travelling on board as a passenger. He went to the bridge to offer his support to the master. The master had activated company emergency plans and a call-out system to inform key shore staff was initiated. Some shore staff gathered in the company's office to provide support from ashore, while others began travelling to Portsmouth to meet the ship on arrival. The DPA maintained communications with the office throughout the incident.

1.4.6 Containment

The chief engineer knew that the ventilation inlet dampers closed automatically, and he requested that the bridge team send someone to close the manual exhaust dampers at the aft end of the main vehicle deck. The off-watch second officer and a deck cadet went to the stern via the upper vehicle deck and, taking EEBD sets as a precaution, closed the dampers.

The chief officer led crew from emergency teams 1 and 2 to the forward part of the upper vehicle deck to provide boundary cooling above the fire. They started to rig two fire hoses at 0319, and could see that the deck was very hot and starting to buckle. The initial flow of water from the hoses was described as being “steaming hot” and made the metal nozzles uncomfortably hot to hold. CCTV cameras on deck 5 recorded a very large cloud of steam being generated at 0324 as water was sprayed onto the deck area immediately above the fire **(Figure 5)**.

[2] Her Majesty's Coastguard's (HMCG) Solent Maritime Rescue Co-ordination Centre, referred to by its short title, Solent Coastguard

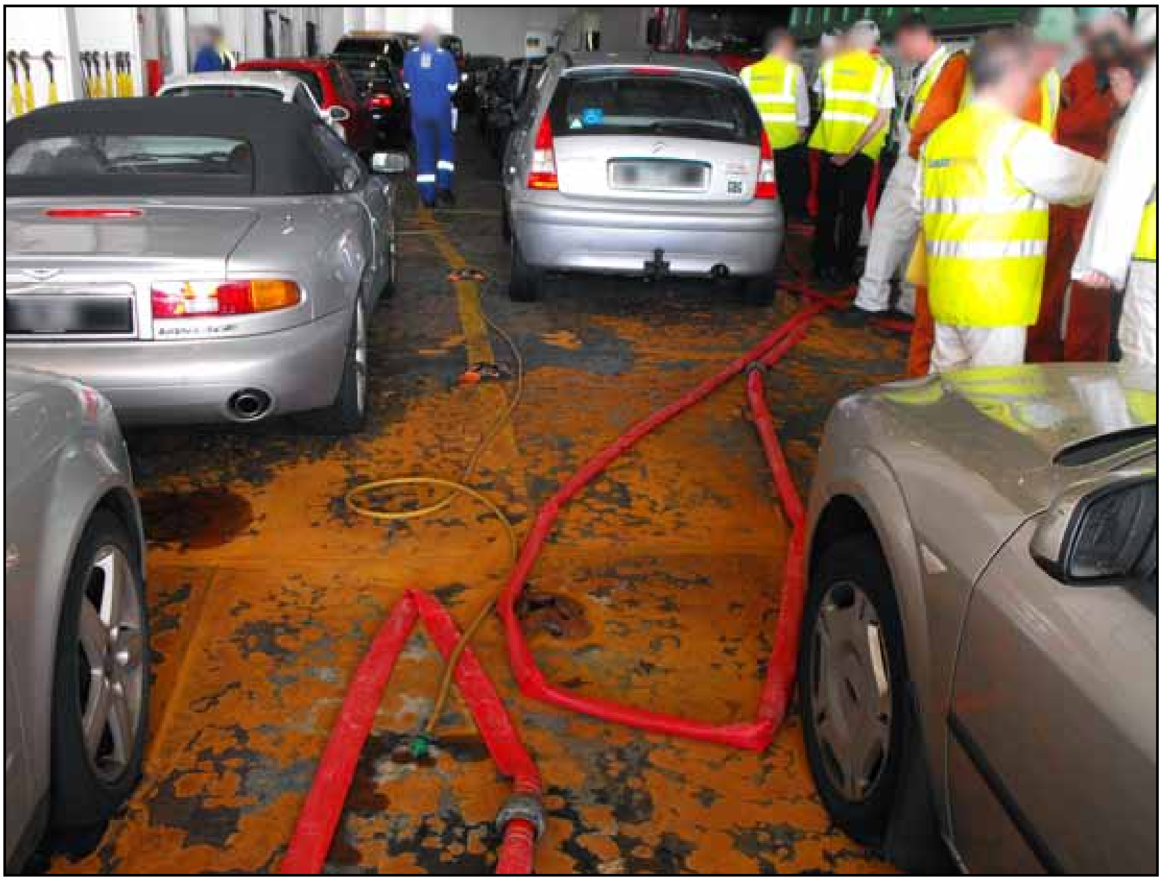
Figure 5

Cloud of steam from the upper vehicle deck as boundary cooling was started
(CCTV timings are in UTC)

The second officer on the bridge called Solent Coastguard at 0327 to update them on the situation. He also requested that a fire-fighting team be sent out to *Commodore Clipper* by helicopter. The coastguard officer confirmed this request and agreed to make the necessary arrangements.

After about 30 minutes of drenching and boundary cooling, the chief and third engineers measured the temperature of the upper vehicle deck using a portable infra-red thermometer. They recorded average deck temperatures above the fire of 180°C, and noted that the steel plating had buckled and the paint coating had gone. The heat did not cause any of the cars parked in the immediate area above the fire to ignite **(Figure 6)**.

Figure 6



Heat damage to the upper vehicle deck

1.4.7 First assessment

Commodore Clipper had continued on its normal course throughout the period since the fire had been discovered, but the master had increased to full service speed when he arrived on the bridge. Consequently, by 0335 the vessel was about 12 nautical miles to the south of the Isle of Wight.

Solent Coastguard officers had paged the MCA's Fire Liaison Manager (FLM) and Duty Area Officer (DAO), and by 0336 both had telephoned the coastguard station and been briefed on the situation. The FLM, a fire and rescue service officer on secondment to the MCA to co-ordinate MIRG activity, asked the coastguard watch manager to confirm if *Commodore Clipper*'s master had specifically asked for a MIRG team to be sent to the ship. A different coastguard officer had communicated with the ship, and the watch manager could not confirm if the master had specifically requested assistance from the MIRG, or just discussed the options available. At 0339, the FLM asked Solent Coastguard to obtain more details about the fire from *Commodore Clipper* and, particularly, to confirm if the master wanted a MIRG team to be sent to the ship. Solent Coastguard interpreted the communications from the ship to mean that the MIRG was not required immediately, but should be asked to standby in case it was subsequently needed.

A few seconds later, just before 0340, *Commodore Clipper's* master called Solent Coastguard reporting that he thought the drencher system and boundary cooling were having a good effect and that the fire might have been extinguished. The master agreed with the coastguard that a MIRG team was not required, but requested that HFRS meet the ship once it was alongside in Portsmouth. The master gave an estimated time of arrival of 0600, confirmed that the ship was carrying no hazardous cargo, and that the burning trailer had been identified as one of the unaccompanied refrigerated trailer units.

1.4.8 Entering the Solent

By 0340, the amount of smoke escaping from the main vehicle deck had reduced significantly, and crew reported that the upper vehicle deck felt comfortably warm as they checked its temperature with the backs of their bare hands. At 0344, the FLM and DAO had a telephone conference call with the coastguard watch manager to review the situation, and it was concluded that the incident could be dealt with by HFRS once the ship was alongside. The master called with another update at 0352; no-one had been into the main vehicle deck to confirm the state of the fire, but he was confident the fire was under control and possibly extinguished. Immediately afterwards, Solent Coastguard called the port control office of the Queen's Harbour Master (QHM) Portsmouth. The coastguard briefed the QHM port control supervisor on the situation and, having considered the risk to the dockyard port, the supervisor agreed to allow *Commodore Clipper* to enter the harbour. Responsibility for Portsmouth harbour is divided between QHM and Portsmouth Continental Ferry Port[3] (PIP). QHM has statutory responsibilities for protecting the dockyard port and so controls traffic entering the harbour. QHM informed PIP about the fire at 0356.

By 0400, the situation on *Commodore Clipper* appeared to be under control and the master allowed the passengers to return to their cabins if they wished. Hotel staff began preparing breakfast and the fire safety doors were reset.

1.4.9 Deteriorating condition

Commodore Clipper continued on its normal passage through the Solent towards Portsmouth until about 0443, when the master noticed that the vessel was developing a list to port, which reached an angle of about 5°. The master and bridge team looked out from the bridge wings to check that water was flowing from the vehicle deck drains. Some water could be seen flowing overboard from the drains, but at a much slower rate than when the drenchers were first started. The bridge team concluded that debris from the fire was partially blocking the vehicle deck drains and, because of concern about the adverse impact an accumulation of water on the vehicle deck could have on the vessel's stability, the decision was taken to turn off the drencher system. With the drenchers turned off, *Commodore Clipper* gradually returned upright, and the crew began a cycle of activating the drenching system until the list reached 2 - 3° and then stopping while the list reduced. Each time drenching was stopped, crew on the upper vehicle deck noted that the temperature of the deck began to increase.

At about 0445 an alarm sounded, indicating that some of the steering pumps had failed. One minute later, the port rudder moved over to 20° to starboard and the ship began to turn. The master took way off the ship and reported the problem to Solent Coastguard while the chief engineer went to the steering gear compartment and centred the port rudder using local hydraulic controls. The chief engineer attempted to reconnect the port control system, but the port rudder was driven back over to starboard. The port control system was disconnected and the port rudder was left centralised. The starboard rudder continued to respond to steering commands and, at 0503, *Commodore Clipper* continued on passage. QHM Portsmouth had overheard the report to the coastguard and offered to send its duty tug to assist.

[3] Portsmouth Commercial Port, also known as Portsmouth Continental Ferry Port, was renamed in January 2011 to Portsmouth International Port (PIP).

The master was concerned that steerage was now reduced and that the fire might lead to control of the starboard rudder being lost. He called QHM Portsmouth and agreed that he would only attempt to enter the harbour with tug assistance. The standby tug, *SD Bustler*, was alerted and told to meet *Commodore Clipper* in the vicinity of the Outer Spit Buoy (OSB) **(Figure 7)**.

Reproduced from Admiralty Chart BA 2037 by permission of the Controller of HMSO and the UK Hydrographic Office

Figure 7

Annotated chart of Eastern Approaches to the Solent

By 0523 it had been reported that more smoke was entering the accommodation from the green stairs and the lift shaft. All the sections of the drencher system were activated and the chief officer left the bridge to close the fire screen doors and assess the amount of smoke in the accommodation. Further earth faults were recorded on the machinery alarm system, and the chief engineer returned to the bridge to discuss the problems with the steering gear controls.

1.4.10 Loss of power to machinery

Commodore Clipper was still on passage and expecting to arrive in Portsmouth at between 0630 and 0640. At this stage of the voyage, the usual procedure was to start and test both bow thrusters. A fault had occurred with one of the bow thruster starter switches on the bridge a few days before the accident. The crew had been unable to repair the switch and had re-arranged the starting circuit so that the bow thruster could be started from the bow thruster compartment. The chief officer had by now returned to the bridge and reported that the green stairs, the access route to the bow thruster compartment, were heavily smoke-logged. At 0546, the chief engineer and chief officer collected BA sets and used these to enter the bow thruster compartment.

With all the drencher sections activated, the vessel's list increased more quickly. At 0552, the DPA noted that the list had reached 6° and the drenchers were stopped. The master commented that he was no longer willing to attempt to enter the harbour, and called QHM by telephone to discuss where he could anchor in the Solent. A few minutes later it was agreed that *Commodore Clipper* would anchor in St Helen's Road **(Figure 7)** east of the Isle of Wight.

The QHM duty officer (DQHM) had been informed about the fire and came to the harbour control office to monitor the incident. He was concerned that *Commodore Clipper*'s condition was deteriorating more quickly than had been anticipated. He called Solent Coastguard at 0600 to inform them that the master was no longer willing to enter the harbour and that the vessel was going to anchor. DQHM asked Solent Coastguard if the MIRG was standing by, and if it should be sent out to the vessel to assess the extent of the fire. Solent Coastguard agreed that they would discuss the options for deploying the MIRG with the FLM.

On board *Commodore Clipper*, the chief engineer had been unable to start the bow thrusters and had gone to check the forward mooring equipment which was powered from the same part of the electrical distribution network. No power was available to either the bow thrusters or the forward mooring equipment, so although the anchor could be let go, it could not be recovered. Consequently, the master advised QHM that he no longer wanted to go to anchor. *Commodore Clipper* was now in the vicinity of OSB, and *SD Bustler*, the duty tug, was standing by to assist if necessary.

The chief engineer returned to the bridge and discussed the situation with the master and DPA. The master called Solent Coastguard by radio, and at 0618 updated them of *Commodore Clipper*'s deteriorating condition. He asked for a *'fire advisor'* to be sent out to the vessel by helicopter as access by pilot ladder was onto the main vehicle deck, and therefore not usable due to the fire. The coastguard officer asked the master to confirm that he wanted to request a fire advisor. The master replied, *'yes, I think so'*.

1.5 INITIAL EMERGENCY RESPONSE

1.5.1 Command and control

Solent Coastguard was responsible for co-ordinating the SAR response, but command of the emergency on board *Commodore Clipper* remained with the master. While he required permission from QHM Portsmouth to enter the harbour, and permission from PIP to berth, it was for the master to request from Solent Coastguard what assistance he felt he required. The Secretary of State's Representative (SOSREP) had not yet been informed about the incident, and the statutory powers of intervention, exercised by him, had not been invoked.

Co-ordination of emergencies within the Solent and surrounding areas requires the co-operation of a number of different agencies, including the emergency services, local government and port authorities. A system known as SOLFIRE has been developed to provide an infrastructure for the command, control and communications needed to manage emergencies. In the early stages of the incident, Solent Coastguard did not consider the fire on *Commodore Clipper* to be serious enough to warrant activating SOLFIRE procedures.

Solent Coastguard had informed the HFRS control centre about the fire on board *Commodore Clipper*, and arranged for HFRS units to meet the vessel at PIP. HFRS units began to assemble at PIP from 0450, and fire officers met with CMS's operations director and technical superintendents to study the ship's plans and discuss how to attack the fire.

1.5.2 Specialist fire-fighting support

The MIRG is a partnership between the MCA and the 15 coastal fire and rescue services[4], and its function is to deal with fires, chemical release and industrial accidents at sea. The MIRG does not have authority to unilaterally deploy to vessels in distress; it is therefore necessary for the master of a vessel to specifically ask for MIRG assistance.

Solent Coastguard called the FLM at 0621, updated him on the deteriorating situation on *Commodore Clipper*, and informed him that the master had asked *'for a fire crew'.* The FLM asked to be put in communication with the master, and a radio telephone call was arranged. The master gave the FLM a summary of what had been done, but was unable to confirm if the fire was still burning. The master reported that crew could re-enter the main vehicle deck to determine the extent of the fire, and the FLM advised the master that it would take 60-90 minutes before a MIRG team could be mustered.

Both the master and FLM interpreted the subsequent discussion differently: the master relayed to the DPA that the FLM did not want to deploy the MIRG until the extent of the fire was known, and the FLM thought the opposite; that the master did not want the MIRG to deploy until the crew had determined the extent of the fire. The conversation was concluded with both men agreeing that the decision to activate the MIRG should be deferred until after the crew had re-entered the main vehicle deck to assess the fire.

Immediately after the conversation with the master, the FLM started making preparations to assemble and deploy a MIRG team in case they were required. He asked Solent Coastguard to identify the nearest helicopter that was capable of carrying six firefighters and their equipment to *Commodore Clipper*. The coastguard

[4] The following Fire and Rescue Services contribute to the MIRG: Cornwall, Guernsey, Hampshire, Jersey, Kent, East Sussex, Suffolk, Lincolnshire, Humberside, Highlands and Islands, Strathclyde, Lothian and Borders, Northumberland, North Wales, and Mid and West Wales.

helicopter stationed at Lee-on-the-Solent was not large enough to lift the team in one go, and Solent Coastguard asked the Aeronautical Rescue Co-ordination Centre (ARCC) at Kinloss to identify a more suitable helicopter. A Sea King helicopter from Royal Air Force (RAF) Wattisham, 49 minutes flying time away in Suffolk, was put on standby.

DQHM had listened to the conversation between the FLM and *Commodore Clipper*'s master and telephoned Solent Coastguard to report that he intended to declare SOLFIRE in his area of responsibility (East). SOLFIRE East, category B, was formally declared by QHM at 0635. QHM expected that personnel from the other organisations responding to the incident would automatically come to QHM's control centre as part of the SOLFIRE plans to co-ordinate activities. Solent Coastguard discussed the implications of the 'B' categorisation and checked the SOLFIRE procedures. Category B was intended for moderate scale incidents, and did not require personnel from different agencies to co-locate at the lead authority's (QHM) control centre, unless they were specifically asked. Accordingly, the coastguard, FLM and HFRS remained in their own separate locations.

1.5.3 First re-entry to the main vehicle deck

The chief officer and off-watch second officer dressed in firefighters' suits and BA, and began to re-enter[5] the main vehicle deck at about 0640. They used an access trunk on the port side of the vessel that was slightly aft of the fire. The trunk led from the upper vehicle deck all the way down to the stabiliser room and had a door and small half landing at deck 4, slightly below the level of the roofs of the freight trailers **(Figure 8)**.

Figure 8

Access platform at deck 4 above the main vehicle deck

[5] Re-enter/re-entry: used in this context to describe the activity of entering a compartment in which a fire is, or was, burning. Usually involves teams of personnel wearing BA.

Finding the stabiliser room smoke-logged, but undamaged by fire, the two officers opened the door onto the landing at deck 4 level. Supported by the second officer and connected by a life-line, the chief officer climbed onto the roof of the closest freight trailer and crawled forward. He could see about 1m through the smoke and was able to move forwards approximately 5-7m, to the end of the trailer. There was not much heat and no sign of glowing or flickering light that would indicate that there were flames nearby. Deciding not to jump onto the neighbouring trailer and get closer, the chief officer returned to the landing; he and the second officer left the main vehicle deck. At 0655 they told the chief engineer, who was waiting nearby, what they had found.

The senior officers gathered on the bridge shortly after 0700 to review the situation. Despite the chief officer not seeing any flames, there was a considerable amount of persistent smoke and he could not confirm if the fire was out, or if it was still burning. The chief and second officers started planning a second re-entry, this time from the green stairs at the forward end of the main vehicle deck on the starboard side.

1.5.4 Preparations for entering harbour

The DPA and master checked the stability calculations that were completed when *Commodore Clipper* sailed from Jersey. They satisfied themselves that the vessel had a substantial margin of stability and could tolerate some drencher water accumulating on the main vehicle deck without becoming unstable. There was no way of calculating, either on board or in CMS's office ashore, what the actual reduction to the ship's stability was, or the maximum amount of water that could be allowed to accumulate on the vehicle deck before the vessel's stability reduced to a dangerous level. CMS did not employ an emergency response service to assist with stability and damage assessments, and there was no regulatory requirement for the company to have such arrangements in place.

DQHM was growing more concerned that *Commodore Clipper* might lose all power and require a second tug to conduct a 'cold move'[6] to bring the vessel into harbour. Cold moves of warships and Royal Fleet Auxiliary vessels within the naval dockyard are commonplace. They are routinely conducted by an Admiralty pilot who controls the tugs and, under the Queen's Regulations for the Royal Navy, takes responsibility for the move from the captain of the vessel. At 0642, DQHM decided to make preparations to despatch a second tug and embark an Admiralty pilot on *Commodore Clipper*. DQHM's intention was that the pilot would: fulfil the role of forward control officer (in accordance with the SOLFIRE plan), support the master, provide assurance that the condition of the vessel would not pose undue risk to the naval dockyard and, take control of the tugs if required.

HFRS had agreed to the FLM's request to put the local MIRG team on standby, and at 0705 the FLM reported that all the arrangements were in place should the MIRG be required. Coastguard officers would normally inform the MCA's duty Counter Pollution and Salvage Officer (CPSO) about a potentially serious incident as soon as they could. They realised that they had overlooked this and briefed the duty CPSO at 0711. The duty CPSO's role was to monitor the incident in order to anticipate and react to risks of pollution, requirements for salvage assistance or other, wider support. The CPSO's role was also to brief the SOSREP, discussing if his involvement was merited, identifying if one of the MCA's specially trained Marine Casualty Officers needed to be deployed to the vessel, or if statutory intervention

[6] 'cold move' – to manoeuvre a vessel without the use of its propulsion system(s).

needed to be considered. However, the CPSO was content with the way the incident was being managed and required no further intervention at that stage, and so did not notify the SOSREP of the ongoing incident.

Commodore Clipper's master held a Pilotage Exemption Certificate (PEC) for Portsmouth harbour and he would not normally have required the assistance of either an Admiralty pilot for the transit through the naval base, or a commercial pilot to berth at PIP. The usual means of embarking a pilot (through a door in the hull plating that led onto the main vehicle deck) could not be employed because the compartment was severely smoke-logged. As an alternative, a pilot could either be hoisted on board using *Commodore Clipper*'s fast rescue boat, or winched down from a helicopter. QHM considered that the quickest option was to transfer the Admiralty pilot by coastguard helicopter; at 0718 DQHM asked Solent Coastguard if this could be arranged. The coastguard officers were in the process of handing over to the oncoming watch, but agreed to ask the helicopter crew. In the meantime, the Admiralty pilot started travelling to the coastguard helicopter base at Lee-on-the-Solent.

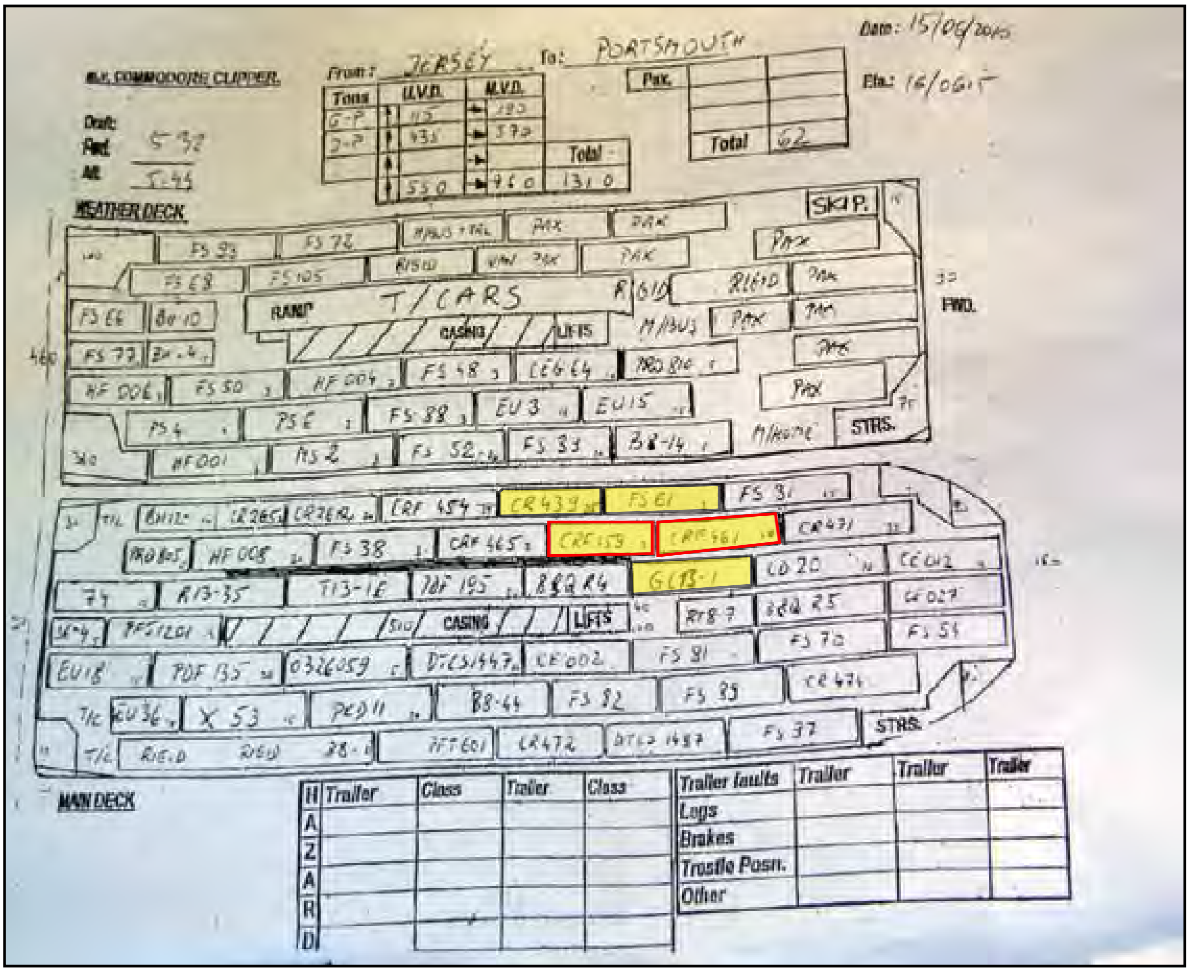
1.5.5 Second re-entry to the main vehicle deck

At around 0720, the off-watch second officer reported to *Commodore Clipper*'s master that more hot spots were developing on the upper vehicle deck at the forward end of the ramp. It was also reported that more smoke was coming into the accommodation from the green stairwell.

A 4-man team was assembled and dressed in fire-fighting suits and BA, and the second re-entry to the main vehicle deck began at 0735. The team entered from the green stairs at the forward end of the main vehicle deck, on the opposite side from the fire. Connected by life-lines, but without hoses or fire extinguishers, the team made its way through the densely packed cargo by crawling under the trailers. The team reported that they could not feel too much heat at deck level, but that visibility was limited and progress was extremely slow. Large numbers of Jersey Royal potatoes had spilled from the fire-damaged trailers; moving through this, the trailer lashing chains, and other debris from the fire was found to be very difficult.

Trailer CRF459 and the one immediately ahead in the same lane, trailer CRF461, were both seen to be on fire **(Figure 9)**. The curtain-sides on the trailers were burning, with the plastic curtain material described as dripping down, giving the appearance of lots of candle flames and leading to multiple seats of fire. The chief officer was able to lift part of the curtain on one of the trailers, and saw that the packaging materials and plastic crates containing the Jersey Royal potatoes were also on fire. There was little evidence that water from the vehicle deck drenchers had penetrated inside the trailer or of having much effect on the fires. The team withdrew and reported their findings to the master at 0755.

Figure 9



Cargo stowage diagram

1.5.6 Planned entry to Portsmouth Harbour

PIP's crisis team had been alerted about the incident at 0710, and accepting that the vessel would need to berth, began to make their preparations for supporting *Commodore Clipper* on arrival in the port. The PIP crisis team set up in the port's conference room, close to the ferry berths.

DQHM and other key QHM staff had relocated to their major operations room, anticipating that personnel from other agencies would start arriving to co-ordinate the response to the incident. At 0736, DQHM called Solent Coastguard to ask for an update and was told that the coastguard watch officer was already in conversation with QHM's port control office. DQHM asked that all communications now be directed through QHM's operations room, which should now be the command centre for the SOLFIRE response. The DAO, FLM and senior officers from HFRS had gone to Solent Coastguard's control room, and as SOLFIRE B procedures did not require them to relocate, they all remained there. CMS staff and other HFRS officers stayed in CMS's offices in PIP.

The second tug, *SD Reliable* began standing by *Commodore Clipper* at 0812. It was anticipated that once the Admiralty pilot had been winched on board by the coastguard helicopter, *Commodore Clipper* would reach OSB at between 0830 and 0845 and enter the harbour shortly thereafter.

1.5.7 Stern ramp hydraulics

The chief engineer, aware that other systems had been damaged by the fire, went to the engine room to check and test the hydraulic system that operated the stern ramp unlocking and lowering mechanism. At 0838, he reported to the master that the system could not be started. With no other way to lower the stern ramp once alongside, the chief engineer assisted by the second and third engineers, and the electrical fitter set about resolving the problem.

Suspecting that fire had damaged electrical control circuits, the chief engineer directed the team to conduct a complete check of the system. They found that, coincidental to the fire, an isolating switch that provided electrical power to the hydraulic pack had failed. The switch was replaced, but the system still would not run, so the team checked all the control circuits. Fire damage to cables connecting emergency stop buttons on the vehicle deck had caused a ‘stop’ signal to be generated, which prevented the system from running. The emergency stop circuit was isolated and the chief engineer briefly started the hydraulic pack to check it would run.

1.5.8 Helicopter transfer

The Admiralty pilot was transferred by pilot boat to Gosport and was collected by one of the coastguard officers from the off-going watch. They arrived at the Lee-on-the-Solent coastguard helicopter base to find that the helicopter crew were not expecting them and had no knowledge of the need to fly the Admiralty pilot out to *Commodore Clipper*. The coastguard officer called Solent Coastguard at 0801 to try to obtain the proper helicopter tasking instructions.

By 0815, the chief helicopter pilot was concerned that his aircraft might not have the capability to remain within the operating rules for normal passenger transfers in the prevailing wind conditions. The aircraft could achieve the task if SAR rules were applied, but coastguard officers would need to declare that transferring the Admiralty pilot was a SAR task.

A commercial pilot from PIP went out to *Commodore Clipper* by pilot boat to assist, and arrived on scene at 0825. At about the same time, DQHM and Solent Coastguard were discussing the problems of flying the Admiralty pilot in the coastguard helicopter. DQHM noted that *Commodore Clipper’*s condition was deteriorating, and that it was critical to get the Admiralty pilot on board so that the vessel could be brought alongside as soon as possible.

In order to provide a potential means of embarking the commercial pilot onto *Commodore Clipper*, the second officer began to prepare the rescue boat so that it could be lowered at short notice. The chief engineer also prepared water cooling attachments for the outboard engine so that it could be started and warmed through before being put into the sea. The plan was to lower the rescue boat so that the commercial pilot could climb onto it from the pilot boat and then be hoisted on board *Commodore Clipper*.

The helicopter was formally tasked at 0827 with instructions to fly with the Admiralty pilot to Hayling Island, embark a Coastguard Liaison Officer (CGLO) and then fly to *Commodore Clipper* and winch both the Admiralty pilot and CGLO on board. This plan should have had the Admiralty pilot on board by about 0850. The plan was relayed to *Commodore Clipper* and the master decided that it was not worth exposing the commercial pilot to the potential risk of being hoisted up in the rescue boat, particularly as QHM had said that an Admiralty, rather than a commercial, pilot was required.

At 0845, the watch manager from the oncoming shift at Solent Coastguard updated ARCC Kinloss on the latest situation. The watch had also recently changed at ARCC Kinloss and both officers agreed that, with hindsight, it would have been prudent to have repositioned the larger helicopter from RAF Wattisham (R125) to Lee-on-the-Solent and embarked the MIRG team to assess the situation. It was accepted that this window of opportunity had now closed and the priority should now be to get *Commodore Clipper* alongside without further delay.

Throughout this period, the coastguard helicopter based at Lee-on-the-Solent (R104) had been undergoing its pre-flight checks and an intermittent problem with its rotor brake had been found. At 0850, the pilot informed Solent Coastguard that the aircraft was unserviceable and that crew were trying to repair the problem. Immediately afterwards, Solent Coastguard requested ARCC Kinloss to scramble R125 from RAF Wattisham. ARCC Kinloss also offered R106, a helicopter similar to R104, based at Portland in Dorset. This offer was initially declined by Solent Coastguard as R106 did not have the capacity to lift a whole MIRG team in one go.

1.5.9 Delay

Commodore Clipper's master called Solent Coastguard at 0905 to update them on the state of the vessel and the urgent need for the Admiralty pilot to be embarked. He confirmed that the fire was contained and that even though a MIRG team was now assembling at the Lee-on-the-Solent helicopter base, their assistance was not required.

At 0916, ARCC Kinloss reported that R125 had taken off and was expected to arrive on scene at 1000. Solent Coastguard then requested that R106 be scrambled from Portland to transfer the Admiralty pilot and CGLO: this request was made some 25 minutes after R104 had been reported as being unserviceable and R106 had been offered as a replacement.

By 0930, R106 was on its way to Lee-on-the-Solent, with an estimated time of arrival of 0952. R104 was being repaired and would not be available for at least an hour. Solent Coastguard instructed the crew of R106 to embark the Admiralty pilot on *Commodore Clipper* immediately, before going to Hayling Island to collect the CGLO.

The DAO asked QHM if a MIRG team should assess the condition of *Commodore Clipper* before the vessel entered the harbour. QHM reported that the tidal stream through the entrance to Portsmouth Harbour was now building and, by 1045, would be too great for the tugs to manoeuvre an unpowered vessel through the entrance with an acceptable margin of safety. It was agreed that deploying a MIRG team at this stage would cause further delays and that securing *Commodore Clipper* alongside should remain the top priority.

1.5.10 Entry into Portsmouth Harbour

R106 landed at Lee-on-the-Solent at 0951 and collected the Admiralty pilot. He was winched onto *Commodore Clipper* at 0956. Immediately after boarding, he called QHM and was given permission for *Commodore Clipper* to enter the harbour. The helicopter departed to collect the CGLO, who was winched on board *Commodore Clipper* at 1015.

The master and Admiralty pilot agreed to secure the tug, *SD Bustler*, to the bow of *Commodore Clipper*. The line was to be kept slack, but be ready for immediate use if *Commodore Clipper* was affected by further steering control problems. *SD Reliable* was instructed to maintain station on *Commodore Clipper*'s quarter. The Admiralty pilot asked QHM to confirm with PIP where the vessel should berth.

Commodore Clipper normally used Berth 5, the most northerly of the linkspan berths available at PIP **(Figure 10)**. While adequate for normal service, this berth was regarded as being the most challenging to use, and PIP offered Berth 4 as an alternative. The master had assessed that Berth 2 was the easiest for him to use; it allowed him to take advantage of the relatively sheltered basin to turn the vessel through 180^{o} and provided enough space for the tugs to be able to work effectively.

Reproduced from Admiralty Chart BA 2631 by permission of the Controller of HMSO and the UK Hydrographic Office

Figure 10

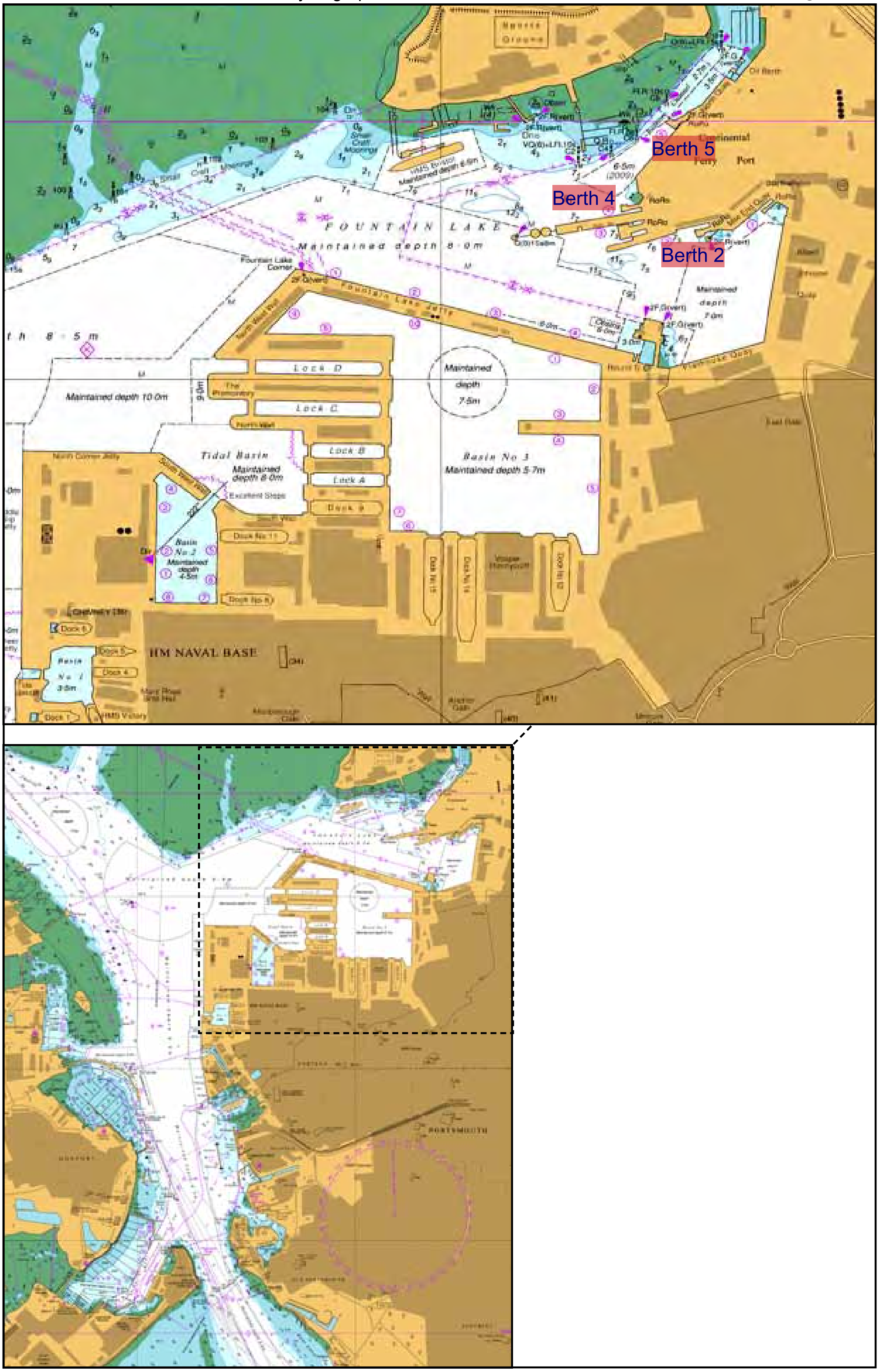


Chart with inset showing the berths available at PIP

The master conned *Commodore Clipper* throughout the transit of Portsmouth harbour. Discussion about which berth should be used continued between Solent Coastguard, QHM and PIP. It was agreed that Berth 2 could be used, but QHM was concerned that the vessel could be unstable and that the 180° turn might lead to a risk of capsize. Consequently, it was recommended that *Commodore Clipper* berth bow onto the linkspan (ship's head east). As the vessel only had a stern ramp and would not have been able to disembark the passengers or cargo, the master, supported by CMS managers and DPA, elected to turn her and berth stern to (ship's head west).

The master commenced the turn at 1037 and *Commodore Clipper* was secured alongside at 1055. Units from HFRS had been told to expect the vessel to use either Berths 4 or 5 and they hurried to relocate to Berth 2.

1.6 EMERGENCY RESPONSE ONCE *COMMODORE CLIPPER* WAS ALONGSIDE

1.6.1 Pedestrian access

The design of *Commodore Clipper* meant that the only access route from the vessel to shore was via the main vehicle deck (deck 3) and through the stern door. In normal service this worked well; the majority of passengers drove their vehicles on board, and any foot passengers were brought on by minibus. The relatively few foot passengers that were carried, and the significant challenges presented by the large tidal ranges in the Channel Island ports, meant that a separate pedestrian access was not required and would have been difficult to arrange. There was no regulation that required the vessel to have a protected route to a position on board where a second access point or gangway could be rigged.

CMS and PIP staff had identified that it would not be possible to gain access to the vessel over the stern ramp, and agreed to use a gangway that had been constructed to serve visiting cruise ships. The gangway was lifted by crane and rested on guardrails on the upper vehicle deck (deck 5). HFRS officers, CMS staff and the PIP harbourmaster were able to board *Commodore Clipper* at about 1130.

The gangway arrangement was not considered satisfactory for further use and permission was given for PIP staff to cut away the ship's guardrail so that the upper end of the gangway could be rested on the deck. The gangway and temporary guardrails were secured at 1145. MAIB inspectors boarded the vessel at 1200 and found that while the gangway itself was adequate, the high density of freight vehicles on the upper vehicle deck made it difficult not only to get off the gangway, but also to move across the deck in order to access the accommodation.

1.6.2 Passenger evacuation

The passengers had all been mustered again in preparation for entering Portsmouth harbour. Some discomfort from smoke was reported, but all the domestic and galley services remained available and passengers were provided with food and refreshments.

CMS, PIP, HFRS and Solent Coastguard all recognised that it would be prudent to disembark the passengers as soon as possible, particularly as the rising tide meant that the gangway would soon become too steep to use. Members of the emergency services and marine personnel who had boarded the vessel had done so without sustaining any injuries, but found moving across the upper vehicle deck difficult. The distances between freight vehicles were, in places, as little as 150mm, and at best 450mm. In many cases it was not possible to walk between vehicles and the only route was to crawl under trailers where they were supported by trestles. Freight vehicles were lashed to the deck with chains, causing trip hazards. Obstructions from ship's fittings, cargo and trailers presented many additional hazards and a high degree of awareness was required to avoid injury when moving across the deck.

MAIB inspectors later found a route through the trailers on the upper vehicle deck that could have been more acceptable for able-bodied passengers to use if they were carefully supervised and escorted. A slightly wider gap existed between the trailers and the centre-line casing. It might have been possible to have followed this gap aft, then cross the mooring deck to the starboard side of the vessel and walk forward to the gangway position.

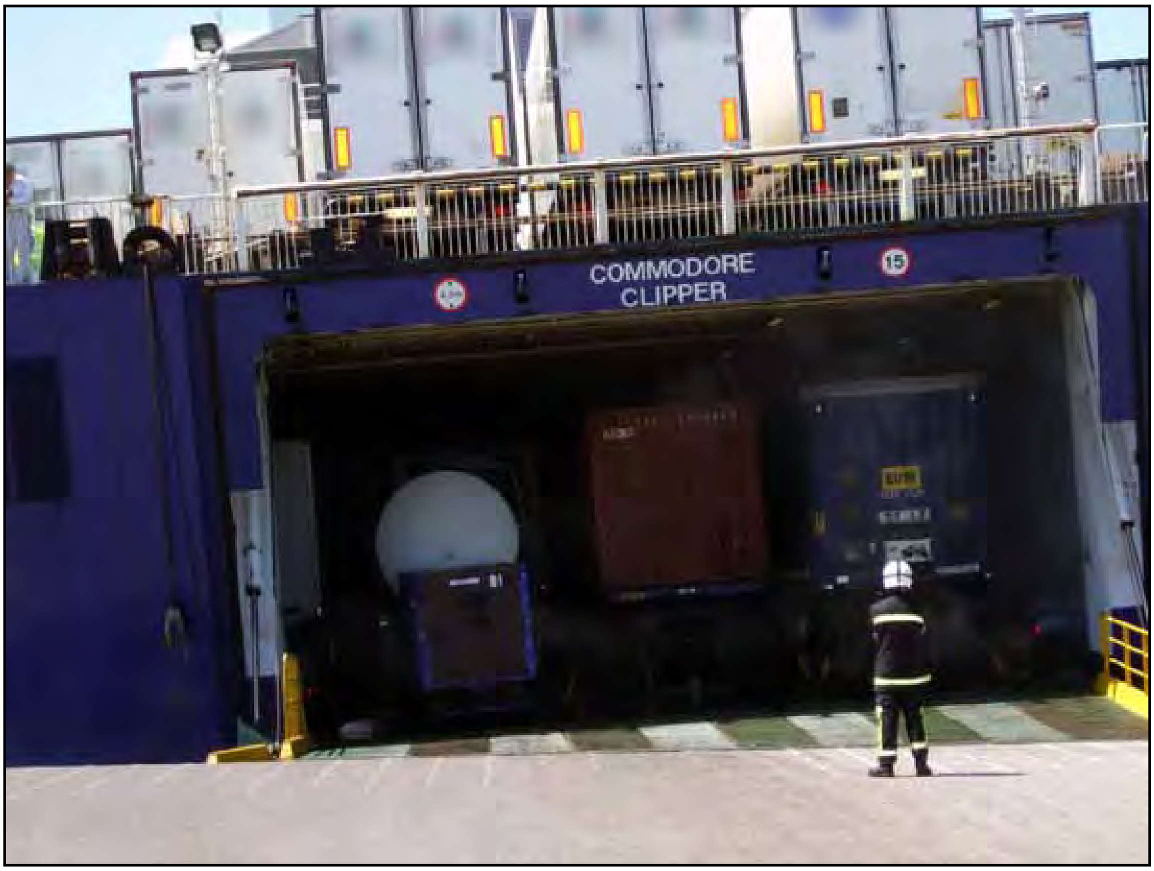
Both the lifeboat and the Marine Evacuation System on the port (outboard) side were available for use if the situation deteriorated suddenly. There is a risk of personal injury when using these emergency systems on any vessel, and it was agreed between CMS senior staff, the PIP harbourmaster, HFRS officers and the CGLO on *Commodore Clipper* that the passengers would be at least risk if they remained on board until the fire was confirmed as having been extinguished, and then disembarked once there was a clear route to walk through the main vehicle deck.

1.6.3 Assessment

HFRS officers concluded that the best means of attacking the fire was to open the stern ramp and allow the smoke to clear before firefighters entered the compartment. The possibility of the fire developing due to the increased ventilation was acknowledged, and hoses were set up at the stern to provide a water curtain to contain the fire. HFRS managers recognised that it would take a significant amount of time and resources to deal with the incident. They called for a mobile command centre, BA servicing workshop and catering unit to come to PIP to support the fire-fighting effort. At 1219, the CGLO informed Solent Coastguard that HFRS believed that it would be a protracted incident.

Commodore Clipper's stern ramp was opened, using controls on the upper vehicle deck, by about 1m shortly after 1230 and then slowly opened to its full extent over the next few minutes **(Figure 11)**. There did not appear to be significant amounts of smoke in the main vehicle deck and no flames could be seen from the linkspan. It was agreed that as much cargo as possible should be removed from the main vehicle deck to improve access to where the fire had started.

Figure 11



View of the main vehicle deck after the stern ramp was opened

As the stern ramp opened, it was noted that it did not make contact with the linkspan over the full area that was needed to spread the load properly. The PIP harbourmaster was concerned that the stern ramp and linkspan might be damaged, or worse, that in this state the structures might not withstand the load from the vehicles as cargo was discharged. At about 1300, the stern ramp was lifted, the gangway removed and *Commodore Clipper* moved astern. The vessel was re-positioned, the stern door re-opened, and from 1315 onwards it was possible for some trade cars and a trailer containing hand baggage to disembark.

The level of smoke in the after part of the main vehicle deck was tolerable initially and crew were able to begin unlashing the freight trailers nearest the stern. The CCTV system in PIP recorded the first three road freight trailers being removed from 1320 to 1325. The amount of smoke increased significantly as personnel moved further into the main vehicle deck and operations to remove freight were stopped.

1.7 FIRE-FIGHTING TACTICS

1.7.1 Visibility

Firefighters rigged hoses and led them into the main vehicle deck towards the forward end of the ship. Visibility was severely reduced as smoke levels increased closer to the seat of the fire. This, combined with the difficulty of moving between trailers and the build up of debris on the deck from spilled cargo, made it extremely slow and hazardous for the firefighters to get close to the fire.

The vehicle deck drenching system was very effective at reducing the levels of smoke, but reduced visibility further while it was operating. It was found that drenching for about 20 minutes and then turning the drenching system off, gave a period of about 15 minutes of improved visibility before the smoke built up again. This tactic was used many times during the next few hours, and each time the firefighters withdrew from the vehicle deck before the drenchers were started. This was reported to Solent Coastguard, but the withdrawal of firefighters was interpreted as being due to them having been beaten back by the fire, rather than as part of a planned strategy.

Fire damage to power cables and ventilation fans in the main vehicle deck prevented any of the vessel’s ventilation systems from being used to clear the smoke. The access doors to the green stairs on the upper vehicle deck were opened and an off-duty chief engineer from CMS, who had come to help his colleagues, donned a BA set and went down the green stairs and opened up the door onto the main vehicle deck. The wind was blowing from the stern, and started to force smoke up the green stairs and into the upper vehicle deck. The forward, semi-enclosed, part of the upper vehicle deck became smoke-logged, but visibility in the main vehicle deck began to improve.

1.7.2 Escalation

Opening up the stern door and the green stairs allowed more air to get to the fire and it started to burn more intensely. During the period from 1330 to 1430, the temperature of the upper vehicle deck gradually increased and more smoke was produced. The vehicle deck drenching system was turned on again, and to prevent any further stability problems, *Commodore Clipper* was trimmed by the stern so that all the drencher water could flow out of the open stern door. Some water had accumulated on one side of the main vehicle deck and from about 1400 to 1415, and again from 1445 to 1500, the heeling system was operated to make the vessel list from side to side to help drain the remaining water. Booms were rigged around the vessel to contain the small amount of oil residues that drained overboard. The combined effect of using the heeling system in this way and seeing water flowing about inside the main vehicle deck gave the appearance of the vessel being unstable and potentially in a state of loll.

MCA Coastguard and surveying staff were observing the vessel from the linkspan. They had not been briefed on the fire-fighting tactics, the use of the drenchers, or heeling system and they became increasingly concerned about the stability of the vessel and safety of the passengers. *Commodore Clipper* had moved about 2m astern to make proper contact with the linkspan, but buildings on the berth now obstructed the cruise passenger gangway and prevented it from being put back in position. Substantial fittings on the upper vehicle deck of the vessel would have had to be cut away in order to re-position the gangway; as it had been decided not to disembark the passengers immediately, it was not replaced. HFRS had rigged a ladder further aft from the gangway position, and at 1500 an Aerial Ladder Platform (ALP) was set up on the linkspan to lift personnel and equipment on and off the stern of the vessel.

At 1510, MCA representatives requested CMS staff to arrange for the passengers to be disembarked using the life saving apparatus. This was declined. Solent Coastguard telephoned QHM at 1515 with a similar request. The content of the call was logged, and it was noted that senior MCA staff were keen for QHM to put pressure on CMS to disembark the passengers. QHM relayed the content of the message to the PIP crisis team.

Smoke from the main vehicle deck had also penetrated the blue stairwell, which led up from the centreline casing on the main vehicle deck to the accommodation. Making a re-entry onto the main vehicle deck from this position had several advantages: the entry point was closer to the fire; and, firefighters could follow the centreline casing, which not only gave them a well-defined route, but also shielded them from the fire. HFRS firefighters could only make a re-entry from this position if the smoke could be cleared, and the off-duty chief engineer increased the speed of the engine room ventilation fans and held open the doors from the engine room into the blue stairwell to allow the excess air to escape and force the smoke out. This method had been successfully developed during an earlier training exercise conducted with HFRS.

With the smoke removed, firefighters were able to make re-entries onto the main vehicle deck from the blue stairwell. Debris from fire-damaged trailers was moved to improve access, but several new fires developed as partially combusted material was exposed to the air. It was observed that the main seat of the fire had spread to two more trailers, CR439 and FS61 in lane 1 on the port side of the main vehicle deck **(Figure 9)**. The fire had spread to trailers GC13-1 and FS61, as burning cargo fell from the neighbouring trailers. A partially burnt potato crate was found stuck to the side of trailer FS61 **(Figure 12)**. The construction of the trailers and their proximity to one another prevented the firefighters from being able to reach all the fires that were burning inside and around the trailers.

HFRS used the ALP to load more equipment and firefighters onto the vessel. The fire was attacked from both the stern and the blue stairwell until shortly after 1600, when visibility became unacceptably low and the drenchers were restarted.

Figure 12

Partially burnt debris on trailer FS61

1.7.3 Cargo handling

When the fire was first tackled via the stern door it had been possible for crew to unlash the trailers near the stern without any need for them to wear BA. Similarly, the smoke levels were low enough for the stevedores to operate the trailer-handling tractors (known generically as tugmasters) in the normal way.

By 1630, the drenchers had damped down the fires and visibility had improved. The main vehicle deck was still smoke-logged further forward, and it was no longer possible to unlash and remove the cargo without wearing BA. HFRS officers were uneasy with the principle of allowing the crew to enter the main vehicle deck while the fire was burning. However, they recognised that the crew were needed to unlash the trailers and that the crew all had basic fire-fighting training and were competent to work in BA. *Commodore Clipper* had only 26 cylinders for the BA sets on board, these were soon used up and the vessel had no means to recharge them. The vessel's BA sets were compatible with those used by HFRS, and it was agreed that crew could borrow charged cylinders from HFRS to fit to their BA sets and work in partnership with the firefighters to progress the removal of the cargo.

The stevedores had no experience of working in smoke-filled environments or wearing BA, and were not able to get far enough into the main vehicle deck to reach the remaining cargo. The fire had, by now, been burning for about 14 hours and CMS's operations director was increasingly concerned that the tyres on the trailers could have been damaged, resulting in the trailers becoming unstable and causing the supporting trestles to collapse. CMS began making arrangements to contract a heavy vehicle recovery company to bring equipment that could be set up on the linkspan and then be connected to each trailer in turn to drag them out of the vessel.

The fire was still contained by the combination of the drenchers and attacks from the firefighters, but it could not be completely extinguished without removing the trailers from the vehicle deck. HFRS officers considered using a firefighter with a heavy goods vehicle licence to operate a tugmaster. However, tugmasters are highly specialised vehicles, with rotating driving positions to operate in the reverse mode, and it was considered unlikely that anyone without prior experience would be able to operate one satisfactorily.

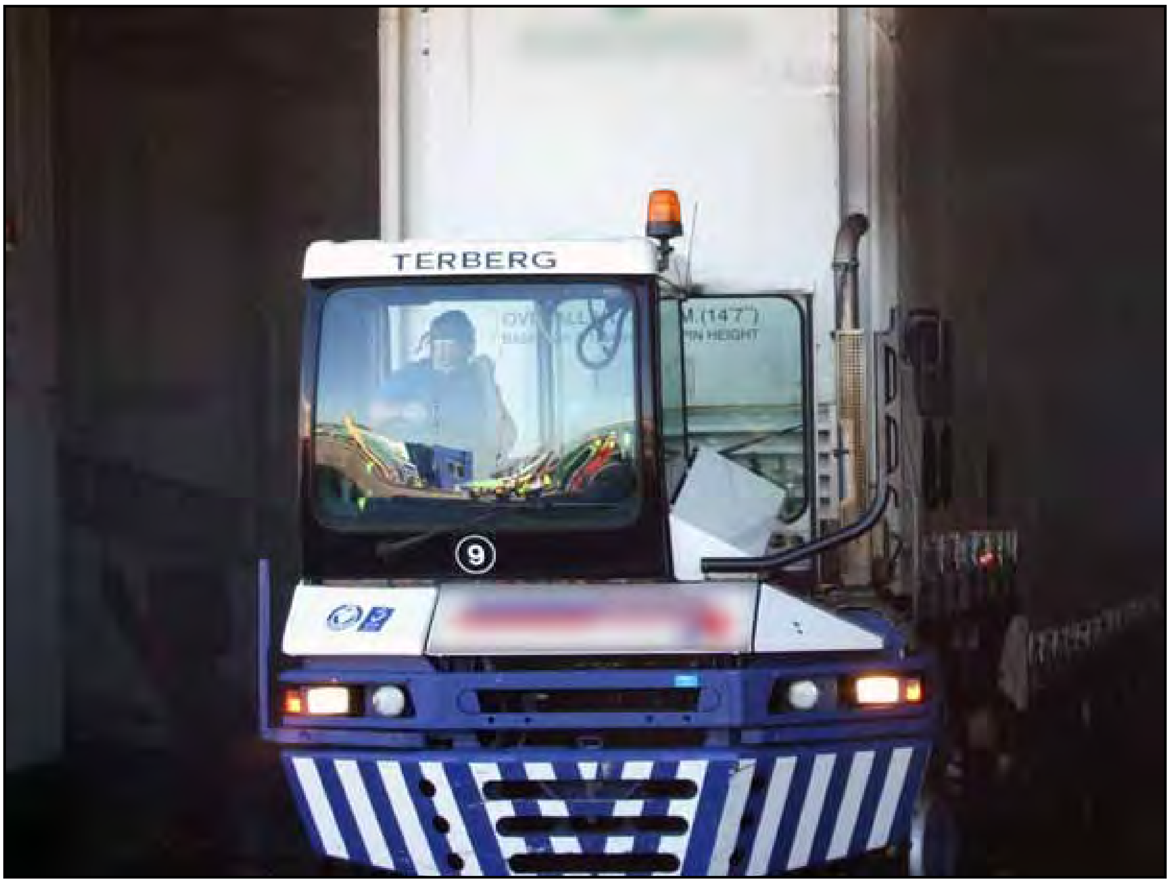
One of the stevedores had previously tried scuba diving while on holiday, and at about 1700 he volunteered to put on BA and continue using his tugmaster to remove the cargo **(Figure 13)**. HFRS officers were extremely concerned about him working in this way, but progress in fighting the fire was limited.

Firefighters gave the stevedore basic training in how to wear BA, and several firefighters were positioned to monitor his safety and assist him if required. Crew entered the vehicle deck using BA and, with firefighters containing the fire, started to unlash the trailers. Once the trailers were unlashed and any refrigerated units unplugged from the electrical sockets, crew cleared the area and the stevedore drove the tugmaster into the main vehicle deck.

Visibility from the cab of the tugmaster was poor, and reduced to zero in the thickest smoke. Due to the limited space in the cab, the BA set had to be put to one side rather than worn conventionally, and the length of the hose between the cylinder and the facemask further limited the stevedore's movement. The stevedore used his knowledge of the vessel and the motion of the tugmaster as the tyres bumped over the lashing securing points in the deck to manoeuvre into the correct position and attach to each trailer.

The stevedore reported that he removed 11 trailers in this manner and used 7 BA cylinders. Each trailer took between 10 and 15 minutes to remove, compared with about 5-6 minutes in normal circumstances.

Figure 13



Stevedore wearing breathing apparatus in order to remove trailers from the smoke-filled vehicle deck

1.7.4 Statutory powers of intervention

At 1710, the DAO briefed the MCA's Duty Operations Director (DOD) on progress with fighting the fire, and informed him that the passengers were still on board. MCA staff had formed the view that *Commodore Clipper* was potentially unstable and that HFRS were having little success in fighting the fire. They considered that the reason for keeping the passengers on board might be due to CMS wanting to avoid unfavourable media coverage of passengers being evacuated from *Commodore Clipper* in a lifeboat.

The DOD directed that the DAO and CPSO should review how the powers of intervention exercised by the SOSREP under the Marine Safety Act[7] might be applied to influence how the incident was being managed. From 1730 onwards, the CPSO and Duty SOSREP started considering how powers of intervention under the Marine Safety Act might be used to compel CMS and HFRS to evacuate the passengers from *Commodore Clipper*. At the same time, the DAO began preparing plans with Solent Coastguard to use helicopters R104 and R106 to winch passengers off the vessel.

By 1800, the CPSO and duty SOSREP had concluded that powers of intervention should not be used as HFRS was now the lead agency for dealing with the emergency and would not intentionally allow the passengers to be left on board at greater risk. The DOD telephoned Solent Coastguard to have his dissatisfaction and objections to the delay in evacuating the passengers recorded.

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[7] Marine Safety Act 2003, Chapter 16, Schedule 1, 'New Schedule 3A to the Merchant Shipping Act 1995 – Safety Directions'

At 1810, the CPSO relayed his conclusions to the CGLO on board *Commodore Clipper*, noting that the incident was under the control of HFRS, the master of the vessel and QHM, all of whom were reported to be satisfied that the passengers were safe. The role of PIP was not acknowledged. The CPSO also discussed the situation with CMS's Operations Director, who explained the fire-fighting strategy and the consideration given to the balance of risk of evacuating the passengers against leaving them on board. The log kept by staff in CMS's office recorded the Operations Director's view at 1839, that the CPSO was content with the current plan.

The duty SOSREP contacted the SOSREP to advise that the DOD had requested the use of statutory powers of intervention to be considered in order to compel the passengers to be evacuated, but that the CPSO considered that the passengers were safe and would be put at greater risk if they were evacuated by emergency means. The SOSREP asked the duty SOSREP to confirm this with the port authorities and arranged for one of his independent technical advisors to assess the situation. At 1915, the SOSREP telephoned the DOD directly to update him and discuss the situation further.

1.8 FIRE EXTINCTION AND PASSENGER DISEMBARKATION

1.8.1 Access to the seat of the fire

Cargo removal continued and the first burning trailer, CRF459, was removed from *Commodore Clipper* at 1855, 10 hours after the vessel had moored alongside. Cargo was still alight inside the trailer and firefighters continued to douse the flames for another 10 minutes after the trailer had been removed from the vehicle deck. HFRS began a planned watch changeover at 1900, fire-fighting and cargo removal continued while personnel conducted their handovers. Fire-damaged trailers CR439 and FS61 were removed at 1910 and 1927 respectively.

As more trailers and debris were removed, additional fires started and two teams, each comprising four firefighters, continued working on the main vehicle deck. A system of communication had been set up to warn the firefighters when the tugmaster was moving in the vehicle deck, so that they could keep well clear. However, at about 1930, two firefighters were following a hose towards the fire, when they saw the tugmaster operating. They retraced their steps and waited until they saw no more movement. As they followed the hose back towards the fire, they heard rushing water and found that the hose had been cut by the movement of the tugmaster and trailer. While they were trying to pass a message for the water to be shut off, they saw the lights of the tugmaster returning and had to move quickly under neighbouring trailers to avoid collision. The near-miss was reported and cargo removal and fire-fighting was then suspended while the remaining handovers were completed and the oncoming incident commander made a full assessment of the situation.

1.8.2 MCA response

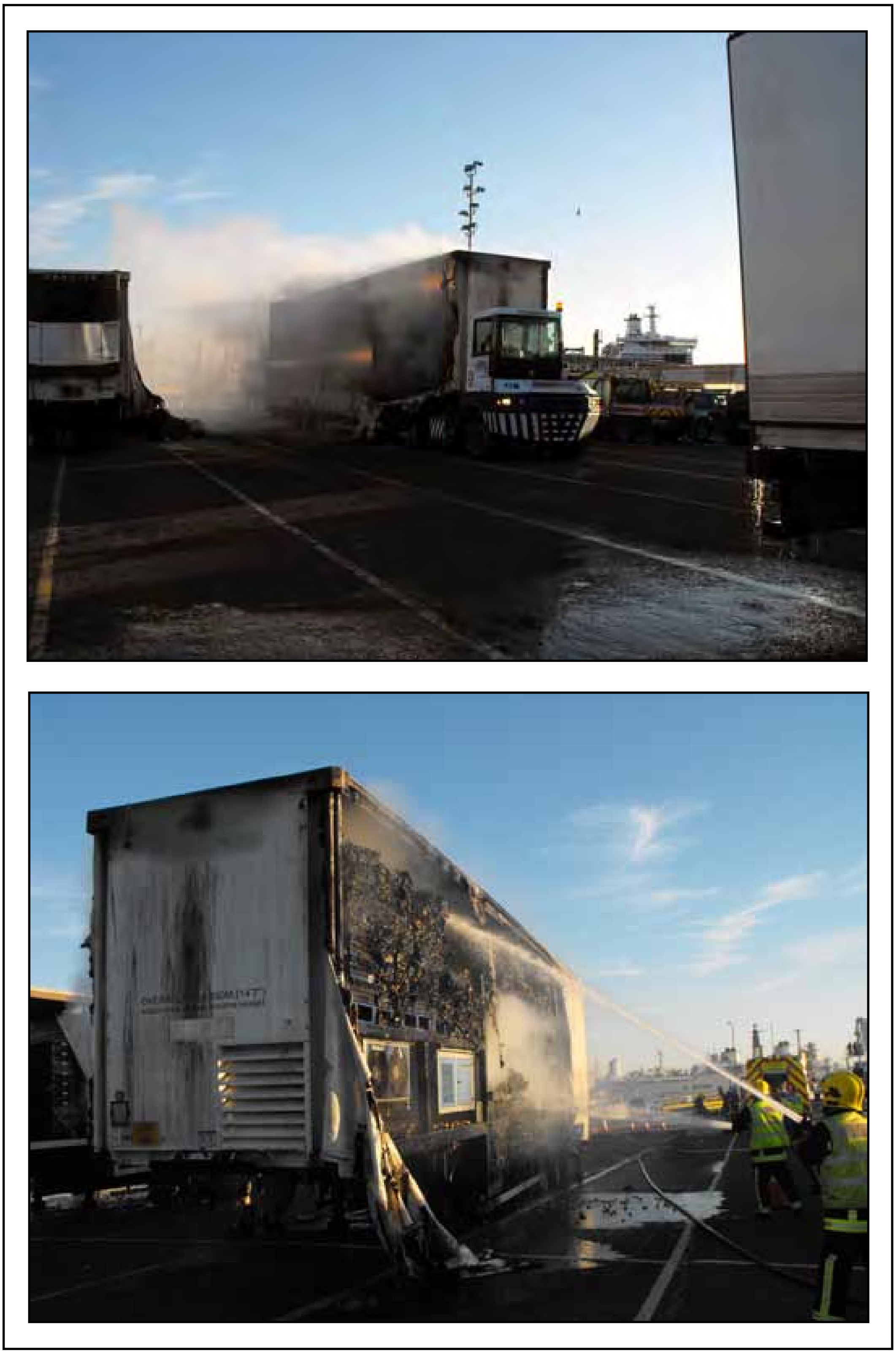
The MCA surveyor stationed on the linkspan issued a prohibition notice to the CMS's Operations Director at 1945, requiring that '*all operational activities (excluding those necessary for the immediate safety of the ship, safety of life, or the prevention of pollution of navigable waters)'* ceased immediately.

By 2015 the SOSREP's independent advisor had reported back to the CPSO, stating that he was satisfied that *Commodore Clipper* was in no immediate danger from loss of stability and that the fire was being tackled appropriately.

1.8.3 Removal of the last burning trailers

Trailer CRF461 was removed at 2015, still burning strongly **(Figure 14)**. It was brought up the linkspan and parked, where the fire was extinguished. The last trailer affected by fire, GC13-1, was removed at about 2100.

Figure 14



Trailer CRF461 continuing to burn after being removed from the main vehicle deck

From 2100 to 2130 firefighters extinguished the last remaining fires in the main vehicle deck. Paramedics boarded *Commodore Clipper* via the main vehicle deck at about 2125, to treat one passenger who was suffering from the effects of a pre-existing medical condition. Debris was removed from a route that had been cleared down the starboard side of the main vehicle deck and passengers were assisted off the vessel and onto a waiting coach at 2155. All the passengers had left *Commodore Clipper* by 2230, nearly 20 hours after the first indications of the fire starting.

1.9 KEY PERSONNEL

1.9.1 Crew

The master of *Commodore Clipper* was aged 52, had spent his whole career at sea and the last 25 years working on ferries. He had spent 17 years on the Portsmouth - Channel Island routes, the last 8 of which he had served as master with an unlimited master's certificate of competency (STCW[8] II/2). He started working on *Commodore Clipper* in April 2010, having transferred from another vessel operated by CMS. This was a routine practice in the company to bring a fresh perspective, both to senior officers' working practices and the operation of the vessels. Like most of the other officers, the master worked a cycle of 2 weeks work and 2 weeks leave. He had also been through a programme of understudy and handover with the existing master of *Commodore Clipper* before taking command himself. The master had previously spent several years working as the chief officer on *Commodore Clipper* when the vessel was first built, and was very familiar with its layout and operation.

The chief engineer was aged 53 and had a varied career at sea and ashore before joining CMS in 1988. He held an unlimited (steam and motor) STCW III/2 certificate of competency and had worked on many of the different vessels in CMS's fleet and also ashore as a superintendent for the company. He returned to sea to become the chief engineer of *Commodore Clipper* when it was first built, and had worked on board the vessel ever since.

The chief officer was aged 39, held an unlimited master's certificate of competency (STCW II/2) and normally worked for another company as a master on its ro-ro vessels. He had provided short-term seasonal cover for CMS during his normal leave periods several times over the last 2 years. On this occasion, he joined the vessel the day before the accident. He had previously completed CMS's induction and familiarisation training on *Commodore Clipper*.

The second officer who was on watch at the time of the accident was aged 25, and kept watches from 0230-1030 and 1830-2230. He completed his cadetship in 2006, held an STCW II/1 certificate of competency and had since worked as a third officer on a bulk carrier and several container ships. He joined CMS on 26 May 2010, and before starting his duties had spent 3 days on board completing familiarisation training and understudying a more experienced second officer. He was due to leave *Commodore Clipper* on the day of the accident to begin 2 weeks leave.

The third engineer was also new to the rank, having previously worked for 25 years at sea as a fitter. He had worked on board *Commodore Clipper* for 3½ years as a fitter, and had very recently been promoted after gaining an STCW III/1 certificate that enabled him to work as an officer in charge of an engineering watch. He worked a different pattern of 12 weeks on board followed by 6 weeks leave, and worked from midnight to 0500 and 1200 to 1900.

All the officers held the appropriate endorsements from the Bahamas Maritime Authority (BMA). The master, chief engineer and chief officer all held additional qualifications in advanced fire-fighting. The regular trading pattern and work schedules for all the key crew members involved in the accident provided them with adequate rest periods.

[8] International Convention on Standards of Training, Certification and Watchkeeping for Seafarers, known by the short title 'STCW'

1.9.2 Company staff

The DPA had worked as a master on CMS vessels for many years before moving ashore. He maintained his master's qualification and pilotage exemption certificates, not only as a means of assessing the performance of staff, but also to provide emergency cover in the event of sickness or other staff absence.

The operations director was also a master mariner, with experience on a variety of vessel types. He also maintained his qualifications and sailed on company vessels regularly to assess the effectiveness of operations and crew performance.

1.9.3 Training

CMS took a very proactive approach to training, and had conducted a number of major evacuation exercises with the emergency services over previous years. These exercises had included the deployment of MIRG teams by helicopter to vessels operated by CMS. Senior CMS staff had built up a good relationship with a number of fire officers in the course of these exercises, and this was reported by both CMS and HFRS to be beneficial during the incident.

Crew familiarisation, as required by the International Safety Management (ISM) Code[9], followed a detailed syllabus that included the response to vessel emergencies. The second officer who was on watch when the fire started had recently completed this training and had successfully passed the compulsory oral examination with the master.

Records of the emergency drills conducted on *Commodore Clipper* showed that the response to vehicle deck fires had been practised most recently on 21 February and 3 May 2010. In the short period that the second officer had been on board, three fire drills had been conducted: in the galley, bow-thruster compartment and forecastle store. It was reported that fire drills were normally initiated by the master telling one of the duty officers that a fire had been discovered in a certain location. While the fire detection system was included in the familiarisation training system syllabus, it was not normally used in drills and would usually only be activated when it was being tested.

1.10 DAMAGE TO STRUCTURE AND SYSTEMS

The damage recorded by the classification society's survey after the fire, is summarised below. The complete report is reproduced at **Annex A**.

1.10.1 Structural damage

The main vehicle deck of *Commodore Clipper* was defined as a special category space in accordance with SOLAS[10] Chapter II-2, Regulation 3.46. The following structural damage was recorded:

- The upper vehicle deck (deck 5) deck plating was found buckled, from frame 74 to frame 86, on the port side, outboard from the internal ramp.
- The supporting structure for the upper vehicle deck (deck 5) (i.e the main vehicle deck-head) was damaged on the port side, outboard from the internal ramp with:
  - multiple longitudinal stiffeners buckled between frames 71 and 89;
  - the web and lower flange of frame 77 buckled.

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[9] International Safety Management Code (ISM) Code, Resolution A.741(18) as amended

[10] International Convention for the Safety of Life at Sea (SOLAS) consolidated edition 2009

The deck boundary between the main and upper vehicle decks was steel and was to ‘A0’ standard in accordance with the provisions of SOLAS Chapter II-2 Regulation 20.5. Consequently, it had no thermal insulation properties.

1.10.2 Steering gear

The port and starboard rudders were separately driven by their own rotary vane type hydraulic units. The power pack for each rotary vane unit was fitted with two pumps, each fitted with its own solenoid valves, which could be operated locally, to control movement of the rudder.

Separate steering control cables were run through the port and starboard sides of the main vehicle deck, mounted in cable trays in the deck-head structure. The steering system on the bridge consisted of a wheel that controlled both rudders, and two separate joystick tillers that provided secondary, independent, control of each rudder. The rudders could also be controlled locally from the steering gear compartment. All four steering pumps could be started and stopped either from the bridge or from the steering gear compartment.

Defects were found that affected all four steering pumps and both control systems due to damage to the 48 core steering control cable that was routed through the deck-head on the port side of the main vehicle deck. In common with the other cables passing through the main vehicle deck, it had the appropriate fire retardant properties that were required by the classification society’s rules. The cables were not required to have any other protection from fire.

The following power and control faults were found on the port steering gear:

- No.1 pump forced the rudder hard to starboard, when operating in remote control.
- No.2 pump automatically started and could not be stopped by the control system. The pump was unable to provide any directional control of the rudder, either in remote or local modes.

Power and control faults found on the starboard steering gear:

- No.3 pump was ‘hunting’ (oscillating either side of the desired position) when in the remote control mode.
- No.4 pump automatically started and could not be stopped by the control system. The pump was unable to provide any directional control of the rudder, either in remote or local modes.

1.10.3 Fire detection system

In addition to the smoke detection sensors immediately above the fire being damaged by heat and flame, damage to cables that were routed through the main vehicle deck made the following loops of the fire detection system inoperative:

- Main vehicle deck (deck 3)
- Steering gear compartment
- Engine control room
- Bow thruster compartment.

Line isolators, that were intended to protect the rest of the system if one part was damaged, were found to have been incorrectly fitted. The fire detection system cables in the main vehicle deck were installed close to main power cables and, as the insulation degraded in the fire, the system was exposed to high voltages. With no protection from the line isolators, high voltages passed through the system and burnt out a section of the motherboard in the control unit on the bridge.

1.10.4 Electrical distribution systems

The main electrical power distribution cable tray running through the deck-head structure on the port side of the main vehicle deck was damaged between frames 74 and 77. This led to the following disruption to electrical systems:

- Both power supplies to the forward switchboard damaged and inoperable.
- Power supplies to both forward and after bow thrusters damaged and inoperable.
- Power supplies to the anchoring and mooring equipment damaged and inoperable.
- The internal ramp (main vehicle deck to upper vehicle deck), control and indication circuits damaged and inoperable.
- Power supplies to both navigation stern lamps and the control circuits indicating lamp failure were damaged and inoperable.
- Power supplies and control circuits to main vehicle deck ventilation fans damaged and inoperable.
- CCTV, public address system and lighting circuits damaged and inoperable.
- In addition, a number of distribution boxes and sockets providing power to refrigerated trailers on the main vehicle deck were damaged by water used in the fire-fighting operation.

1.10.5 Fire-fighting and water spraying systems

Commodore Clipper was fitted with an approved, manually operated, fixed pressure water spraying system in the main vehicle deck as required by SOLAS Chapter II-2, Regulation 20.6 and Resolution A.123(V) **(Annex B)**. The system was divided into longitudinal and lateral sections, each covering a discrete area of the main vehicle deck, and water was provided from a 360m^3/hour capacity pump. The system could be operated remotely from the bridge, or locally from the '*drenching room*' just off the blue stairs on deck 4. The chief engineer was aware that the valves needed to be opened in the correct sequence to ensure that the pump primed correctly and did not trip. He controlled the operation of the system throughout the incident.

The intensity of the fire caused the firemain distribution pipework running through the main vehicle deck-head to buckle between frames 74 and 77. The distribution pipework for the water spraying system was also found to be buckled in the same location. The water spraying system was tested after the fire, before repairs were started, and was found to work satisfactorily, with water coming from all the drencher heads and no leaks in the damaged area being evident. It was confirmed that routine tests of the system were done with the drencher heads removed to ensure that debris was flushed through and not left to accumulate and cause blockages.

1.10.6 Ro-ro hydraulic systems

A number of hydraulic pipes were routed through the deck-head structure of the main vehicle deck. Pipes and coupling seals immediately above the fire were found to have been affected by high temperatures, but the pipework had remained intact.

1.11 STABILITY

1.11.1 Approved stability book

Commodore Clipper's stability book was approved by Det Norske Veritas (DNV) on 20 December 1999, and included the following warning regarding the drainage of vehicle decks:

> *The Master's attention is drawn to dangers of flooding. The Master must be aware of the adverse effect that water trapped on the Vehicle Decks has on stability, for example when the drenching system is in operation. Therefore, it must be ensured that the drainage deck drains on the Vehicle Decks are always clear of obstructions, rubbish, etc, and free at all times for operation.* [sic]

1.11.2 Damage stability information

An assessment simulating the vessel's ability to retain an adequate margin of stability with specified types of damage to the hull was approved by DNV as complying with the requirements of IMO Resolution A.265(VIII)[11]. These requirements stipulated that maximum permissible vertical centre of gravity (VCG) data should be available to the vessel's master, along with "*all other data and aids which might be necessary to maintain the required stability after damage*". This data was incorporated into the stability book in tables and diagrams that illustrated the combined maximum VCG values for both intact and damaged hull scenarios. Crew could check that they complied with the stability requirements by calculating the VCG for the vessel's condition and making sure that it did not exceed the maximum VCG values stated in the stability book. This facility meant that *Commodore Clipper* did not need to have a specific damage control manual.

The stability book stated that the maximum VCG values had been derived from the most pessimistic damage cases. It did not describe the assumptions that these cases had been based on. Consequently, it was not clear if the maximum VCG values included the effect of accumulated water from fire-fighting attempts being entrained on the main vehicle deck. The stability book outlined details of the requirement to be able to survive an accumulation of water in the damaged part of a passenger ro-ro space that was agreed at the 1995 SOLAS Conference[12]. However, this requirement was dependent on the size of a vessel's residual freeboard after damage had occurred. In *Commodore Clipper*'s case, the residual freeboard in the specified damage scenario was greater than the limiting value of 2m. Therefore, there was no need for the vessel to be able to withstand any accumulation of water on the main vehicle deck. This was not explained in the stability book, beyond the general warning that drew the master's attention to the dangers of flooding (reproduced in paragraph 1.11.1).

[11] Adopted on 20 November 1973, Agenda item 10, Regulation of Subdivision and Stability of Passenger Ships as an Equivalent to Part B of Chapter II of the International Convention for the Safety of Life at Sea, 1960 (1960 SOLAS Conference Recommend 6, SOLAS Ch II-1 Part B)

[12] SOLAS/CONF.3 - Resolutions of the Conference of Contracting Governments to the International Convention for the Safety of Life at Sea, 1974 - (November 1995) - Resolution 14 - Regional agreements on specific stability requirements for ro-ro passenger ships - (Adopted on 29 November 1995)

1.11.3 Approved onboard loading computer

The vessel had a stability and longitudinal strength software program, known by the proprietary name *CPC*, installed on board. This program had also been approved by DNV, and the vessel was given the class notation "*Loading Computer System approved and certified for calculation and control of loading conditions with respect to Longitudinal Strength, Intact Stability and Damage Stability*". Although the maximum permissible VCG data for damage stability was incorporated in the program, the version of the software that was on board *Commodore Clipper* did not have the capability to assess the effect of damaged or flooded compartments.

1.11.4 Loading condition for 15-16 June 2010

The vessel's loading condition on departure from Jersey on 15 June 2010 was calculated by ship's staff using the *CPC* software. Following the accident, the MAIB identified a number of minor inconsistencies between the data entered into the *CPC* software and that contained in the vessel's logbook. Both the calculated and corrected loading conditions, however, met the required intact stability criteria with healthy margins.

1.11.5 Effect of drenching water on stability

Commodore Clipper listed to an angle of about 5° during the attempts to control the fire using the main vehicle deck drenching system. As the angle increased, drenching was temporarily suspended to allow the water to drain away through the partially blocked deck drains and reduce the list **(Figure 15)**. This reaction was due to concerns regarding the detrimental effect of this water on stability; no calculations were conducted either by ship's staff or the company ashore during the incident to verify the extent of the problem.

The MAIB has conducted a simplified[13] stability analysis simulating the presence of various amounts of water on deck 3; the actual quantities of water were unknown due to the uncertainty regarding the extent of deck drain blockage at any given time. For the purpose of these calculations, the only interruption to the water's free surface[14] was assumed to be provided by the vessel's internal structure. In reality, the free surface would also have been disturbed by various minor items such as the trailer wheels and trestles.

The analysis confirmed that all but very large amounts of water on deck would have had a ballasting effect on stability (due to deck 3 being around 1m below the overall loading condition VCG). However, with the vessel upright and water assumed to be covering the entire surface of deck 3, the large free surface moment would have dangerously degraded stability, causing both a negative righting lever (GZ) curve and transverse metacentric height (GM).

The MAIB also modelled other flooding scenarios in order to determine how much water on the main vehicle deck would have been required to cause the 5° list. Given that most of the drenching effort was concentrated on the port side and the vessel was observed to list to port, the effect of hypothetical accumulations of water on this side of the upright vessel's deck were analysed. The worst case was found to be with water to a uniform depth of about 5cm, which resulted in a minor failure of one of the stability criteria. Marginally increasing this depth of water across the port half of the deck was found to slightly improve stability[15], with the relevant criteria now being met.

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[13] Calculations were based on small angle assumptions and a dynamic model was not constructed.

[14] Free surface in this context refers to an unconstrained liquid surface which is free to move transversely as a vessel heels to one side. This movement results in the liquid's centre of gravity also transferring towards the direction of heel, which therefore counters the righting moment attempting to bring the vessel back upright, and thus reduces the overall stability.

[15] An increase in the depth of the water from 5cm to 10cm, although doubling the weight of water (which would be significant, given the large surface area), would result in only a minor increase of the water VCG from 8.625m to 8.65m (which is below the overall VCG).

Figure 15

Deck drain blocked by potatoes

Deck drain cover with potatoes removed

The final part of the analysis explored the effect of various amounts of water on deck transferring into wedges on the port outboard side of deck 3 as the vessel listed to 5°. Although these assumed wedges resulted in a slight increase in VCG, the effective breadth of water as it formed into a wedge shape decreased, which reduced the free surface moment. This resulted in the vessel meeting the stability criteria fully. It was calculated that between 10 and 20cm of standing water on the vessel's port side, transferring to form an equivalent wedge of water weighing 150 tonnes, would have caused a 5° list. The intact stability criteria could have still been met with the vessel listing to angles greater than 5° list and with larger weights of water. A damaged stability model, with greater capability than either the information held on board *Commodore Clipper* or the simplified analysis conducted by the MAIB (based on the same information), would be required to calculate the maximum angle of list that could have been reached safely.

1.11.6 Requirements for prevention of fire-fighting water accumulating in ro-ro spaces

SOLAS regulation II-2/20.6.1.4[16] highlights the potential serious loss of stability that could arise from the accumulation of large quantities of water on deck during the operation of a water-spraying fire-extinguishing system. Regulation II-2/20.6.1.4.1.1 requires that deck drains should be fitted to spaces above the bulkhead deck[17] on passenger ships to ensure that such water is rapidly discharged directly overboard. Regulation II-2/20.6.1.4.1.2 states that for cargo ships, where the requirements for clearing such water cannot be met, the adverse effect upon stability of the added weight and free surface of water shall be taken into account as deemed necessary by the Authority in its approval of the stability information. Such information shall be included in the stability information supplied to the master as required.

In June 2009, IMO circular MSC.1/Circ.1320[18] provided guidelines for SOLAS regulation II-2/20.6.1.5 regarding the requirement for effective measures to ensure floating debris does not block drains in spaces where fixed water-based fire-extinguishing systems are provided; this SOLAS regulation came into effect on 1 January 2010 for ships constructed on or after that date, with existing ships to comply by the first survey thereafter. The circular recommended that an easily removable screen or grating should be installed over each drain, raised above the deck or installed at an angle to prevent large objects from blocking the drain.

A large mesh box, that could be fitted over existing drains and met the requirements of MSC.1/Circ.1320, had been trialled on *Commodore Clipper*. The trial was considered acceptable but the prototype had been removed to provide a pattern for the remainder to be fabricated in good time to meet the required deadline.

1.12 TECHNICAL INVESTIGATION

1.12.1 Examination of the fire scene

Once the trailers and cargo debris were removed from the main vehicle deck, there was no evidence of a seat of fire in the vessel's structure or major items of equipment. The freight trailers and their cargoes provided the vast majority of the available combustible material.

Most of the fire-damaged trailers, apart from GC13-1, were refrigerated units, and all were inspected as they were removed from *Commodore Clipper*. Trailers FS61 and GC13-1 were hard-sided, and generally only had external structural damage where burning cargo from neighbouring curtain-sided trailers had fallen onto them. Burning debris on the deck had charred the tyres on the right-hand side of GC13-1[19], causing them to delaminate in places **(Figure 16)**.

[16] SOLAS amendments 2008 and 2009, Resolution MSC.256(84)

[17] Bulkhead deck is the uppermost deck to which the transverse watertight bulkheads are carried (which for Commodore Clipper, is the main vehicle deck)

[18] Guidelines for the Drainage of Fire-Fighting Water from Closed Vehicle and Ro-ro Spaces and Special Category Spaces of Passenger and Cargo Ships, 11 June 2009

[19] All damage to trailers is described in relation to the trailer's normal road-going orientation. Unaccompanied trailers were reversed onto *Commodore Clipper*, so the rear of the trailer would have been pointing towards the bow of the vessel and the towing end pointing to the stern.

Figure 16

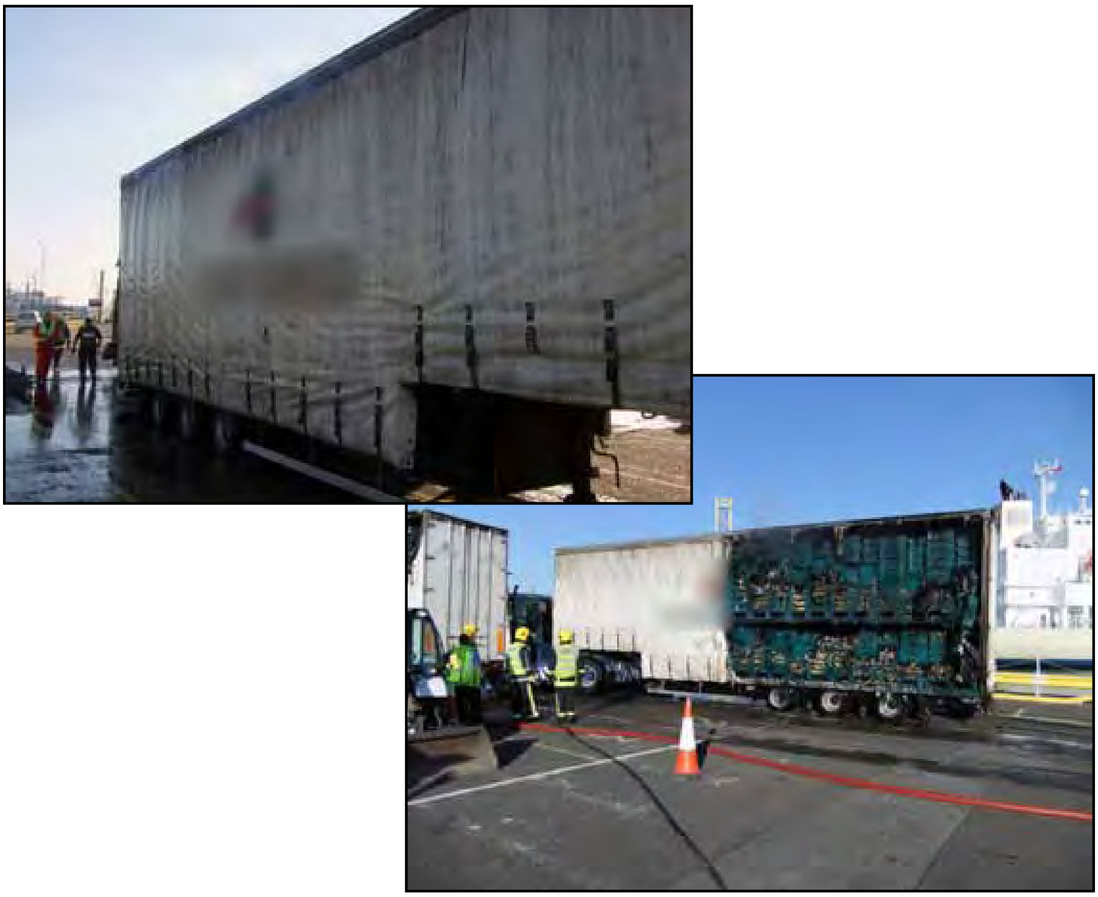
Charred and delaminated tyres on trailer GC13-1

Trailer CR439 had curtain-sides, but the only fire damage was to the cargo area at the rear on the left-hand side. The curtain had been burnt away over the last half of the trailer, and the outer edges of the exposed cargo of pre-packaged potatoes had been involved in the fire **(Figure 17)**.

The curtain-side on trailer CRF461 had been burnt away over the front two-thirds on both the left and right-hand sides **(Figures 14 and 18)**. The front end of the trailer was fire-damaged, but the rear part had not been involved in the fire.

Trailer CRF459 had the most extensive damage, with the entire curtain on the right-hand side having been burnt away **(Figure 19)**. There was extensive damage to the cargo in the central section on the right-hand side, immediately above the electrical power distribution circuits. The composite aluminium/glass reinforced plastic roof had also been destroyed in this area, with remnants of molten and solidified aluminium at the periphery. The left-hand side was less damaged, but the curtain had detached at the top over the rear three-quarters of the trailer. Some cargo on the upper levels had also been involved in the fire, but the amount of damage reduced considerably lower down.

Figure 17

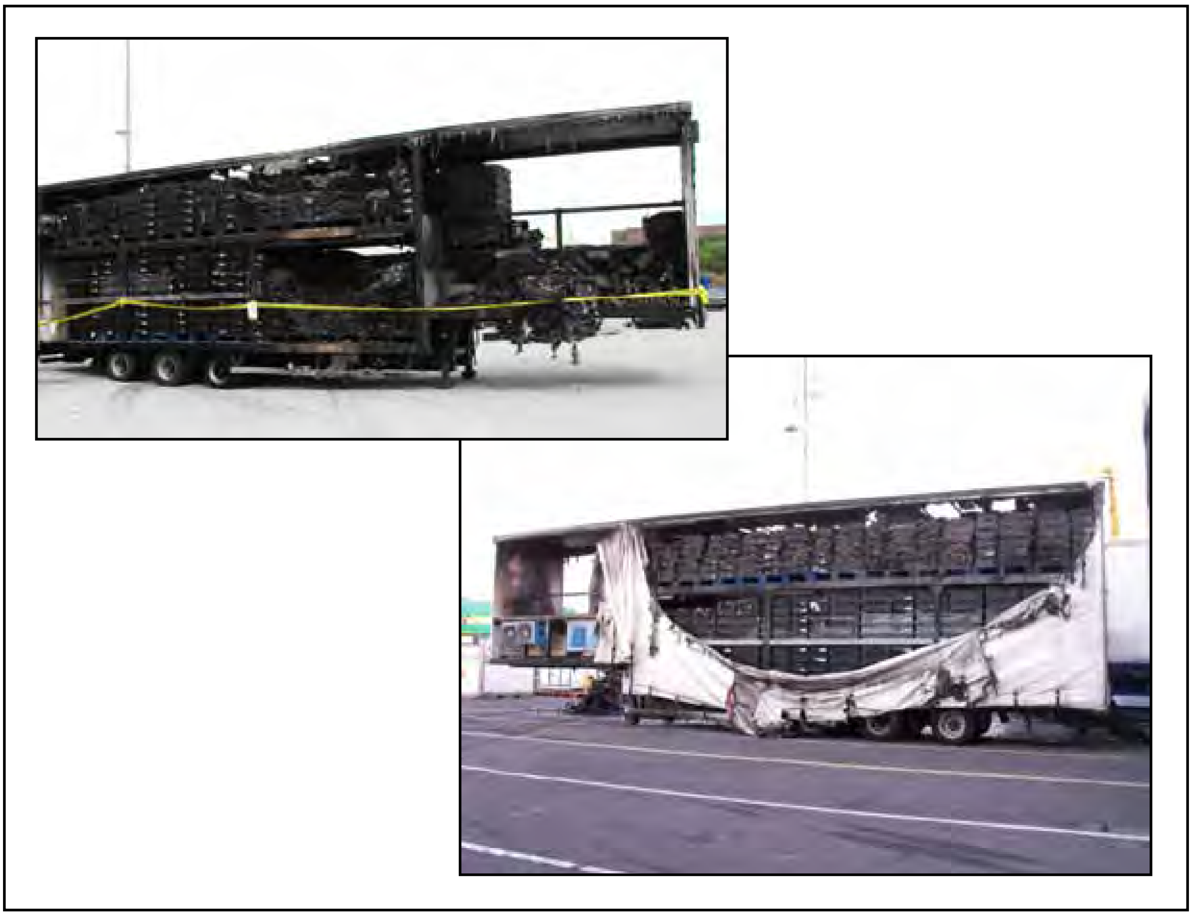


Trailer CRF439

Figure 18

Trailer CRF461

Figure 19



Trailer CRF459

1.12.2 Refrigerated trailer system

Trailers CRF459 and CRF461 were similar triple-decked units, designed to carry fresh produce, chilled to between 5º and 8°C. When full, each trailer was capable of carrying about 18-20 tonnes of packaged potatoes. The curtain-sides were made from two outer layers of tough plastic which enclosed a central layer of flexible insulating material. The curtain-sides hung just below the sides of the load-bed and were secured in place with webbing straps **(Figure 20)**.

The refrigeration system was manufactured by Frigoblock to meet a high customer specification for performance and reliability. It consisted of a small diesel-electric generator unit which provided power to a separate, electrically driven refrigeration compressor. Both units were mounted at the forward end of the trailer on the left-hand side. Beneath these units, mounted underneath the load-bed was an aluminium fuel tank **(Figure 21)**. The economic benefits of purchasing fuel in the Channel Islands meant that all the refrigerated units carried on this leg of the route were likely to have been full of fuel, and CRF459 and CRF461 each carried approximately 200 litres of diesel. Four chiller units, mounted on the dividing decks, circulated air throughout the cargo space to maintain the required temperature. The refrigeration systems were checked on a 6-month maintenance cycle, and CRF459 was last serviced on 13 May 2010.

Figure 20

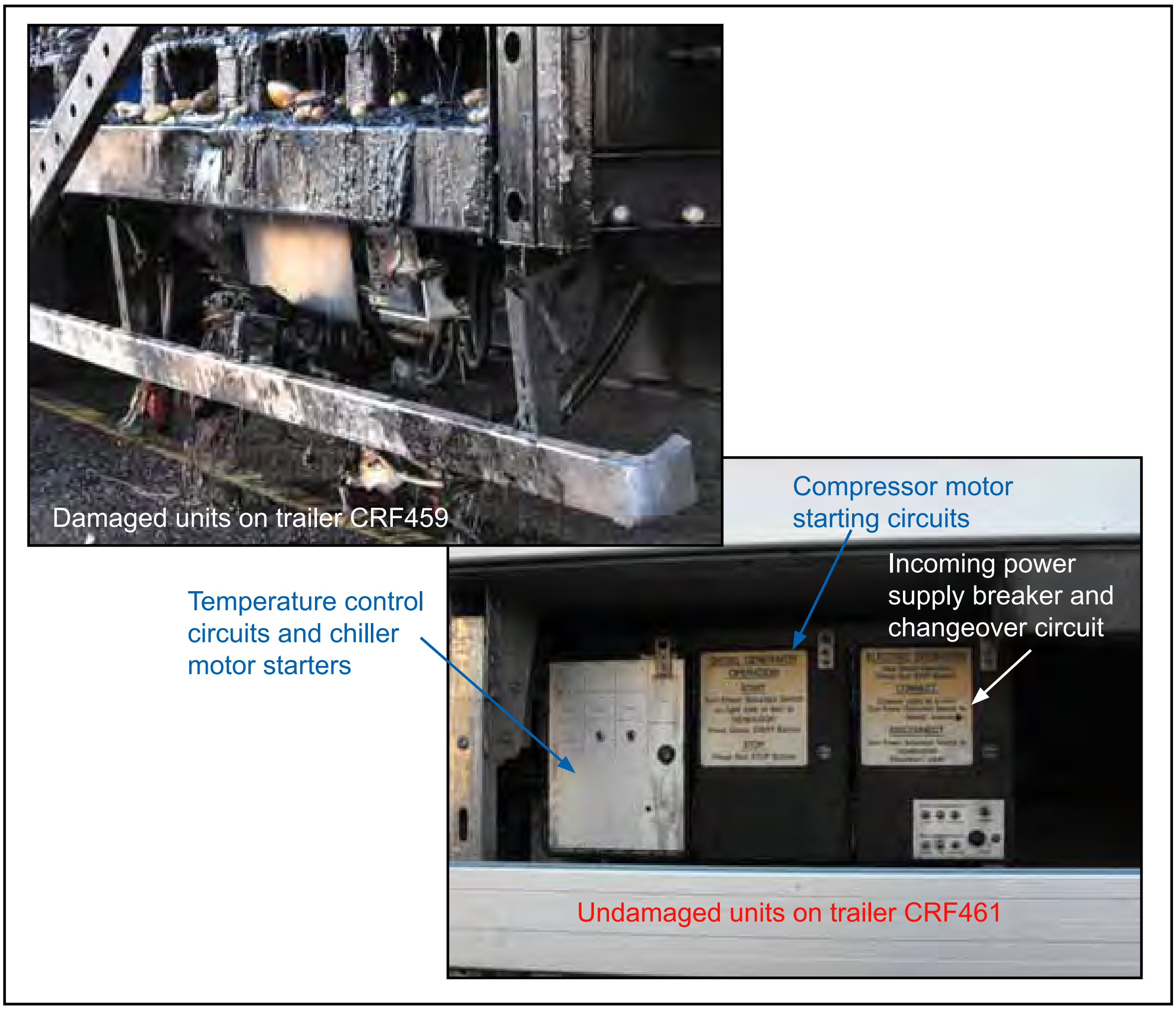
Insulated curtain-side material

Figure 21

Diesel generator, refrigeration compressor and fuel tank

Three electrical control and power distribution cabinets, manufactured to meet IP67 ingress protection standards[20], were mounted on the right-hand side of the chassis beneath the load-bed of trailer CRF459 **(Figure 22)**. The cabinet that was furthest forward housed the incoming power supply breaker, distribution circuit and a changeover switch that allowed the fridge unit to be powered by the trailer's own generator or an external supply. The changeover switch was found in the external power supply position. The next cabinet along, housed the compressor motor starting circuits. The third cabinet housed the control circuits and contactors for the chiller fan motors. A separate cabinet further forward contained a temperature data logging unit.

Figure 22



Electrical control and power distribution boxes

The socket for an external power supply was mounted to the underside of the load-bed to the rear of the three cabinets **(Figure 23)**. The socket was connected to a phase changing device, which automatically sensed the phase rotation of the power supply and corrected it to suit the correct rotation of the compressor motor.

All the electrical components in the trailer's refrigeration system had been selected so that they could function satisfactorily on a wide range of input power. The system could operate on input voltages in the range of 200V to 690V AC, at frequencies of between 25Hz and 87Hz without causing overheating of windings or chattering of contactors.

[20] Ingress protection standards as defined in the International Electrotechnical Commission (IEC) standard '*Degrees of protection provided by enclosures'* IEC60529

Figure 23

External power supply socket

The external power supply socket on trailer CRF459 was found to have detached from the underside of the load-bed, and had indications of internal overheating, rather than external charring from fire **(Figure 24)**. Insulation materials which were fitted into the load-bed, and the lower flange of the steel beam forming the outer edge of the load-bed in the area where the socket was fitted, were also damaged by heat. It was possible to determine that part of the plug fitting from *Commodore Clipper*'s power supply was still attached. The remainder of the plug had been consumed by fire, and the parts of the cable terminals that were left were heavily charred. The cable was no longer attached.

Crew who had been involved in the unlashing and removal of trailers were able to confirm that they had unplugged all the vessel's power supply cables from refrigerated trailers, apart from one that was too badly damaged. Although they could not confirm which trailer this was, they were certain that this was the only one that was pulled out by the tugmaster where the cable had not been removed.

One power cable, which had consisted of two standard 20m lengths plugged together, was found lying in a straight line leading from socket No.9 on a bank of power supply sockets close to frame 101, to a position in lane 2 at frame 201 **(Figure 25)**. The connecting ends of the two standard cables were found pulled apart at frame 86. The plug and sockets shared a common pattern of damage that was likely to have been sustained during the fire-fighting and cargo removal operation, indicating that they had been connected during the accident. The end of the cable that would have been connected to the trailer was the only one without a plug, and the bare wires were exposed. Another set of power supply sockets was closer to the trailers involved in the fire, and these could have been used to avoid the need to use an extension lead.

Figure 24

Damaged external power supply connection on trailer CRF459

Figure 25

Reefer power supply cable

1.12.3 Electrical examination

Power supply system

The power supply system for the refrigerated trailers was fed from *Commodore Clipper*'s switchboard through a distribution network via 250A and then 125A breakers. The system used three phases and an earth: there were no transformers or neutral points in the system. Although the classification society required the power supply sockets on the main vehicle deck to have a minimum ingress protection (IP) rating of 55, this had been overlooked, and the vessel's plugs and sockets all had the lesser IP44 rating.

Power to the supply breaker feeding socket no.9 at frame 101 had been isolated at the main switchboard, and after the fire the supply breaker was found in the 'on' position. The breaker was a '*System pro M*' manufactured by Asea Brown Boveri (ABB) and rated at 32A. It had a *'K-characteristic'*, which was described by the manufacturer as making it suitable for cable and appliance protection. Accordingly, it had electromagnetic and delayed thermal trips to take account of high motor starting loads and give protection against longer term overload currents. When tested by an electrical contractor, the breaker tripped after a few seconds at a fault current of 84A; in subsequent tests the breaker tripped at 77A and then at 70A[21]. This was in accordance with the manufacturer's specification, and the progressive reduction was due to the build up of heat in the thermal tripping mechanism as each test was done.

Trailer electrical distribution boxes

All the electrical distribution boxes on trailer CRF459 were severely damaged by fire. The power supply breaker on the trailer was in the 'off' position, but as this was also fitted with a thermal tripping device, heat during the fire would have caused it to trip if it had not already done so for other reasons. The compressor motor circuit was fitted with phase imbalance and winding overheating detection. The compressor motor windings were found to have the correct resistance, the motor and compressor were free to turn, and there was nothing else to indicate a current overload had occurred in the trailer's refrigeration system.

The electrical distribution circuits were cut away from the trailer and examined in more detail by a specialist contractor. All the components showed evidence of external damage from having been involved in a fire. There was no evidence of arcing or wires 'beading' from current overload, and all the terminations were tight and well made.

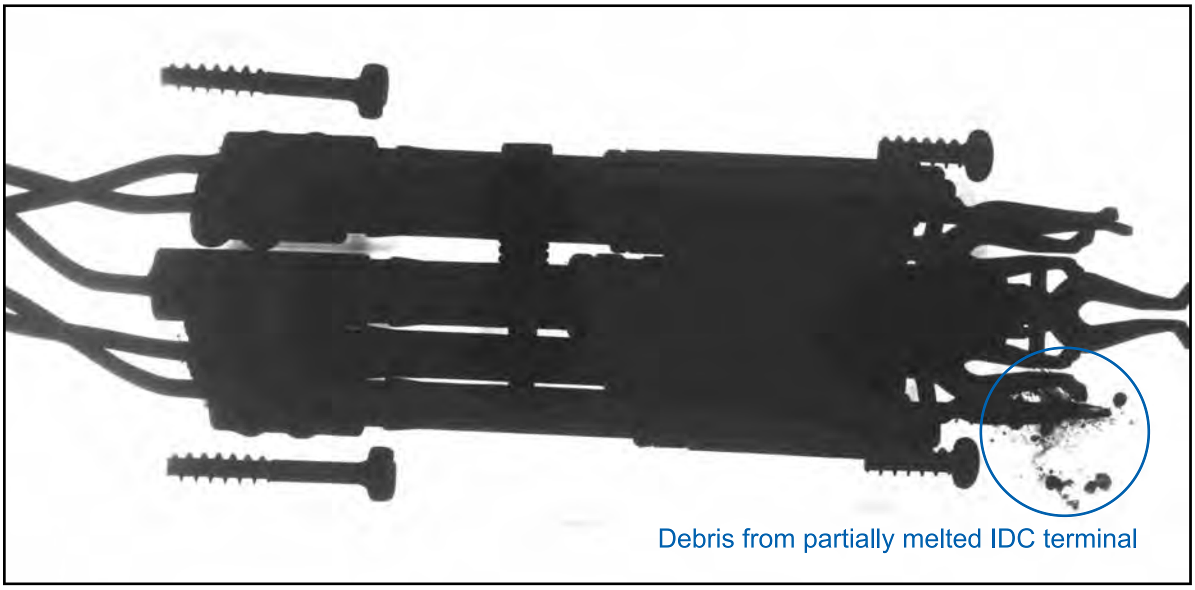
Power supply plug and socket connections

The power supply cable plug and socket were removed from CRF459 and x-rayed to determine the condition of the terminals. The x-ray showed several globules of metal around the area of one of the plug terminals where the ship's power supply cable was connected **(Figure 26)**. The plug was identified as a 'StarTop' type, manufactured by Mennekes.

The plug and socket were separated; there was no damage to either the male or female connectors. Screwed cable terminations in the trailer socket part were all well made, none were loose, and there were no signs of arcing or overload. Charred material around the terminations of the plug part was removed to expose the terminals. The terminals were of the insulation displacement connector (IDC) type. These cut through the cable insulation securing the conductor in position and are intended to save assembly time by avoiding the need to strip wires or tighten terminal screws.

[21] Other refrigerated trailer power supply sockets on the main vehicle deck were fitted with fuses rated at 35A, instead of breakers. A fuse was tested for comparison; it did not blow at the maximum test load of 100A.

Figure 26



X-ray of the external power supply connection on trailer CRF459

One of the terminals had partially melted and the several wire strands could be seen welded onto the remains of the terminal **(Figure 27)**. The terminal material was reported by the manufacturers to have a melting point of between 900 and 925ºC. It was possible to determine, from the orientation of the terminations and comparison with an undamaged plug, that the melted terminal was the brown phase.

Figure 27

Examination of the reefer power supply plug attached to trailer CRF459

The bare ended reefer cable removed from the main vehicle deck of *Commodore Clipper* was examined further, and characteristic beads were found at the end of several strands of wire from the brown phase.

The examination concluded that the termination of the brown phase had become loose inside the plug, leading to increased resistance in that phase, heating and arcing. In these circumstances, the fault current would have been limited to the load current of around 25A and the ship's supply breaker would not have tripped.

The complete report of the electrical examination is at **Annex C**.

1.12.4 Reefer cables

The cables providing ship's power to the refrigerated trailers, known on board as reefer cables, had previously been manufactured ashore. Responsibility for making up new reefer cables was passed to the crew from 1 May 2006 with the ship's electrician and electrical fitter doing this work. The crew ordered cable and connectors directly from commercial suppliers, and items from several different manufacturers were in use. In April 2009, the first batch of StarTop plugs was ordered. These were the first type of connectors with IDC terminals that had been used on board. A second batch was ordered in May 2010.

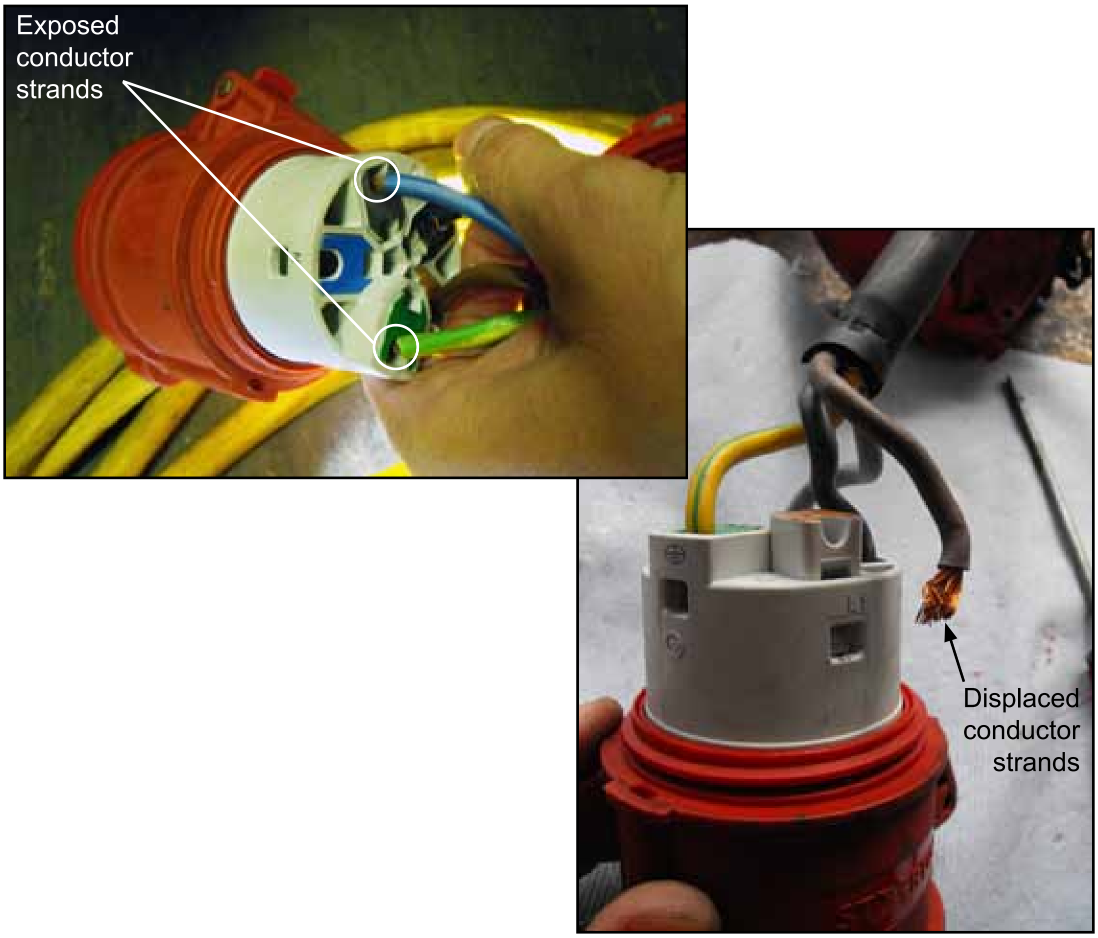
The StarTop plugs were suitable for up to 440V and 32A and were IP44 rated. The cable cores used on *Commodore Clipper* were the maximum size that the StarTop IDC terminals could accommodate. Each plug was supplied with a small instruction leaflet **(Figure 28)** that was secured to the terminals inside each plug assembly and indicated that insulation should not be removed from the conductors. Instead, each core of the cable should be inserted into the plug and the cap pushed down by hand or levered into place using a screwdriver. This forced the cable core into the IDC and cut the insulation, securing the conductor to the terminal. In practice, a considerable amount of force was required to achieve this successfully when using the maximum cable size.

Figure 28

StarTop plug instruction leaflet

The three other examples of reefer cables found on board *Commodore Clipper*, that were fitted with StarTop plugs, were examined **(Figure 29)**. In each case, the insulation had been removed from the ends of the cable cores before they had been inserted into the IDC. It is normal practice to remove insulation for a traditional screw terminal, but when using an IDC, the insulation is required to support the strands of the conductor and secure them in position. In the undamaged examples, the strands of the conductors were found to be displaced and at risk of not making adequate contact with the terminal. This would have been exacerbated if the cable gland became loose and the handling loads were transferred to the terminals.

Figure 29



Other StarTop plug connections assembled on board *Commodore Clipper*

The vessel's planned maintenance system required all the reefer cables to be inspected annually. This was timed to occur at the beginning of the potato season in May. The condition of a cable was otherwise checked only if it was found to be defective in service. Systems to identify each reefer cable had previously been tried, but were considered unsuccessful, and there was no means of monitoring the service history of an individual cable.

1.12.5 Reaction to fire tests

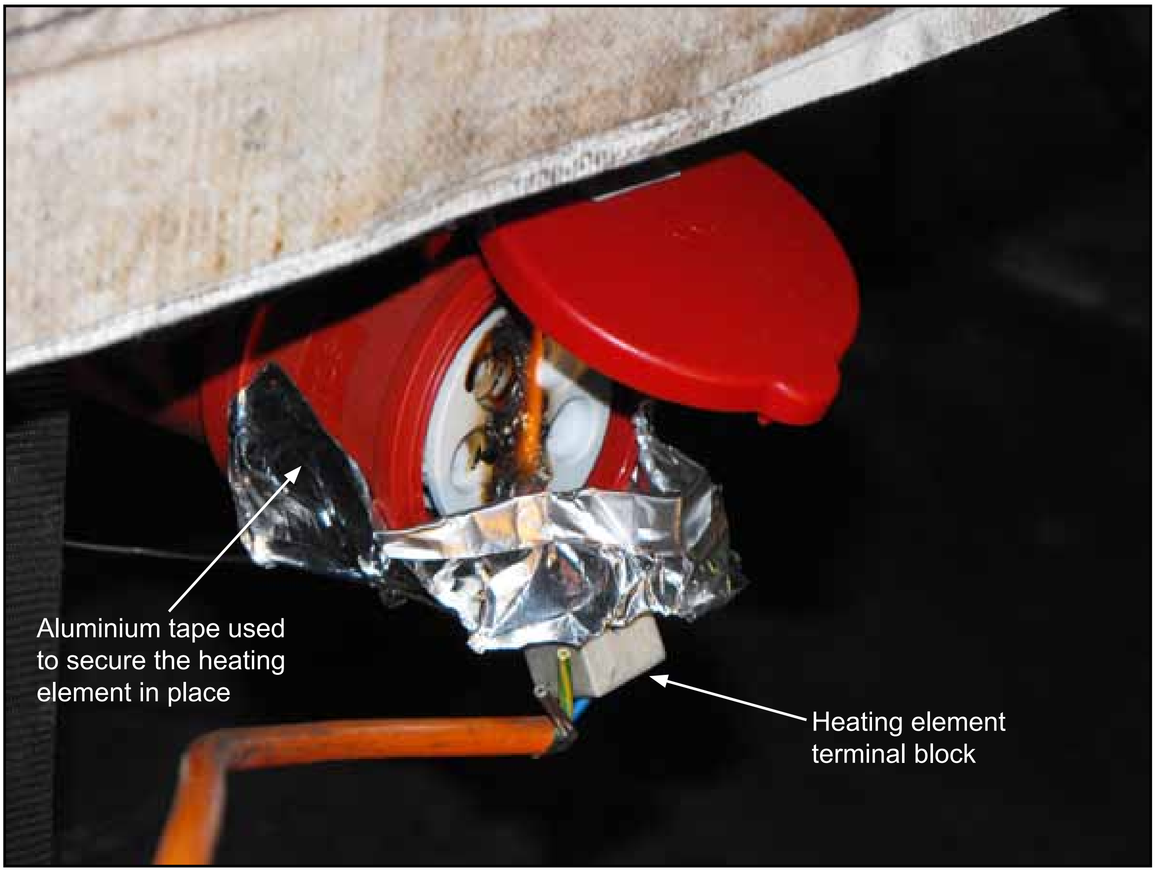
The StarTop plug, curtain-side material, webbing securing straps and plastic potato crates were subjected to a series of tests, conducted by specialist contractors, to examine their reaction to fire. The full reports of these tests are at **Annex D**.

The StarTop plug was manufactured to meet the EN 60309-2 standard, which required the plug to pass a ‘glow wire test’. This test is designed to show that the plug material that surrounds the terminals will not ignite when put in contact with a glowing hot wire. Consequently, the white material around the terminals was a polyamide reinforced with glass fibre (PA 6 GF20 FR[22]). The remaining red material of the body was polyamide 6.

In the reefer cable application, the plug was conducting around 25A at 400V, equivalent to 8kW (at an assumed power factor of 0.8). As one of the terminals had melted, it was known that temperatures inside the plug had been in excess of 900°C. A platinum coil was constructed so that it could be inserted inside one of the female connectors on the plug. Current and voltage was selected so that when power was applied to the coil, it was able to reach a similar temperature.

After approximately 10 minutes of sustained heating, the white plastic material around the terminals ignited. One and a half minutes later, flames had spread upwards and started to affect the red plastic cap **(Figure 30)**.

Figure 30

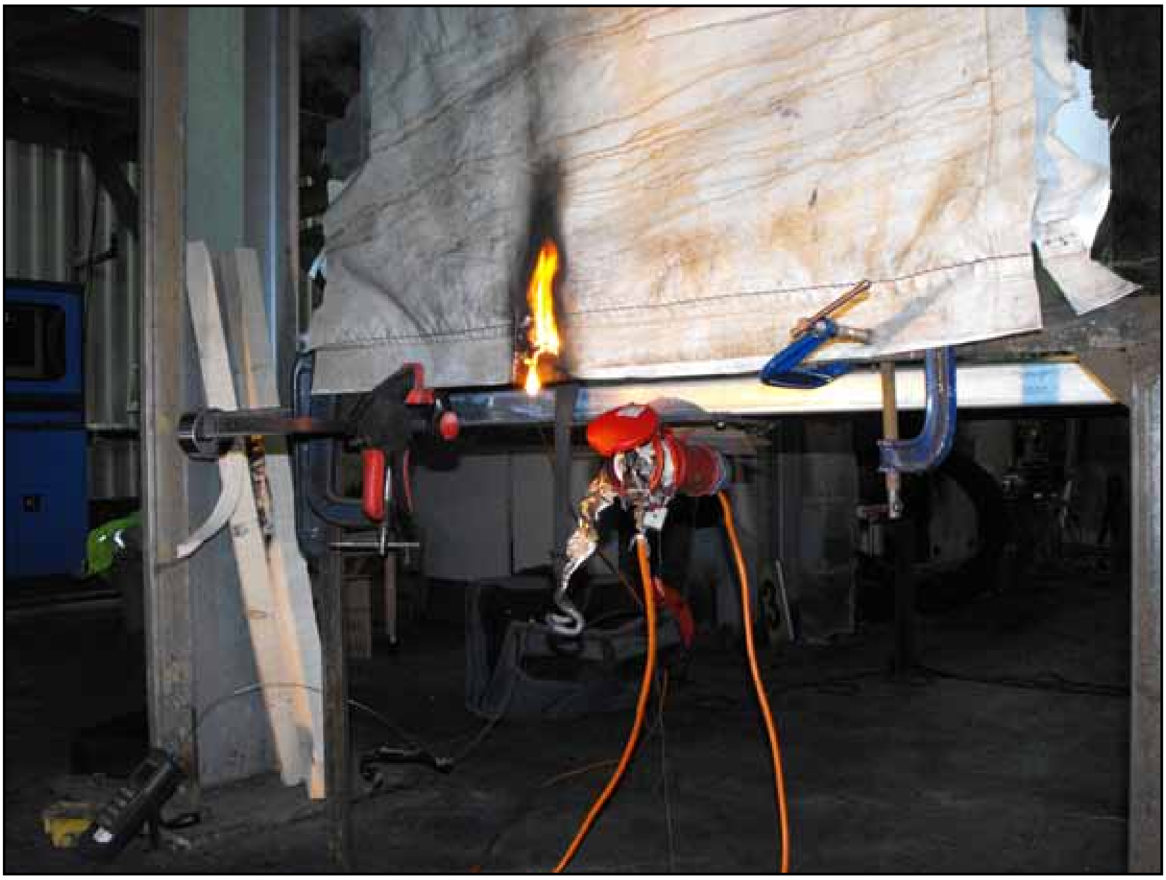


Ignition of the StarTop plug after sustained internal heating

The StarTop plug had been arranged underneath a vertical section of curtain-side material to re-produce the arrangement of trailer CRF459. In the tests, it was not possible to contrive the flame to spread from the cap of the StarTop plug to the webbing strap. However, a section of webbing strap was held above the flaming plug and it ignited readily. The curtain-side material also ignited readily **(Figure 31)**.

[22] Halogen-free and phosphorus-free flameproofed injection moulding grade with free-flow properties, good electrical properties and low smoke density; resistant to glow wire test to 960°C.

Figure 31



Ignition of the curtain-side material

The webbing strap, curtain-side and potato tray materials were subjected to more controlled tests to determine the critical heat flux required to ignite the material, the heat release rate once burning and smoke generation properties.

It was found that the critical heat flux required to ignite the curtain-side material was so low that further specialised tests would have been needed to estimate the actual value. The material then burnt readily developing temperatures approaching 700°C. The webbing strap ignited at an estimated critical heat flux of between 7.3 and 12.6 kW/m^2 and when burning, generated temperatures in excess of 800°C. The potato crates required a more sustained period of heating, but at a relatively low estimated critical heat flux of between 3.4 and 11.4 kW/m^2, before igniting. Once alight, temperatures of over 900°C were achieved.

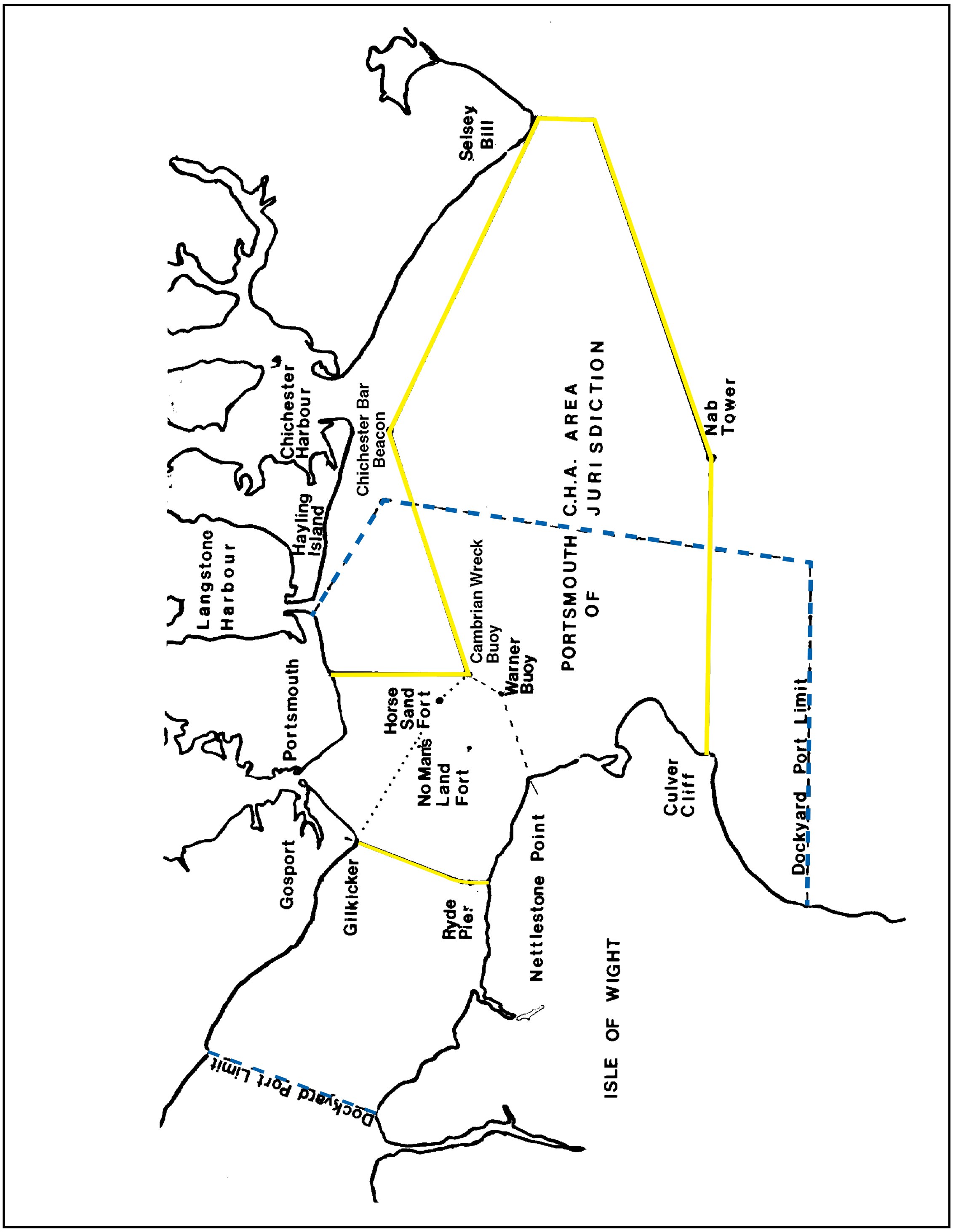
1.13 PORT INFORMATION

1.13.1 Portsmouth harbour authorities

The control of Portsmouth harbour is divided between military and civil authorities. QHM is the regulatory authority for the parts of the harbour defined by the dockyard port limit, deriving that authority from the Dockyard Port Act, 1865. QHM has a statutory responsibility to the Secretary of State for Defence for the protection of the dockyard port. His orders, regarding entry to the harbour, prevail. The commercial ferry port was opened in the mid 1970s, the facility is owned by Portsmouth City Council whose representatives act as the Competent Harbour Authority (CHA) under the 1987 Pilotage Act. The geographic areas that these responsibilities apply to are also different **(Figure 32)**.

Figure 32

Courtesy of Portsmouth International Port



Division of Statutory and Competent Harbour Authority areas of jurisdiction

The effect of this arrangement is that a commercial vessel entering Portsmouth harbour must have permission from QHM to enter and transit through the dockyard port, and permission from PIP to enter and berth at the commercial port. Pilotage functions are separated, with the CHA responsible for all acts of pilotage on commercial vessels. All the Admiralty pilots were civilian MOD employees with commercial master's certificates of competency. They were not authorised to conduct acts of pilotage on commercial vessels to PIP berths, but regularly controlled the movement of commercial vessels entering the dockyard port for maintenance work.

Commodore Clipper's master held a PEC for the commercial port. This qualification included the control of tugs to aid manoeuvring and berthing. While PIP can provide berthing tugs, the dockyard port has far more capable vessels which can be made available to assist commercial vessels at short notice. However, Admiralty pilots have far greater experience of conducting cold moves than a typical PEC holder would have.

1.13.2 Portsmouth International Port

The principal types of vessel trading at PIP were ro-ro passenger and freight ferries and refrigerated cargo vessels, but the port had diversified more recently and an increasing number of small cruise ships were calling.

The port complied with the Port Marine Safety Code (PMSC) and maintained a safety management system. A cargo fire in a ferry alongside had not been included in the risk register, and no specific control measures (beyond a standard emergency response) had been identified. No formal consideration had been given to which of the berths might be most suitable for dealing with a vessel that was arriving in the port and needed emergency assistance. While port staff had practised emergency drills, none of these included responding to a fire of this scale in the vehicle deck of a ferry.

1.13.3 Port infrastructure

Apart from the linkspans for vehicle traffic, PIP had a gangway that had been procured to serve cruise vessels, and a three-tiered access tower that had been designed to suit a different company's vessels. The three-tiered tower was a bespoke design, with very short gangways at each of its three levels, which made it difficult to use for anything other than its intended purpose. The cruise ship gangway was 8m long and, with self-levelling steps, suitable for passengers to use at angles of up to 45^{o} from the horizontal. The height of *Commodore Clipper*'s weather deck above the jetty meant that this limitation would have been exceeded as the tide began to flood.

Stevedoring services were contracted to a separate company. Their role, and the capability that they could provide, had not been recognised in the port's emergency plans.

1.14 COMMAND AND CONTROL OF EMERGENCIES

The MCA conducted an internal review of the coastguard's response to the incident on board *Commodore Clipper*. It considered the following areas:

- Co-ordination of the incident, including:
    - Jurisdiction
    - Tasking of MIRG
    - Role of rescue helicopters
    - Deployment of the CGLO
- Command and control within the MCA's duty officer system
- Principles and application of SOLFIRE.

The review concluded that the jurisdiction and responsibility for co-ordinating SAR in harbours and inland waters was unclear, leading to confusion and conflict. This was compounded by not sending a liaison officer to QHM's control centre when SOLFIRE procedures were initiated. The review found that the availability and use of MIRG had not been adequately explained to the master of *Commodore Clipper*, despite all the appropriate resources being available. Deployment of the CGLO was not in accordance with coastguard procedures, and there was uncertainty among MCA staff about whether statutory powers of intervention could be used.

The MCA's review made a number of high level recommendations to senior managers, including:

- Production of definitive instructions on the jurisdiction and legal responsibilities relating to the conduct of maritime SAR.
- Review of all existing local arrangements (such as SOLFIRE) nationwide to ensure that they meet national policy and are consistent with coastguard operating instructions.
- Incorporation of the lessons learned from the incident in new operational doctrine already being developed, with particular reference to:
    - Effective information gathering techniques
    - Unambiguous communication with vessels in distress and other agencies
    - Developing coherent action plans to manage emergencies.

1.15 OTHER SIMILAR ACCIDENTS

A total of 38 cases involving fires on vehicle decks of ro-ro ferries have been reported to the MAIB from 1995 to 2010. Analysis of these cases determined that the most frequent causes of fires were:

- Eleven electrical fires specifically recorded as having occurred on refrigeration trailers
- Eleven electrical fires on other vehicles
- Seven fires in vehicle cabs.

During this investigation, a report was received of a reefer cable that was being disconnected in St. Helier, being hot to the touch. Five days after the fire on *Commodore Clipper*, a ferry on an Irish Sea route reported an overheating transformer in the power supply system for refrigerated trailers carried on deck.

The most significant loss of life in a ferry accident in recent years occurred on the *Al Salam Boccaccio 98* on 3 February 2006. The accident occurred when a fire broke out on the car deck. Deck drains became blocked and a combination of water from the fire-fighting efforts being entrained on the car deck and counter ballasting led to the vessel capsizing. Of the 1418 who were on board, 1031 people were either reported missing or confirmed dead.

On 6 February 2008 the ro-ro freight vessel *Und Adriyatik* suffered a fire that started in a freight trailer. Crew were unable to activate the vehicle deck drenching system, and the fire spread rapidly to all the cargo spaces within 20 minutes. Fire blocked the route to the lifeboats, and the 9 passengers and 22 crew were forced to climb down from the accommodation using fire hoses and ropes. They managed to make their way to the forecastle and, as the fire approached, abandoned the vessel to the one remaining six-man liferaft. They were all recovered. The fire continued to burn for the next 2 days, and the vessel was a total constructive loss.

During the night of 8/9 October 2010, a major fire was reported on the vehicle deck of the ro-ro passenger ferry *Lisco Gloria*. The vessel was on passage from Kiel to Klaipeda, with 236 people on board. The fire developed very rapidly and everyone on board abandoned the vessel less than an hour after the fire was first reported. The fire continued to burn over the next few days before it was extinguished, and the vessel was declared to be a total constructive loss. The investigation into this accident was still ongoing at the time of publication.

On 17 November 2010, a fire started on the vehicle deck of the ro-ro passenger ferry *Pearl of Scandinavia* while it was on passage from Oslo to Copenhagen. The fire was extinguished after 2 hours through a combination of the vehicle deck drenching system and manual fire-fighting by both the crew and shore-based firefighters, who were flown out to the vessel. The damage resulted in the vessel being out of service for 6 days. The investigation concluded that the fire began in the batteries of an electrically powered car. The batteries were being recharged from the ship's power supply at the time.

1.16 ONGOING DEVELOPMENT WORK AT THE IMO

1.16.1 Water spraying systems

Resolution A.123(V), *Recommendation on fixed fire extinguishing systems for special category spaces*, was published in October 1967. Since then, it has been recognised that the fire-loading of densely packed vehicles and their cargoes is significant, and that a traditional water drenching system may not be able to extinguish such a fire[23]. The 2009 consolidated edition of SOLAS now refers to such systems as water spraying systems, in recognition that they may no longer be able to extinguish the fire as implied by the title of A.123(V) **(Annex B)**.

New approval criteria were published in MSC.Circ 1272 in June 2008 for a performance based approach to fixed fire-fighting systems for vehicle, ro-ro and special category spaces. The criteria allow for automatic and manually operated systems that are capable of fire suppression and control. Alternative systems have been developed, and at least one water mist system has been type approved. However, there is no requirement to be able to extinguish a fire in all circumstances, and the new criteria only apply to vessels constructed after 2008.

1.16.2 Structural fire protection

SOLAS Chapter II-2, Regulation 20.5 allows a special category space to have an A-0 class boundary, where an open deck space is on the other side. This was the case on *Commodore Clipper*, and the deck separating the main and upper vehicle decks was a steel structure with no heat insulation properties. The regulation does not take into account the purpose of the open deck or the risk of heat transfer to vehicles that might be there.

The problem of heat transfer between such compartments was recognised by the Fire Protection sub-committee in April 2007, but the issue was outside the scope of work at the time and was not progressed. The Chinese administration subsequently requested that the issue be reviewed, and amendments to SOLAS were approved at MSC88 in December 2010. These increase the fire protection required between vehicle, ro-ro and adjacent spaces, but only apply to passenger vessels carrying not more than 36 passengers, and do not include special category spaces.

1.16.3 Stability

In February 2007, document SLF 50/4/7 was submitted by China to the IMO Sub-Committee on Stability and Load Lines and Fishing Vessels Safety (SLF) proposing revisions to the Intact Stability Code regarding the effects on stability of

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[23] MCA research project, '*Assessment of the fire behaviour of cargo loaded on Ro-ro vehicle decks in relation to the design standards for fire suppression systems*', conducted by BRE Fire and Security, November 2006.

water accumulating on the ro-ro deck of passenger ships. The document proposed that such vessels should be provided with information on the potential adverse effects on stability of water accumulating on a ro-ro deck, in particular when undertaking fire-fighting actions. This was to be in the form of a curve of water accumulation height against heeling angle. The SLF Sub-Committee considered this proposal, but decided to take no further action, as SOLAS regulation II-2/20.6.1.4 already required deck drains to ensure the rapid discharge of accumulated water on deck.

1.16.4 SOLAS amendments 2008 and 2009

Additions to the 2009 consolidated edition of SOLAS, that had not entered force, were published separately in the booklet 'SOLAS amendments 2008 and 2009'. This introduces new requirements for: the 'Safe Return to Port' concept; means of embarkation; and protection of vehicle, ro-ro and special category spaces in newly built ships.

<u>Safe Return to Port</u>

Resolution MSC.216(82) Annex 3 includes new requirements for passenger vessels with a length of more than 120m and three or more main vertical sections that are built after 1 July 2010. Regulations 21, 22 and 23 were added to SOLAS Chapter II-2, respectively describing the requirements for:

- Casualty threshold, Safe Return to Port, and safe areas
- Design criteria for systems to remain operational after a fire casualty
- Safety centres on passenger ships.

Collectively, these regulations require that the vessel can withstand a specified amount of damage and continue to function with an adequate margin of safety so that it can return to port.

<u>Means of embarkation/disembarkation</u>

Resolution MSC.256(84) includes the addition of Regulation 3-9 to Chapter II-1 which requires that ships constructed after 1 January 2010 have a *Means of embarkation and disembarkation*. This is required for use in ports and port-related operations, and must be installed, maintained and inspected in accordance with guidelines published in MSC.1/Circ.1331.

<u>Protection of vehicle, ro-ro and special category spaces</u>

Additions to Chapter II-2 Regulation 20, regarding the protection of vehicle, ro-ro and special category spaces are also described in Resolution MSC.256(84). These refer to improved arrangements for draining water from decks.

SECTION 2 - ANALYSIS

2.1 AIM

The purpose of the analysis is to determine the contributory causes and circumstances of the accident as a basis for making recommendations to prevent similar accidents occurring in the future.

2.2 CAUSE OF THE FIRE

The first indications of smoke were recorded on the CCTV system at 0237. Given that neither of the second officers smelled any smoke in the accommodation before or after their handover, it is unlikely that the fire started much before this time. The main vehicle deck was a large compartment, and it is not surprising that the fire did not produce enough smoke to activate the detection system until 0242.

2.2.1 Reefer cable assembly

The fire started due to sustained overheating in the reefer cable plug that was connected to trailer CRF459. This was due to a high resistance fault in the brown phase, where the conductors in the cable core made contact with the IDC terminal inside the plug. It is likely that this fault had existed since *Commodore Clipper* departed from Jersey the previous evening. Heat built up inside the plug assembly during the following 7 hours, until it was sufficient to melt the cable core and part of the terminal material. This indicates that a temperature of at least 900°C was achieved inside the plug assembly. The fault was almost certainly caused by the cable conductors making a poor electrical contact with the IDC terminal inside the plug.

Poor electrical contacts result in a high resistance to current flow, which leads to local overheating and arcing as intermittent contact is made, or currents jump across small air gaps between the cable conductor strands and the terminal. In the latter stages, as the plug began to burn and the insulation broke down, electrical currents would have arced between the phases, and it is likely that this was related to the earth fault that caused the bus-tie breaker to trip.

Two reefer cables, with a combined length of 40m had been connected together to power trailer CRF459. Some voltage drop would have occurred across this length, and the current that was drawn would have increased accordingly. This would have added to the heating effect across all the connections. Other reefer cable power points, closer to the trailer, were available and could have been used instead of an extension cable. The extent to which this exacerbated the overheating cannot be determined, but it was poor practice, and the use of extension cables should be avoided.

Three other plugs of the same type as that involved in the fire were found on *Commodore Clipper*; none had been assembled in accordance with the manufacturer's instructions. The insulation on each cable core had been removed before putting the cable core into the IDC terminal. Examination of the exposed conducting strands on the undamaged plugs showed that several had been distorted. Without the insulation, the strands of wire were not held in place securely, and there was little to prevent individual strands from splaying apart and making only partial contact with the terminal. While there were no signs of overheating in any of the three undamaged plugs, it was evident that the conductor strands were not making proper contact with the IDC terminal. Given that three out of the four StarTop plugs that were on board *Commodore Clipper* were found to be assembled incorrectly, it is reasonable to conclude that the fourth, the one that was involved in the fire, was put together in the same way.

The instructions provided with the StarTop plugs were printed on a small leaflet that was attached to the plug terminals so that it would be found during assembly. The pictorial instructions referring to the preparation of cables could be interpreted incorrectly, and there was a risk that the leaflet could be discarded. The significance of not stripping the cables and potential effects of removing the insulation were not adequately emphasised.

Reefer cables operate in a very harsh environment and it was evident, from examining the other StarTop connections, that two had loose cable-gland nuts. This would have allowed any strain on the cable to be transferred to the individual cable cores at the point where they connected to the IDC terminal, making them more likely to become loose. The cable-gland nut on the plug connected to trailer CRF459 was consumed by fire, but it is possible that it was also loose. If so, this would have exacerbated the assembly error and contributed to developing a high resistance fault at the IDC terminal.

The annual inspection of the reefer cables provided some assurance that they were in an adequate condition at the beginning of the potato season. However, the maintenance system did not take sufficient account of the wear and tear each cable received in regular use.

2.2.2 Refrigerated trailer equipment

There was no evidence of electrical faults on trailer CRF459's refrigeration system. The equipment had a wide operating range and was extremely unlikely to be adversely affected by any voltage and frequency fluctuations in *Commodore Clipper*'s power supply. The windings of the compressor motor were found to be in good order, and there were no other indications of mechanical or electrical overload.

2.2.3 Electrical protection

The overheating was due to high resistance in a single phase, and the only electrical symptom would have been a slightly higher current being drawn by the brown phase, when compared with the other two phases. Although the electrical protection system on the refrigerated trailer was capable of detecting this type of fault on the trailer, the ship's supply breaker was not. Consequently, the supply continued and as the trailer refrigeration system functioned correctly, no faults were apparent and neither breaker tripped.

It is likely that the high resistance fault had existed since the reefer cable was connected to the trailer, but it took several hours to deteriorate to the point where arcing and the high temperatures were achieved. Once arcing had begun, the conductor strands would have melted fairly quickly, an open circuit fault would have occurred, and the trailer's breaker would have tripped. However, by this time sufficient heat had been generated to ignite the surrounding materials.

The StarTop plug was constructed to the appropriate IEC standard, but this only required the material surrounding the terminals to withstand a glowing hot wire without igniting. The material was not intended to be able to withstand the heat generated by a resistance fault, particularly when it was sustained over several hours, and tests showed that it could be ignited by a high internal temperature. The remainder of the plug casing had no fire resistant properties and it burnt readily.

The reefer power supply connections on the main vehicle deck and reefer cable fittings all had an IP44 rating, rather than the minimum IP55 rating that was required by the classification society. This shortfall had been overlooked during the survey process. While the high resistance fault in the plug was unrelated to ingress protection, connectors provided by Mennekes with a higher IP rating were more robustly constructed and did not use IDC terminals. It is therefore considered less likely that a high resistance fault would develop in a connector with a higher IP rating and, if one did, more likely that the connector would be able to contain the fault without igniting.

2.2.4 Trailer ignition

There was no requirement for the materials used in the construction of road trailers to have any fire resistant properties, and tests showed that the curtain-side and webbing straps were relatively easy to ignite. The plug was mounted directly under the load-bed of trailer CRF459, and the heat from the resistance fault would have transferred straight onto the curtain-side material or a webbing strap if one was nearby. Insulation material in the load-bed above the plug and socket was severely damaged by heat. This was in contrast to trailer CRF461, which was of similar construction and had also been involved in the fire, but had no damage to the insulation in the load-bed. Flame from the burning plug casing would have ignited either of the materials after being in contact for a few seconds.

Ideally, reefer power sockets should be mounted away from the curtain-side or other combustible materials so that, if one should overheat, the chance of this resulting in a fire is minimised. However, power sockets also need to be accessible, and this limits the options for mounting them well clear of flammable materials. Given the vulnerability, it is of utmost importance that owners and operators recognise this risk, and take steps to ensure that trailer power supply fittings and connections are fit for task and appropriately maintained at all times.

2.3 INITIAL RESPONSE AND FIRE ESCALATION

2.3.1 Crew response to the fire alarm

The second officer on the bridge made the correct response in sending the lookout to investigate the first fire alarm. He then allowed himself to be persuaded by the third engineer that the alarm was due to a fault, and he concentrated on trying to silence the alarm rather than challenge the third engineer’s analysis. The third engineer had not smelled any smoke and because a breaker tripped at about the same time, he made a link between the alarm and the breaker, interpreting them both as being due to an electrical fault on the main vehicle deck. While this was correct (the fire was due to an electrical fault), he did not consider the cause of the problem any further, other than to call the electrical fitter to investigate. In the absence of any other corroborating information, he did not associate the electrical fault with a fire.

Commodore Clipper did not have a particular history of spurious, nuisance fire alarms, but the second officer had experienced this problem before on other vessels. Both the second officer and the third engineer preferred to believe that a faulty alarm was more likely than a fire. They reinforced each other’s false belief in their subsequent conversations and collective actions, that resulted in them silencing and resetting the system a total of 18 times in less than 7 minutes. Although both officers had a basic understanding of the fire detection system from their familiarisation training, the system was not routinely used as part of the fire drills, and the alarm was normally activated only during maintenance or testing.

The second officer’s and the third engineer’s mistaken opinions could have been changed by either a report from the lookout or by the second officer looking at the CCTV picture of the main vehicle deck. However, the lookout initially only went as far as the restaurant, and despite the CCTV recordings showing the build up of smoke in the main vehicle deck the second officer did not report seeing any indication of there being a fire. The interpretation of the fire detection system being faulty was confirmed in both officers’ minds when it stopped working at 0249, only 7 minutes after first activating.

The lookout had smelled smoke in the restaurant, but when he returned to the bridge, the second officer was in conversation with the third engineer, and he waited before making his report rather than interrupt. The lookout's report started to challenge the second officer's perception of the problem, but lacked urgency, and as the lookout had not actually seen a fire, this was not enough to persuade the second officer to start alerting the rest of the crew. There was no other information that could make the second officer change his mind about what was happening, and he was also frustrated that the lookout had not gone to the vehicle deck in the first instance. He sent the lookout away again to check if there was a fire, and decided to take no further action until he had a definite report. The lookout's faulty radio meant that confirmation was further delayed.

The delay in verifying that there was a fire on the main vehicle deck had allowed the fire to escalate, and by the time the chief engineer left his cabin there was a strong smell of smoke in the accommodation. Although smoke later caused problems to the emergency teams and discomfort to the passengers, it did make it immediately obvious to the chief engineer why the fire alarm had been activated. When he arrived on the bridge, it was also clear to him that no actions had been taken to control or extinguish the fire, and he reacted immediately. The materials involved burnt readily, and temperatures would have increased rapidly. Machinery alarms indicated that damage to electrical cables began within the first few minutes of the fire and well before the drencher system was started. The fire also had time to become well established inside the trailer, where it was sheltered from the drencher water.

Given the potential for rapid fire development on vehicle, ro-ro and special category decks, it is essential that crew react positively at the first indications of a fire and initiate the proper emergency response. Detection systems must be reliable and incorporated into training drills so that crew can become confident with the system and trust the information that is provided. While obtaining confirmation of the location and extent of a fire from an eye-witness is important, it must be understood that this information could come at a high cost. Firstly it could take time to obtain and, secondly, it may well put the eye-witness at risk. The lookout entered a potentially dangerous, smoke-logged compartment with a faulty radio and an EEBD; equipment that is designed solely for emergency escape and is not suitable for investigating fires.

Activation of a smoke detector, unexplained electrical faults, and a smell of smoke high in the accommodation should be enough information to persuade duty officers that emergency response plans should be activated.

2.3.2 Effectiveness of the vehicle deck water drenching system

It is evident from this accident, and from the language used in successive documents published by the IMO, that a water drenching system in a vehicle deck should not be relied upon to extinguish a fire. Resolution A123, published in 1967, describes a fire extinguishing system, but the 2009 consolidated edition of SOLAS merely requires a water spraying system. The implication that it may not put out a fire is contradicted by the continued reference to the performance standard described in Resolution A123. Yet, even in the most recent performance standard for equivalent systems described in MSC.Circ 1272, there is still no requirement to actually extinguish the fire.

Technically, it is extremely demanding for a traditional water drenching system to extinguish a fire on a densely packed vehicle deck. Vehicles are designed to resist water ingress, but are, by comparison with the materials allowed in the construction of passenger vessels, extremely flammable. A CO_2 system might be more effective, but could put passengers at greater risk and, understandably, is not considered appropriate for special category spaces. However, improved methods that meet the performance standards described in MSC.Circ 1272, should be encouraged on existing vessels in service.

2.3.3 Ability of crew to fight the fire at sea

Crew entered the main vehicle deck on three separate occasions before *Commodore Clipper* berthed at PIP, and HFRS teams subsequently entered the compartment many times. The crew did not attempt to fight the fire because of a combination of three factors: firstly, they expected the drenchers to extinguish the flames; secondly, they knew very well that moving around the main vehicle deck was hard enough without attempting to handle charged hoses as well; and lastly, they expected professional firefighters from ashore to put the fire out more effectively than they could once the vessel was alongside.

Firefighters from HFRS found it extremely difficult to work in the main vehicle deck and could not direct their hoses onto all the seats of fire. Consequently, no matter how hard they tried, fires continued to burn, sheltered by the vehicle structures and cargo.

The conclusion from both the crew and HFRS's experience is that it is impractical to expect a well-developed fire, that is located deep in a fully loaded special category space, to be extinguished by traditional manual techniques. This could not be achieved even after *Commodore Clipper* was alongside, and is therefore even less likely while such a vessel is at sea.

2.3.4 Containment

This accident demonstrates that it is unlikely that even a moderate fire in a special category space will be extinguished while the vessel is at sea. It is therefore essential that the fire can be contained such that either an orderly evacuation can be conducted, or the vessel can continue to a port of refuge. This is the aim of the Safe Return to Port amendments to SOLAS. However, these apply only to vessels built after 2010 that are greater than 120m in length, or have more than three vertical zones; the majority of ro-ro passenger ferries currently trading will not be built to these standards.

The deck boundary between the main and upper vehicle decks on *Commodore Clipper* met the requirements of the existing regulations and was to A0 standard. This offered no thermal insulation, and heat from the fire was very quickly transferred to the deck above. Were it not for the activation of the drenchers and the boundary cooling applied by the crew, it is highly likely that the heat would have ignited the tyres of the cars on the deck above and the fire would have developed on both decks.

The current SOLAS regulations consider vehicle, special category and ro-ro decks together as a group, and only require thermal insulation at their outer boundaries. While this is understandable in theory, in practice a fire can only be contained within a single compartment inside this envelope by using fixed systems and boundary cooling. If these should fail, there is so much fuel available from the vehicles being carried, that a fire would grow quickly to such an extent that abandonment becomes the only possible course of action. This was evident from the outcome of the vehicle deck fires in both the *Und Adriyatik* and *Lisco Gloria* cases.

While the complexities of retro-fitting thermal insulation in between special category spaces and vehicle decks on the weather deck are obvious, this would be a logical method of limiting the rate of fire spread.

2.4 FIRE DAMAGE TO SHIP'S SYSTEMS

2.4.1 Consequences of fire damage to systems

Steering control system

The damage to *Commodore Clipper*'s steering control cable affected both steering systems, even though only the port cable was damaged. The damage caused the port rudder to be driven over to a large angle, and control of the starboard rudder became unstable in certain conditions. It is extremely difficult to predict the effect of such damage on modern microprocessor-controlled equipment, and there is no obligation in the regulations to do so. While crew should be able to revert to emergency control methods if there is sufficient time to respond, it would be extremely difficult to prevent a collision or grounding if a rudder suddenly moved to a large angle when a vessel was in confined waters. The requirement to separate the cables within the compartment assumes that the systems have similar electronic separation. However, this may not necessarily be the case, and this accident demonstrates that it is possible to satisfy the wording of the regulation without achieving its intent.

Fire detection system

It is expected that fire detection sensors in the immediate vicinity of a fire are likely to be burnt out. Systems are therefore designed so that the damage to individual sensors has minimal effect on the system as a whole. The detection system in *Commodore Clipper* had been incorrectly installed, probably at build, with isolating devices in the wrong positions. This allowed high voltages from other damaged cables to enter the fire detection network, overload the control circuits, and shut down the whole system.

The consequences of the fire detection system failing so early during the incident were significant. Firstly, it reinforced the duty officers' perception that there was a technical fault, rather than a fire, and secondly it denied the crew any more information about the extent and development of the fire. This type of equipment installation error would have been difficult to detect in service and can only be avoided by careful quality control during build. Even so, it is impractical to expect a ship to be built without any defects; pre-planned emergency responses must therefore be designed so that they are resilient to the effects of equipment failure. In this accident, failure of the fire detection system meant that a system of patrols was required to detect any further spread of the fire.

Fire main and drencher pipework

Both the firemain distribution pipework and the drencher pipework were damaged by the heat generated by the fire. It was fortunate that once the systems were activated, the flow of water through the pipes was sufficient to prevent further heat damage. It is important to note, however, that this water flow was interrupted many times when the drenchers were turned off to help maintain the vessel's stability and with the intermittent need for boundary cooling.

It is possible that if the fire had been more intense in the early stages, or the flow of water turned off for longer periods, the pipework could have been ruptured. The resulting leaks would have disrupted efforts to fight and contain the fire, potentially leading to greater damage.

Power supplies

Damage to the power supply cables began soon after the fire began and led to the loss of vehicle deck ventilation, the forward mooring equipment and bow thrusters. While this certainly limited the options available to the master and reduced the vessel's ability to berth without tug assistance, it did not unduly affect the condition of the vessel. Removing the option of going to anchor (except in an extreme emergency when the anchor could have been jettisoned) was arguably a positive influence, as it put the emphasis firmly on getting *Commodore Clipper* alongside. It would have been far more difficult to fight the fire and drain water from the main vehicle deck with the vessel at anchor, and the inevitable delay would only have led to the situation deteriorating further.

Far more significant was the damage to the ro-ro hydraulic control circuits. Were it not for the chief engineer and his team's skill and tenacity in repairing the two separate faults, it would have been extremely hard to open the stern door. This would have: severely hampered the fire-fighting efforts; prevented the removal of cargo; and, as the stern door was also the pedestrian access route, obliged the passengers to use other, more hazardous exit routes.

2.4.2 Effectiveness of regulations

It is inevitable that vehicle decks take up the majority of the space in a ro-ro ferry and that cables and pipework are subsequently routed through these spaces because other routes are inaccessible. The regulations allow this practice, with the proviso that cables for critical systems, such as steering gear controls, are duplicated and separated as far as possible. There is no requirement for these cables to be protected from fire or heat damage, beyond cable insulation being made of a fire retardant material. This property is of limited value if cables are exposed to a well-developed fire.

Similarly, there is no requirement to protect pipework from heat damage, and so the systems that are essential to help contain the fire are also at risk from it. Hydraulic pipework, necessary to operate moveable decks, ramps and doors can be damaged, and, if breached, will not only deny the use of this equipment, but also add to the intensity of the fire.

The effect of the design is that any of the ship's systems that need to be routed along any major part of the length of a ro-ro ferry are likely to pass through a vehicle carrying compartment. Where this occurs, the protection from fire that is required by the regulations is minimal and damage must be expected.

Many of these issues are addressed for new build passenger vessels of more than 120m by MSC.216 (82) Annex 3 which contains the requirement for them to make a 'Safe Return to Port'. Applying these provisions retrospectively to existing vessels might be disproportionately burdensome on the industry; the benefits and practicalities of this option should be carefully considered by the member states of the IMO. However, until such time as international regulations are changed, it remains the responsibility for owners and operators to identify the critical system and fire protection vulnerabilities in their vessels, as required by the ISM Code, and take appropriate mitigating actions.

2.5 STABILITY ISSUES

The potential loss of stability due to the accumulation of fire-fighting water on ro-ro passenger ships is of serious concern. This was most evident in the massive loss of life during the accident on *Al Salam Boccaccio 98*, when the vessel capsized during attempts to control a fire on a vehicle deck.

2.5.1 Deck drain blockages

The main vehicle deck water drenching system on *Commodore Clipper* was used constantly to contain the fire until the vessel began to list. The master and DPA thought that this was probably due to the main vehicle deck drains becoming partially blocked and water accumulating. As the list increased to 5° they decided to use the water drenching system intermittently, allowing more time for the water to drain away and the list to reduce. The master was mindful of the warning in the vessel's stability book highlighting the potential danger from this situation, and made a logical decision to safeguard the vessel's stability. However, cessation of drenching allowed the fire to intensify. Had the crew been able to use the drenching system continuously, it is likely that the fire damage to the vessel and its cargo would have been reduced.

The cause of the blockage was subsequently confirmed as being due to the potatoes escaping from some of the trailers, after being dislodged by the action of the fire and drenching. The loose potatoes would have floated in the water on deck, but effectively plugged the circular holes in the drain covers as the water attempted to flow away **(Figure 15)**. Although the stability book highlighted the general risk of blockages, there was nothing that the crew could have done to clear the drains during the incident; access to the covers would have been hindered both by the trailers and the fire itself.

It is evident that the design of the drains, although intended to prevent blockages, was ineffective in allowing the water to clear. The introduction of SOLAS Regulation II-2/20.6.1.5 in 2010, combined with the guidance offered in the IMO circular MSC.1/Circ.1320 regarding effective measures to ensure floating debris does not block such drains, should help to reduce the risk of similar blockages in the future.

2.5.2 Margin of stability

The decision to stop drenching was based on *Commodore Clipper*'s increasing list, but the information that was available to conduct any further analysis was limited and difficult to use. Consequently, neither the crew nor company staff ashore were able to make an objective assessment of the remaining margin of stability or the maximum permissible angle of list.

Despite both the stability book and the stability computer on board containing maximum permissible VCG data for damage stability, the data and explanatory information were limited by the following factors:

- No information was available to explain how the maximum VCG data had been derived, in particular whether it included the scenario of accumulated fire-fighting water on the main vehicle deck.

- Information was not readily available on either the effects on stability of water accumulating on deck 3, or of the arrangement of the space itself. This information was vital in calculating the volume and free surface of any accumulated water on deck.

- Although the stability book contained details of the 1995 SOLAS Conference requirement for the permissible volume of seawater on the ro-ro deck following damage, there was no analysis of the effect this would have on *Commodore Clipper*.

- Despite its approval by DNV as appropriate for the calculation of damage stability, the vessel's loading software did not incorporate a damage stability module that allowed the effect of damaged or flooded compartments, such as the main vehicle deck, to be assessed.

The stability analysis conducted by the MAIB was based on the same information that was available to the crew. It was time consuming, required reference to ship's drawings for the calculation of geometric details and a number of assumptions had to be made in order to quantify the unknown factors. It would be impractical to conduct such an assessment in an emergency situation.

Although the vertical position of the main vehicle deck, around 1m below the vessel's overall VCG, meant that all but large quantities of water on deck would have had a ballasting effect on the vessel, the potential free surface was of greater concern. With even a small depth of water covering the entire main vehicle deck area, the large effective free surface moment would have degraded the vessel's stability margins sufficiently to introduce a real risk of capsize. However, the effect of free surface would have been reduced if water had only covered part of the deck. For example, in a hypothetical scenario of water accumulating only on the vessel's port side, the stability criteria would have been met, except with very small quantities of water. Stability would even have improved as the water depth increased. As the vessel listed, any water on deck would have transferred to form a wedge, reducing the free surface effect. However, unless longitudinal sub-division can be introduced, this accumulation of water has the potential to create a state of loll. Therefore, the need to ensure the water is drained away quickly must remain a high priority.

In the analysis conducted by the MAIB, it was estimated that a wedge of about 150 tonnes of water would have generated a 5° list, and that the vessel would have complied with the required intact stability criteria in this condition. The analysis further suggested that these criteria would still have been met with even larger wedges of water that produced angles of list greater than 5°. It was not possible, within the constraints of the data and analysis methods, to determine what the maximum permissible angle of list would have been. A more detailed damage stability model or a series of hypothetical damage case examples would have been needed to provide this information.

Therefore, although the decision to stop drenching when the vessel started to list was understandable, had appropriate tools and supporting information been available to allow the vessel's stability to be quickly and accurately assessed, it is likely that the drenching could have been continued for longer. Without the ability to determine what effect the accumulation of water was having on stability, the risk of continuing to use the drenching system was unknown. Achieving the optimum balance between trying to control the fire and maintaining adequate stability, was impossible given the time and the quality of the information that was available during the incident.

2.5.3 Requirements for damage stability information

Although IMO Resolution A.265(VIII) required that the vessel's master be provided with all necessary information to ensure that adequate stability was maintained following damage, there are differences of opinion regarding the amount of information that should be available. The proposals submitted in document SLF 50/4/7 to the IMO in February 2007, went some way to resolving this. However, they were not taken forward by the IMO as it was considered that the requirement for adequate deck drains addressed the risk. SOLAS Regulation II-2/20.6.1.4.1.2 requires that further stability information, regarding the accumulation of fire-fighting water on deck, is provided to the masters of cargo ships. However, this applies only where the requirements for removing such water cannot be met.

Although the recent requirement and guidance provided in MSC.1/Circ.1320 and SOLAS should reduce the risk of debris blocking vehicle deck drains during water-based fire-fighting operations, it is unlikely that these can prevent water from accumulating in all circumstances. Therefore there is still a need for more damage stability tools, and information to be available to masters so that they can manage the effects of accumulated fire-fighting water on deck.

2.6 USE OF SPECIALISED PROFESSIONAL FIREFIGHTERS

2.6.1 Information gathering and assessment

In any emergency situation, there is a natural desire to want to find out as much detail as possible about what is happening. The right information is critical to enable effective decision making and for the optimum response to be provided. However, there is a point where the delay, effort and risk incurred from gathering information outweighs the benefit gained. The point at which this occurs will naturally vary depending on the perspective of the different organisations and individuals that are involved, but the overall balance should be considered. Difficulties in achieving this balance were evident throughout the incident, but were most acute during the early stages, when *Commodore Clipper* had not yet entered harbour.

There were two requests from *Commodore Clipper* for specialised firefighters to be flown out to the vessel; Solent Coastguard began drawing up MIRG tasking plans soon after they were first alerted at 0313. The first request from the vessel was made at 0327, shortly after boundary cooling had been started, when the fire's severity became evident to the crew. However, the request was retracted by the master soon afterwards because the information that was available to him suggested that the fire might have been extinguished. This was not the case, and subsequent investigation showed that the drenchers were unlikely to have been able to put out a fire that was capable of generating such high temperatures. Professional firefighters were far better qualified to interpret the information available at the time and, had they been able to board *Commodore Clipper*, would almost certainly have determined that the fire had not been extinguished.

The second request for specialised fire-fighting assistance came at 0618, after the extent of damage to the vessel's systems became clear. The misunderstanding between the master and the FLM led to the crew making two re-entries to the fire. They made no attempt to fight the fire; the purpose was solely to gain more detailed information to feed back to the emergency services ashore. Both re-entries exposed crew to some risk and the benefit gained was marginal. They simply confirmed that the fire was still burning; a conclusion that could have been drawn from the heat and smoke that was still coming from the main vehicle deck.

The information that the crew did obtain was passed back to firefighters via the master and coastguard officers. Inevitably, the amount of detail and relevance of the information was diluted through this chain of communication, so the risk ultimately outweighed the benefit. Similarly, the two re-entries started at around 0630 and took about 1.5 hours in total. The fire continued to burn throughout, and the time could have been better used in getting the vessel to a suitable berth, where the fire could be tackled more effectively.

Deploying professional firefighters to *Commodore Clipper* offered two potential benefits; the most significant being that HFRS could have gained first-hand knowledge of the nature and extent of the fire. This would have been relayed back to senior fire officers ashore using the terminology and format that they were familiar with. The second potential benefit was that firefighters could have started to understand the constraints on fire-fighting imposed by the vessel's design, and assess the best way to fight the fire.

In this accident, the heat and smoke that were present should have signified that the fire was still burning. The value of the information gained by the crew from their re-entries to the main vehicle deck was far outweighed by the delay caused and the risk that they were exposed to. If a high level of detailed information about the extent of a fire is considered to be absolutely necessary, then it would be better for a specialist firefighter to gather it. Firefighters are best placed to understand what information is needed, report the findings and make an assessment on the most effective way to tackle the fire.

2.6.2 Role of the master

The master did not use any distress or urgency prefixes in his first radio contact with Solent Coastguard, and his report was transferred to a working radio channel. This, and the tone of the subsequent conversation, gave the impression that the incident was relatively minor. The impression persisted, and was reinforced soon after when the master reported that the fire was possibly out. Later reports described the deteriorating situation, but never prompted Solent Coastguard to consider that it warranted a “Mayday” or “Pan Pan” designation, or to instigate SOLFIRE procedures. It is understandable why crew may not want to overstate an emergency on board their vessel. This does, however, carry the risk that it may then become difficult to subsequently change the emergency services’ perception of the severity of the situation, and of the help that is therefore needed. The consequence, as in this case, is that the most appropriate level of response may not be provided.

Solent Coastguard was the search and rescue co-ordinating authority and the statutory powers of intervention exercised by SOSREP had not been used. The Fire Services Act does not apply to vessels at sea and HFRS had no jurisdiction until *Commodore Clipper* was alongside. Consequently, *Commodore Clipper*’s master remained in command of dealing with the emergency, and to request any assistance that he felt to be appropriate was at his discretion. While this position might seem clear in isolation, in practice it was complicated by the need to obtain QHM’s permission to enter Portsmouth harbour. Similarly, when communicating with the emergency services it is natural to defer to their judgment and to comply with their requests.

In the early stages of the incident, the master’s intention was to berth as normal and request HFRS to deal with the fire on arrival at PIP. This was a logical plan; the master was very experienced in normal ferry operations and knew the crew were unlikely to be able to enter the main vehicle deck and fight the fire successfully, because the trailers were parked so close together. His report at about 0340, that the drenchers might have extinguished the fire, was reasonable in the circumstances; a detailed study of SOLAS and the relevant circulars, or practical knowledge of serious vehicle fires would have been needed in order to appreciate that vehicle deck drenchers are no longer considered to be capable of extinguishing such fires.

Doubt was cast on the plan to enter Portsmouth harbour at about 0500, when *Commodore Clipper*’s list became apparent and control of its steering equipment deteriorated. The risk of the vessel capsizing, or being in collision increased considerably, and in those circumstances it was not desirable from either the vessel’s or the port’s perspective for *Commodore Clipper* to enter confined waters. However, the crew’s efforts and the tug provided by QHM had mitigated these risks by about 0630, and the master’s original plan became a viable option again.

Further deterioration in the vessel’s condition was possible and Solent Coastguard and QHM made further contingencies. Solent Coastguard focused on assessing the condition of the fire and QHM on navigational safety. Both were prudent precautions, but each placed additional burdens and delays on the master. The master held the appropriate PEC, but QHM’s requirement for an Admiralty pilot was an implicit condition on granting permission to enter Portsmouth harbour. Similarly, the master felt obliged to provide more detailed information about the extent of the fire.

With tugs on station, a master who was an experienced PEC holder, and a fire that was burning but contained, *Commodore Clipper* could have entered Portsmouth Harbour from 0630 onwards and been alongside soon after 0700. However, the master (and the DPA, who was on the bridge throughout) were heavily influenced by the shore authorities and were reticent in challenging their requirements.

2.6.3 Constraints on the use of MIRG

The MIRG does not have authority to unilaterally deploy to vessels in distress and must obtain the master's permission to do so. The FLM needed to check that this permission had been given and asked Solent Coastguard officers to confirm that *Commodore Clipper* had requested MIRG assistance. The FLM was expecting the coastguard officers to simply confirm or otherwise that a request had been made. However, it was clear from the coastguard's response, that they interpreted this request for confirmation as a challenge rather than the assurance that was intended. This led to the coastguard officers, and ultimately the FLM, to communicate with the master to check if the MIRG was required. The master also interpreted this check as more of a challenge than a confirmation, and committed his crew to enter the fire in an attempt to gain the information that he thought was needed.

In the event, the confusion over whether a request had been made, and subsequent misinterpretation of the conversation between the FLM and the master, led to the MIRG not being deployed. Requests from vessels for MIRG assistance must be accurately recorded and, where clarification is required, it should be made very clear that this is simply to confirm, rather than to challenge the request.

If a MIRG team had been activated, there would still have been several obstacles to overcome before they could have made a positive contribution. In order to be credible, a MIRG team is likely to consist of at least six firefighters all carrying the associated marine safety and fire-fighting equipment. The team takes time to assemble and is a substantial load to transfer by helicopter. It is considered to be preferable for the whole team to be transferred in one helicopter movement; even if it had been serviceable, R104 was thought to be too small to achieve this task. The helicopter from RAF Wattisham (R125) was sufficiently large, but would have taken at least an hour to reach Lee-on-the-Solent before the MIRG team could embark.

If the MIRG team had been activated immediately after the request at 0618, it is unlikely that they could have been on board much before 0830. Once on board, they would have had to make their preparations before assessing the fire. It is estimated that they would not have been able to provide a detailed report on the condition of the fire until about 0930. It is likely that a larger MIRG team would have been needed on board before they would have considered entering the main vehicle deck.

While a MIRG team could have provided a detailed assessment of the fire on *Commodore Clipper*, this would have taken several hours to achieve. In order to avoid unnecessary delay, if deployment of a MIRG team is thought to be beneficial, it must be started at the earliest opportunity. Even if a MIRG team had been deployed, it is likely that they would have reached the same conclusion: that the most effective way of fighting the fire was to bring the vessel alongside a berth.

2.6.4 Specialised planning

Senior fire officers were aware that *Commodore Clipper*'s vehicle deck drenchers were unlikely to extinguish the fire and that a large number of firefighters would be needed to deal with what they expected to be a protracted incident. Conversely, the crew, company managers and coastguard officers felt that once the vessel was alongside, firefighters would extinguish the fire relatively quickly and the incident would soon be over. These different expectations demonstrate that there is a clear benefit to seeking specialised fire-fighting advice early on in an incident to influence how the marine phase of the emergency is managed. Activating SOLFIRE procedures early during the incident would have provided the means to achieve this.

2.7 ENTRY TO HARBOUR

2.7.1 Pilotage requirements

QHM staff were confronted with two conflicting problems: satisfying themselves that *Commodore Clipper* did not pose an unacceptable risk to the military port, but at the same time being aware that the vessel's condition would deteriorate (and the risk would increase) while they did so.

The duty tug was sent to assist the vessel in case further steering problems were encountered. As the situation deteriorated, sending the second tug was a prudent precaution as *Commodore Clipper* could still be brought into the harbour even if it lost all power. It was QHM's standard procedure to have an Admiralty pilot to oversee vessel movements in such circumstances, and therefore it was logical to do so in this case. Equally, transfers of personnel by military helicopter are more common for warships and MOD vessels and QHM would not necessarily appreciate the potential limitations of the coastguard helicopter's operating rules. It is therefore understandable, when the background to the decision is considered, that QHM thought that embarking an Admiralty pilot by helicopter offered additional assurance without imposing a significant delay.

The crew of R104 had not been briefed about the situation on *Commodore Clipper* or formally tasked to embark the Admiralty pilot. They did not appreciate the significance of the task and were concerned that they should not breach their operating rules. Given the potential consequences of any further delay to getting *Commodore Clipper* alongside, it ought to have been reasonable to conduct the task under SAR rules, as was done later. Solent Coastguard did not make this declaration, and instead sought to circumvent the problem by embarking a CGLO as well. It was unfortunate that, after the confusion was resolved, R104 was found to be unserviceable. However, if the significance of embarking the Admiralty pilot had been recognised properly, R106 could have been tasked immediately and the additional 25 minute wait that followed could have been avoided.

Problems with embarking the Admiralty pilot by helicopter led to a 2 hour delay, from about 0800 to 1000. PIP attempted to assist by sending a commercial pilot out to *Commodore Clipper* by boat. He could have been brought on board using the rescue boat, but as the impression was given that only an Admiralty pilot could be used and that he would be embarked at any moment, the master saw no benefit in exposing the commercial pilot to the potential risk of being hoisted up in the rescue boat. QHM and PIP had not discussed pilotage, but if they could have agreed that a commercial pilot was acceptable, he could have been on board by about 0830.

It was an understandable reaction for QHM staff to want an Admiralty pilot on board *Commodore Clipper* to give them first hand assurance that it was safe for the vessel to enter the harbour and to provide expert assistance in case the propulsion failed and a cold move was required. However, in practice the Admiralty pilot could only achieve a limited amount and the consequences of the delay in him getting on board outweighed the benefit of him being there. The Admiralty pilot was not authorised to pilot a commercial vessel to a PIP berth and the master was already qualified by his PEC to transit through the harbour and control the tugs. The master conducted the act of pilotage when *Commodore Clipper* did eventually enter Portsmouth harbour and, while the presence of the Admiralty pilot was welcomed, it was not necessary.

The delay caused by the confusion and technical difficulties in embarking a pilot led to further fire damage and needless risk. At the first sign of delay, the need to embark a pilot should have been re-evaluated and alternative solutions considered. There were at least three other options available, including: embark the commercial pilot; allow the master to continue using his PEC, or conduct remote pilotage from a boat. The delay also prompted renewed debate over whether to deploy a MIRG team to *Commodore Clipper*. The tidal window for an unpowered vessel to safely enter Portsmouth harbour was closing, and the delay that would have been incurred by either a MIRG deployment or waiting for the next tidal window would have been substantial.

2.7.2 Planning and co-ordination

Delays to berthing all stemmed from the need to check the condition of the fire and mitigate potential navigational risks. It was clear that the vessel would attempt to enter port at some point and it was widely assumed that it would go to its usual berth.

As the condition of the vessel deteriorated, the master preferred to use one of the more accessible berths, ideally Berth 2. He was also well aware that he would need to turn the vessel through 180° in order to lower the stern ramp onto the linkspan and provide the necessary access to shore. However, despite the time available, this phase was not discussed in much detail until after 1000, when *Commodore Clipper* had started the entry to the harbour.

Both CMS and PIP staff had expected *Commodore Clipper* to use either Berth 4 or 5 and HFRS had set up its equipment accordingly. QHM staff had thought it too risky to turn the vessel, and suggested that it berthed bows onto the linkspan. The master's decision to turn the vessel and use Berth 2 was entirely logical, and was agreed with PIP, but because it had not been discussed with all the other organisations involved, HFRS had set up in the wrong place and insufficient consideration had been given to how this might affect access or passenger evacuation.

The lack of planning and co-ordination meant that firefighters had to relocate from one berth to another, and it denied them the opportunity to make best use of the port's infrastructure. Proper discussion, between PIP, CMS, HFRS and *Commodore Clipper*'s master, and appropriate preparations were needed; it might have been possible to use a different berth, even if it was only temporarily, to provide better options for access to the vessel.

2.8 PASSENGER DISEMBARKATION

2.8.1 Design factors and the effect of regulations

All vessels are required to have a means of access to shore. In ro-ro ferries, this can be via the vehicle ramp, provided there is a barrier to separate pedestrians from vehicle traffic. *Commodore Clipper* traded to ports where the tidal ranges are large, and in the order of 10-13m. Few foot passengers were carried and there was no commercial need, or regulatory requirement to make the substantial investment that would have been needed to provide a separate foot passenger access that would work at all states of tide. Consequently, this had not been considered as a design or operational factor.

SOLAS requires that a protected means of access is provided from assembly areas to life saving appliances, but there is no similar requirement to provide a protected route to a shore access point. As most of the available weather deck was taken up by cargo, there were very few places where a gangway could be secured. The design of the vessel also meant that access routes from the accommodation areas to a gangway were obstructed, to a varying extent, by vehicles. On 16 June, the density of vehicles on the upper deck precluded passengers from using the gangway during the short time that it was in place. If the vessel had arrived earlier on the rising tide and the best routes through the vehicles been researched, it might have been possible, under careful supervision, to disembark the able-bodied passengers with an acceptable degree of risk.

Another possible option might have been to use the forward mooring deck and it is conceivable that, at an appropriate berth, a gangway could have been secured there. Assuming that the route past the relatively well-spaced passenger cars at the forward end of the upper vehicle deck had been kept clear of smoke[24], passengers could have been escorted down the green stairs to the upper vehicle deck, onto the forward mooring deck and ashore. However this was not possible as the part of the berth that was adjacent to the forward mooring deck was a raised platform and it would not have been possible to put a gangway there.

SOLAS regulations are intended to provide a protected route to life saving appliances in an emergency. The need for a similar pedestrian access route to shore should be considered.

2.8.2 Port infrastructure

It was fortuitous that PIP had a gangway that was capable of reaching *Commodore Clipper*'s weather deck, a crane and the personnel available to lift it into place. While the layout of Berth 2 limited where the gangway could be positioned, there were places where the gangway, HFRS's ladder and ALP could be set up. These provided alternative means of access to *Commodore Clipper* which might not have been possible to arrange at other types of berth, particularly those where mooring dolphins are used.

PIP had not carried out a structured assessment of how assistance might be provided to a distressed vessel in its port, and was fortunate that it had resources available to support the vessel and the emergency services. All port operators should consider how their infrastructure and resources could be used in an emergency, particularly to support the vessels that call regularly. A structured assessment might conclude that:

- a berth that is most suited to supporting a vessel in distress is identified;
- a list of staff with specialised skills who can be called to advise and assist, is compiled;
- a list of sub-contractors who can provide specialised equipment or services is kept
- or, that a port is unsuited to supporting anything more than a minor incident.

Whatever the outcome of the assessment, the conclusions should be readily available to inform and advise managers and the emergency services on the most effective action in the event of future incidents.

2.8.3 Balance of risk to the passengers

It is a fundamental principle that people should be evacuated away from the scene of an emergency so that fewer are put at risk of injury. However, it is difficult to justify putting this principle into practice when the risks associated with the evacuation are considered to be greater than those faced at the scene. This was the case on *Commodore Clipper* where the cargo density, limitations of the vessel's design and the layout of the berth combined with the potential risks from using the vessel's life saving appliances. The consensus that the passengers were safer remaining on board was logical and was borne out during the incident. However, it was an undesirable situation imposed by shortcomings in the design of the vessel and its equipment, all of which were allowed by SOLAS regulations.

[24] When *Commodore Clipper* first berthed alongside, the forward end of the upper vehicle deck was free of smoke. Smoke accumulated in this area later when the green stairwell was opened up to help smoke exhaust from the main vehicle deck.

If it is accepted that a fire in a special category space might not be extinguished while the vessel is at sea, then a means of disembarking passengers and crew with a minimum risk of injury should be provided once the vessel has berthed. Although lifeboats and marine evacuation systems can be used when a vessel is alongside, in principle it should be safer to allow passengers to walk (or be assisted) ashore via a gangway.

The 2008 and 2009 amendments to SOLAS address this issue and the addition of Regulation 3.9 to Chapter II-1 requires that a means of embarkation and disembarkation for use in port is provided. However, this only applies to vessels constructed after 1 January 2010, and there is no requirement for there to be a protected route from the assembly station to the point of disembarkation. On existing ro-ro passenger ferries where this regulation does not apply, it would be good practice for operators to consider how they might disembark pedestrians under the requirements of the International Safety Management[25] Code to establish emergency operating procedures.

2.9 FIRE-FIGHTING TACTICS

2.9.1 Access to the seat of the fire

All ferry operators need to carry the maximum amount of cargo in their vessels to make voyages economically successful, and there are no regulations that specify a minimum distance between each vehicle. In practice, access routes between vehicles are only maintained where crew have to reach equipment, or where passengers need to get out of their cars. The issue becomes most acute with unaccompanied freight trailers that are loaded by stevedores and lashed down by the crew. Crew are expected to be able to move under the trailer load-beds and through narrower gaps than would be expected of passengers. The distance between trailers on the main vehicle deck of *Commodore Clipper* was generally in the order of 150-450mm and in some cases, adjacent trailers were nearly touching. This density of trailers encourages higher rates of fire growth and reduces the effectiveness of fixed drencher systems and portable fire-fighting equipment.

Crew and firefighters saw water from the drencher system bouncing off the roofs of the trailers and running down their sides, while the cargo continued to burn inside, sheltered, yet ventilated through the damaged curtain-sides. Moving around the main vehicle deck was very difficult in normal circumstances and became far worse when wearing BA. Similarly, man-handling a charged fire hose in between trailers to direct water onto fires set deep inside trailers was also extremely challenging. All this was made harder by the low visibility, cargo debris and chain lashings.

Effective access could only be gained from the stern ramp, and ventilation was needed to maintain adequate visibility. HFRS officers accepted that this would increase the intensity of the fire and, although they attempted to mitigate this, they were unable to prevent it completely. If this method of attacking the fire is to be used, it must be expected that the fire will intensify before it is brought under control. The potential risk to any passengers on board will increase during this period and it would be preferable to evacuate all non-essential personnel before attacking the fire in this way.

Balancing the priorities of evacuating passengers and creating access to fight the fire requires a thorough understanding of the constraints of the vessel's layout and the time needed to extinguish a fire of this type.

[25] ISM Code, 2010 edition, section 8, emergency preparedness

2.9.2 Cargo handling

It was evident from the attempts of both crew and firefighters that the most effective way to attack the fire was to remove some freight trailers and improve access. This required specialised skills and equipment and could only be achieved with co-operation between HFRS, the crew and the stevedores. The crew soon used up the limited supply of charged BA cylinders kept on *Commodore Clipper*. There was no means to recharge them on board and, if there had been, it would probably have been time consuming and risked filling the cylinders with smoke-contaminated air. It was good fortune that the BA sets on the vessel were compatible with those used by HFRS, and the experience gained from previous joint exercises allowed agreement to be reached for the crew to use HFRS' cylinders.

The operation to remove cargo was suspended when the smoke became too thick for the stevedores to continue working. More cargo still needed to be removed and the alternative solutions of using firefighters to operate a tugmaster or utilising heavy recovery contractors both had significant limitations. The rate of progress with either option would have been slower, and both brought additional risks of injury and damage.

HFRS, PIP and CMS had not been confronted with a similar problem before, and there was no contingency plan to fall back on. It is possible that, with some of the cargo removed, firefighters could have had a better chance of putting out the remaining fires, but progress would have been very slow and difficult.

The stevedores working at PIP had no formal role in responding to emergencies in the port and had no training for working in smoke-filled environments. That one of them should volunteer to work in BA, when his only prior experience was a holiday scuba-dive, was extremely commendable. The risk of him becoming trapped or injured as a result of his unfamiliarity with the equipment was clear, but the potential benefits, if he could do the work safely, were substantial.

The stevedore who used BA to continue operating his tugmaster was monitored very carefully. A step-by-step procedure was agreed that should have meant that there were no crew or firefighters in the main vehicle deck when the tugmaster entered. This required close supervision, constant communication and careful co-ordination. It was extremely fortunate that when this broke down later on, the two firefighters who found themselves in the path of the approaching tugmaster were able to escape.

Ultimately, the ability to remove the unaccompanied trailers was one of the key factors in dealing with the fire successfully, but it was time consuming, labour intensive and required a combination of specialised skills and equipment. Three trailers were still alight when they were removed, despite many hours of drenching and other fire-fighting efforts. Had it not been possible to remove the trailers, the fire-fighting tactics would have needed to be very different and probably focused on containment until the fire burnt itself out. Far more material would have been involved, including the vehicle tyres and the diesel fuel carried by the refrigerated trailers. The damage would have been significantly greater and, inevitably, the passengers would have had to be evacuated by lifeboat and via the marine evacuation system.

2.10 MANAGEMENT OF THE EMERGENCY RESPONSE

2.10.1 Responsibility

No single person or organisation had responsibility for the whole incident. Responsibilities were broadly divided as follows:

- Master of *Commodore Clipper* – safety of the passengers, crew and the vessel; prevention of pollution
- CMS – supporting the master and managing the commercial matters associated with the incident
- Solent Coastguard – co-ordination of maritime search and rescue
- MCA – maritime search and rescue, MIRG, salvage and counter-pollution response co-ordinating with the SOSREP and statutory port state inspection of the vessel
- HFRS – MIRG and fire-fighting once the vessel was alongside
- QHM – instigator of the SOLFIRE response, safety, and regulatory authority of the military port
- PIP – SHA for their berths and CHA for the wider Portsmouth harbour area.

All shared a common aim, but each had a different perspective on how this should be achieved and what the relative priorities were. There were conflicting risks that needed to be balanced, and each organisation relied on the others for advice and resources. It was evident, from the discussions during the incident, that a shared strategy was never agreed between all the parties and that a common understanding of the priorities was not reached until very late on. The scope of the decisions that needed to be made was apparent in discussion about the following subjects:

- Whether *Commodore Clipper* should enter Portsmouth harbour or go to anchor
- The extent of the fire, and whether the MIRG team should be deployed
- What the effect of the fire was on the vessel's condition
- What were the most appropriate fire-fighting tactics once the vessel was alongside; and
- When and how the passengers should be evacuated.

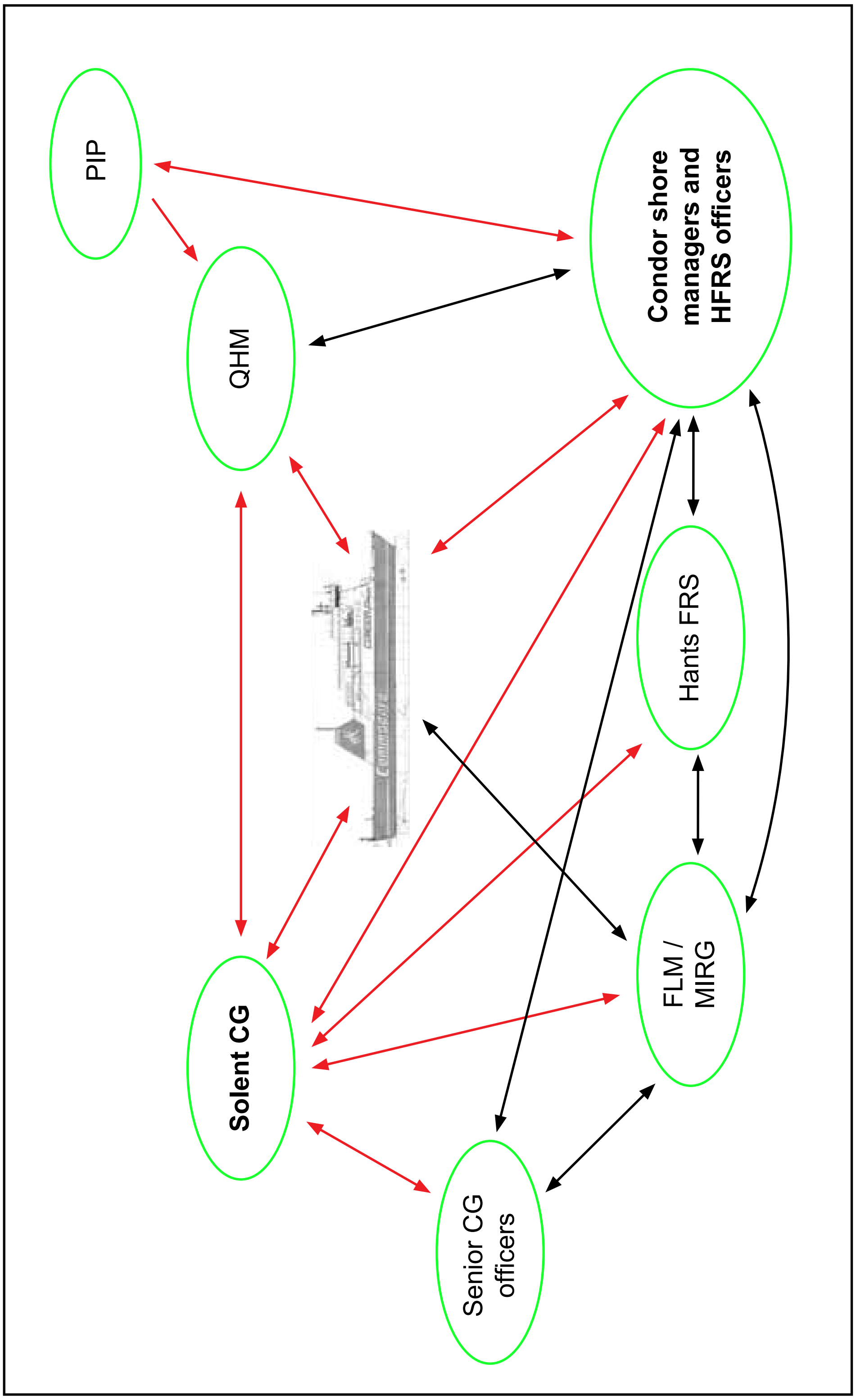
While these issues have been recognised by the MCA in its internal review of the incident, they are relevant to all organisations that could find themselves involved in a similar emergency.

2.10.2 Communication and co-ordination

The key to managing all the phases of the incident efficiently was communication and co-ordination between all the organisations. This is exactly what the SOLFIRE procedures were intended to support, but because the requirement to send representatives to a common control centre was interpreted differently, the potential benefits were not realised.

Instead, local control centres proliferated: on board *Commodore Clipper*; Solent Coastguard; HFRS, CMS company office, CMS office at PIP, PIP emergency team and so on **(Figure 33)**. Maintaining effective communications and a common sense of purpose in that environment was almost impossible. This was most evident during the middle phase of the incident, from 0630 when *Commodore Clipper* was attempting to enter the harbour, to 1230 when shore-based fire-fighting operations began in earnest. Significant amounts of time were lost at a critical point because none of the organisations could adapt quickly enough to the changing circumstances on their own. All the control centres were interdependent, and the lines of communication were not good enough to enable them to function collectively.

Figure 33



Lines of communication during the response to the incident

In any incident where multiple agencies need to co-operate, it is essential that they can share a central focus to communicate and co-ordinate their activities. If, as in this case, an incident appears to be minor at the outset and there is doubt as to whether such effort and infrastructure are warranted, it is far easier to scale back an organisation than to build one in a hurry, and the worst case should be planned for.

2.10.3 The role of the SOSREP

The role of the SOSREP has been designed to provide a focus for managing marine emergencies. In this case, the CPSO was informed several hours after the incident began, and then did not take an active part until later on in the afternoon. The SOSREP was not aware of the incident and did not become involved until much later. He had little opportunity to understand the situation or direct the CPSO and his own staff.

Although statutory powers of intervention were not required and the SOSREP's role was limited in this incident, in different circumstances there were several potential areas where his expertise and statutory powers could have been beneficial. These might have included:

- Advising that local contingency plans (such as SOLFIRE) be activated or enhanced
- Obtaining a 'port of refuge'
- Obliging the master to accept a tow
- Obliging the master to accept a marine casualty officer to assess the condition of the vessel
- Requiring evacuation of passengers and non-essential crew/staff.

For any of these measures to be effective, it is essential that the SOSREP is properly briefed via the coastguard and CPSO reporting chain.

2.10.4 Jurisdiction

The problem of co-ordination was compounded by issues of jurisdiction. Portsmouth harbour's operation is complicated by the co-existence of the military and commercial ports, but the major issues apply to most port areas.

The master remained in command of his vessel throughout and Solent Coastguard was, by legislation, the co-ordinating authority for maritime search and rescue. Neither search nor rescue was required and its role was largely to facilitate transfer of the Admiralty pilot for QHM and to make arrangements with HFRS. However, Solent Coastguard also had a responsibility to its parent organisation, the MCA, to inform potential counter-pollution, salvage and port state inspection responses.

Transfer of responsibility was complicated when QHM instigated SOLFIRE procedures. These stated that responsibility for control of the incident should pass from Solent Coastguard to QHM. While this might be possible at a practical level, there was neither the mechanism nor intention to transfer all the MCA's responsibilities to a harbour authority. There was no formal handover of responsibility and the limit of QHM's control was not discussed or defined.

Similarly, PIP had jurisdiction as CHA for the whole area and SHA for their berths, but did not have an active role until relatively late in the incident. There was no record indicating that PIP had agreed to *Commodore Clipper* berthing in its port, and the vessel's arrival could be interpreted as a 'fait accompli'. PIP's limited involvement in planning and managing the early phases of the incident restricted the opportunity for them to influence pilotage or make best use of the port's infrastructure.

The MCA's search and rescue function was discharged when *Commodore Clipper* berthed at PIP and the Fire Services Act applied, making HFRS the lead emergency service. Counter-pollution, salvage and port state responsibilities remained, however, and as the incident was still essentially a marine emergency, the MCA clearly had an ongoing interest. This was tested during the afternoon as MCA personnel became increasingly concerned about the safety of the passengers.

The duty CPSO had not been told about the incident until several hours after it had started, and neither he nor the port state control surveyor had been involved in discussions about the fire-fighting tactics and passenger evacuation. Both had important responsibilities, but because they did not have a full appreciation of what was happening they interpreted events, such as the use of the heeling system to help drain water from the vehicle deck, incorrectly.

It was apparent that MCA staff did not fully appreciate how the extent of their jurisdiction or the powers of the relevant legislation should be implemented in this case.

It was fortunate that the disagreement over the disembarkation of the passengers was defused; it was an unnecessary distraction to those who were attempting to fight the fire. It is more concerning however, to consider what might happen in a genuine dispute, where the wider aims of SOSREP differ from local objectives. It is essential that the MCA works with SOSREP, the fire and rescue authorities and the ports industry to develop a common understanding of how control of a marine emergency is managed as a vessel in distress approaches the coast, enters port and berths.

2.10.5 Understanding specialised vessel types

This accident demonstrates that dealing with a fire on a ro-ro ferry requires careful thought and co-ordination due to the specific needs and limitations of the vessel's design. The best example of this was the importance of access to the main vehicle deck – for embarking the pilot, fighting the fire and disembarking the passengers. Understanding the layout and operation of *Commodore Clipper* was vital in fighting the fire effectively and safeguarding the passengers. For example, QHM's advice not to turn *Commodore Clipper* off the berth, was well intended. However, this would have hindered attempts to fight the fire.

In order to enable coastguard officers to provide the best response, the MCA should work with vessel operators and the ports industry to identify the key factors to consider when dealing with the principal types of specialised vessel. This should result in producing guidance, available to all the organisations likely to be involved in an emergency, which should include areas such as:

- Main risk factors and high priority issues associated with the vessel type
  - eg. vehicle deck drenching systems are unlikely to extinguish a fire and may reduce a ro-ro vessel's stability
- The main limitations and requirements of the vessel type
  - eg. firefighters will have great difficulty fighting a fire on a vehicle deck densely packed with high-sided vehicles and trailers

- The type and extent of information that needs to be gained from the vessel in distress in order to inform decisions
  - eg. are manoeuvrability and stability at risk or degraded as a result of the fire?
- The range of potential options that should be considered
  - eg. take time to assess the vessel at sea, or bring it alongside as soon as possible to limit further damage
- The factors that should be considered in reaching a decision
  - eg. availability of berths with a compatible linkspan and/or passenger access facilities
- Specialised skills and equipment that might be required
  - eg. cargo handling equipment

This guidance should be readily available and tested routinely in exercises to ensure that it remains relevant and is of value when it is needed.

2.10.6 Effective use of available assets

A MIRG team was available and could have been deployed to *Commodore Clipper*. If a team had been on board, they could have provided valuable information to their counterparts ashore that might have improved the overall response to the incident. However, this information would have taken time to gather and, if this option was to be used without imposing undue delay, it should have been done as soon as possible. In this case, the most appropriate time to deploy the MIRG would have been after the first request from *Commodore Clipper* at 0327.

Coastguard helicopters are provided to conduct SAR operations. Embarking the Admiralty pilot fell outside the strict definition of SAR yet, if it is accepted that his presence was essential, it had a direct influence on the safety of *Commodore Clipper* and everyone on board. Coastguard officers must have the ability to identify when it is appropriate for SAR assets to be used outside their normal definitions of employment, and also have the confidence to authorise such activity.

2.10.7 Shared strategic plan

With several organisations involved, a common strategy for dealing with an incident is fundamental to providing and co-ordinating the most effective response. Although all the organisations involved in assisting *Commodore Clipper* had the same ultimate aim and were equally well intentioned, there was little shared planning and no combined strategy. It was inevitable that, while individual component parts worked well, the overall response was disjointed and delayed while organisations sought to keep pace with the incident.

The most effective way of developing a common strategy would have been for the different organisations to co-locate at a shared control centre. This was what QHM had intended by instigating SOLFIRE procedures. It is essential that all organisations contribute to these local procedures in order to realise the benefit of shared planning and control.

2.11 WIDER RISKS

2.11.1 Vulnerability of vehicle decks

With ro-ro decks and special category spaces taking up such a large proportion of a typical ferry, emergencies in these areas will have a significant impact on the vessel as a whole. This is exacerbated by the lack of any structural fire protection between special category spaces and weather decks where vehicles are stowed, and compounded by the limited effectiveness of fixed water spray systems. Without prompt and effective boundary cooling, a moderate fire can spread rapidly throughout its own deck and into adjacent vehicle stowage areas.

In theory, the passenger and crew areas are protected by "A60"[26] boundaries, but so much flammable material is available in a vehicle fire that it can grow to an extent where it will overcome an A60 rated material. This was evident in both the *Und Adriyatik* and *Lisco Gloria* cases, where the fires grew so rapidly that all those on board were forced to abandon ship. In contrast, the fires on *Commodore Clipper* and *Pearl of Scandinavia* were only contained by the vehicle deck drenchers and manual fire-fighting methods. Without these, and the skill of the crew in using them reliably, it is almost certain that the fires would have spread and threatened passenger and crew areas.

As well as posing a fire risk to the rest of the vessel, the special category space on *Commodore Clipper* was a critical compartment for many other functions. Access (in several forms), integrity of ship's systems and stability were all compromised, and the vessel became increasingly vulnerable due to what was only a moderate fire in a single compartment.

2.11.2 Flammability of road cargoes

There are no requirements to limit the flammability of the materials used in the construction of road trailers that are carried on ships. The constructive total losses of *Und Adriyatik* and *Lisco Gloria* clearly illustrate the effects of a fire involving many burning vehicles. Tests conducted in this investigation indicate that the curtain-side and cargo packaging materials were easily ignitable and released significant amounts of thermal energy. Yet these were innocuous vehicles and cargoes, typical of many and difficult to justify describing as being 'hazardous'.

Measures to limit the flammability of road trailers that are carried on ships should be considered. This would not only benefit marine traffic, but also reduce the risk to road transport, particularly where trailers pass through major tunnels or are stored in other enclosed structures.

2.11.3 Ability of existing measures to control fires in vehicle decks

The 38 cases involving fires on vehicle decks of ro-ro ferries reported to the MAIB in the 15-year period from 1995 to 2010 indicate the potential future risk posed by fires in special category spaces. However, existing fixed systems and structural fire protection on ro-ro vessels may not be able to contain or extinguish a fire. Prompt crew intervention is required just to contain the fire, and if a full cargo is being carried there is little chance of the crew being able to extinguish anything more than a small fire while the vessel is at sea.

Existing measures to control fires in vehicle decks are not capable of dealing with a well-developed vehicle and cargo fire. The current efforts that are underway at the IMO, to improve the fire safety of ro-ro ferries, should be supported. However, it must be remembered that most of these measures apply only to new vessels.

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[26] In accordance with the provisions of SOLAS Chapter 11-2 Regulation 20.5

Retrospective action to control the risk on existing vessels, should be considered more widely as the likelihood of electrical faults can often increase with older equipment.

This report, along with the reports into the fires on board the ro-ro vessels *Lisco Gloria* and *Pearl of Scandinavia*, should be reviewed by the IMO sub-committee on Flag State Implementation as a basis for stimulating a comprehensive review, the aim of which is the improvement in fire protection measures on ro-ro vessels constructed prior to 1 July 2010 to enhance their survivability and safe return to port.

2.12 FATIGUE

There is no evidence that any of the crew were suffering from fatigue and, therefore, it is not considered a contributing factor to this accident.

SECTION 3 - CONCLUSIONS

3.1 SAFETY ISSUES DIRECTLY CONTRIBUTING TO THE ACCIDENT WHICH HAVE RESULTED IN RECOMMENDATIONS

1. The electrical protection devices fitted to *Commodore Clipper*'s reefer power supply system met the classification society's requirements and were functioning correctly. However, they were not capable of detecting the fault in the reefer cable that was connected to trailer CRF459. [2.2.3]

2. High cargo density and debris severely restricted the ability of crew and firefighters to move inside the main vehicle deck, and limited their ability to fight the fire. [2.3.3]

3. Due to the high cargo density, the best route for firefighters to attack the fire was through the stern ramp. This ventilated the fire, increasing its intensity. It would have been preferable to evacuate non-essential personnel before attacking the fire in this way. [2.9.1]

3.2 OTHER SAFETY ISSUES IDENTIFIED DURING THE INVESTIGATION ALSO LEADING TO RECOMMENDATIONS

1. There were no appropriate tools and supporting information available to assess the effect of the entrained water on the main vehicle deck on the vessel's stability. Consequently, the only remaining option was to cease drenching while the list reduced. [2.5.2]

2. Despite the introduction of practical measures to reduce the likelihood of deck drains being blocked, it is impossible to completely prevent water from fire-fighting efforts from being entrained on vehicle decks. The need for adequate stability tools and information to be available to masters remains. [2.5.3]

3. The value of the information gained by the crew from their re-entries to the fire was outweighed by the delay caused and the risk that they were exposed to. If such detailed information about the extent of a fire is required, it is best gathered by a specialist firefighter who understands what is needed and how to report the findings. [2.6.1]

4. Constraints on the deployment of a MIRG team mean that a positive request must be received before one can be activated. There is also a significant lead time from when they are requested, to when they can begin to achieve positive results. If a team is to be deployed, the request must be unambiguous and the team should be activated at the earliest opportunity. [2.6.3]

5. The lack of planning and co-ordination over which berth *Commodore Clipper* should use led to further delay, as firefighters had to relocate from one berth to another, and denied any opportunity to make best use of the port's infrastructure. [2.7.2]

6. The design of *Commodore Clipper* meant that there was no effective shore access point for passengers other than via the main vehicle deck and stern ramp. This met the requirements of the regulations. [2.8.1]

7. While PIP had the resources to offer support to *Commodore Clipper* and the emergency services, this had not been previously considered. It was good fortune that it was available. All ports should conduct a structured assessment of how their infrastructure and resources might be used to best effect in the event of a similar emergency, particularly to support vessels that call regularly. [2.8.2]

8. The decision not to disembark the passengers until after the fire had been extinguished was logical and based on the balance of risk. However, this decision was dictated by shortcomings in the vessel's design and the associated regulations. It would be good practice for all ferry operators to consider how they might disembark pedestrians in similar circumstances, under the requirements in the ISM Code to establish emergency operating procedures. [2.8.3]

9. The ability to remove the cargo from *Commodore Clipper* was a key factor in dealing with the incident successfully, but it was time consuming, labour intensive and required a combination of specialised skills and equipment. [2.9.2]

10. It is essential that the MCA works with SOSREP, the fire and rescue authorities and the ports industry to develop a common understanding of how control of a marine emergency is managed as a vessel in distress approaches the coast, enters port and berths. [2.10.2]

11. In order to enable coastguard officers to provide the best response, the MCA should work with vessel operators and the ports industry to produce guidance that identifies the key factors that should be considered when dealing with the main types of specialised vessels. [2.10.3]

3.3 SAFETY ISSUES IDENTIFIED DURING THE INVESTIGATION WHICH HAVE BEEN ADDRESSED OR HAVE NOT RESULTED IN RECOMMENDATIONS

1. The fire started due to sustained overheating, caused by an assembly error in the reefer cable plug that was connected to trailer CRF459. [2.2.1]

2. There was no evidence of any electrical faults on trailer CRF459's refrigeration equipment and no sign of electrical or mechanical overload. [2.2.2]

3. The reefer power supply connections on the main vehicle deck were to IP44 rating rather than the IP55 rating that was required by the classification society. While the high resistance fault in the plug was unrelated to ingress protection, connectors with a higher IP rating are more robustly constructed and less likely to develop, and ignite from a similar high resistance fault. [2.2.3]

4. There was no requirement for any of the materials used in the construction of road trailers to have any fire resistant properties. The materials that were used in the curtain-side and cargo packaging materials in trailer CRF459 were, by comparison with other materials used in passenger vessels, easy to ignite and burnt readily. [2.2.4]

5. Although both the second officer on the bridge and the third engineer responded to the fire alarm very quickly, both initially interpreted it as being due to a technical fault, delaying the response to the fire. Given the potential for rapid fire development on vehicle decks, it is essential that crew react positively to fire alarms and initiate the proper emergency response. [2.3.1]

6. There is no requirement in the regulations for a vehicle deck water drenching system to be able to extinguish a fire, and it would be technically demanding to achieve this where vehicles are carried in high densities. Vehicles are designed to resist water ingress but are, by comparison with other materials used in the construction of passenger vessels, extremely flammable. [2.3.2]

7. At sea, it would be impractical for a crew to manually extinguish a well-developed fire that is located deep in a fully loaded ro-ro vehicle deck. [2.3.3]

8. The deck boundary between the main and upper vehicle deck had no thermal insulation. Without the boundary cooling that was applied by the crew, it is likely that heat would have ignited the tyres of the cars parked on the upper vehicle deck, allowing the fire to develop dramatically. [2.3.4]

9. Fire damage to cables and pipework running through the main vehicle deck caused several important systems to malfunction and threatened the vessel's ability to contain the fire and return to port. [2.4.1]

10. Regulations require that only minimal protection is given to systems that pass through special category spaces. In the event of a fire, damage to these systems must be expected. [2.4.2]

11. Early communication from the master created the impression that the incident was relatively minor, and did not generate the level of response from the emergency services and shore authorities that was later found to be necessary to deal with the incident. [2.6.2]

12. Activation of SOLFIRE procedures early during the incident would have provided the means for specialist fire-fighting advice to be sought and used to influence the most effective way of managing the marine phase of the emergency. [2.6.4]

13. The delay caused by the confusion and technical difficulties in embarking the Admiralty pilot led to further fire damage and avoidable risk. At the first sign of delay, the need to embark the Admiralty pilot should have been re-evaluated and alternative solutions considered. [2.7.1]

14. In any incident where multiple agencies need to co-operate, it is essential that they can share a central focus to communicate and co-ordinate their activities. This is what the SOLFIRE procedures were intended to support, but because the requirement to send representatives to a common control centre was interpreted differently, the potential benefits were not realised. [2.10.1]

15. The role of the SOSREP provides a natural focus for the management of marine emergencies. For this to be effective, it is essential that the SOSREP is properly briefed via the coastguard and CPSO reporting chain. [2.10.3]

16. Coastguard officers must have the ability to identify when it is appropriate for SAR assets to be used outside their normal definitions of employment, and also have the confidence to authorise such activity. [2.10.6]

17. There was little evidence of shared planning between all of the organisations involved, and no combined strategy for managing the incident. This is precisely what SOLFIRE procedures were meant to avoid and it is essential that all organisations contribute to these initiatives in order to realise the value of shared planning and control. [2.10.6]

18. The main vehicle deck on board Commodore Clipper was critical to many of the vessel's functions. Access, integrity of ship's systems, and stability were all compromised, and the vessel became increasingly vulnerable due to a moderately sized fire in a single compartment. [2.11.1]

19. Measures to limit the flammability of road trailers that are carried on ships should be considered. This would not only benefit marine traffic, but also reduce the risk to road transport, particularly where trailers pass through major tunnels or are stored in other enclosed structures. [2.11.2]

20. Existing measures to control fires in vehicle decks are not capable of dealing with a well-developed vehicle and cargo fire. The current efforts that are underway at the IMO to improve the fire safety of ro-ro ferries should be supported. However, it must be remembered that most of these measures apply only to new vessels. Retrospective action, to control the risk on existing vessels, should be considered more widely as the likelihood of electrical faults can often increase with older equipment. [2.11.3]

SECTION 4 - ACTION TAKEN

4.1 MAIB ACTIONS

In July 2010, the MAIB issued a Safety Bulletin **(Annex E)** highlighting the potential risk that power supply cables fitted to refrigerated trailers carried on ships could overheat. The safety bulletin recommended that operators should:

- Take immediate action to ensure that all power supply cables and fittings provided for refrigerated trailer units are in good condition and that electrical protection devices will activate at an appropriate level.
- Until such time as the exact causes of the fire on *Commodore Clipper* have been established, make additional checks of refrigerated trailers powered by ships' electrical systems to provide early warning of any overheating.

The Chief Inspector of the MAIB has written to the Secretary General of the IMO to request that the IMO sub-committee on Flag State Implementation, in discharging its obligation to review the contents of this report, carefully considers the safety issues identified, together with those contained in the marine accident reports submitted by Turkey, Germany and Denmark on the fires which occurred on, respectively, the ro-ro vessels *Und Adriyatik*, *Lisco Gloria* and *Pearl of Scandinavia*. In doing so, consideration should be given to identifying improvements that can be made to the fire protection standards applied to ro-ro passenger vessels constructed before 1 July 2010 to facilitate enhancement of their survivability and safe return to port in the event of a vehicle deck fire.

In addition, the MAIB has also published a flyer **(Annex F)**, for wide dissemination to the industry, describing the main safety issues for ferry and port operators.

The MAIB has also brought this case to the attention of the relevant sections of the Department for Transport responsible for freight vehicle construction standards.

4.2 ACTIONS TAKEN BY OTHER ORGANISATIONS

Mennekes, the manufacturers of the StarTop connector has:

- Revised the instruction leaflet provided with StarTop connectors to clarify that insulation should not be removed before inserting cables into IDC terminals.

Condor Marine Services has:

- Arranged for vehicles affected by the fire to be independently assessed immediately after the accident. Affected vehicles were cleaned and, where necessary, tyres were replaced.
- Satisfied the conditions of the prohibition notice served by the MCA.
- Completed its own investigation into the accident, and as a result has taken the following actions:
  - Removed all StarTop connectors from *Commodore Clipper* and all other vessels in its fleet, and prohibited future use of IDC type terminal connectors.
  - Re-introduced a system to uniquely identify each reefer power supply cable and planned maintenance to assess the condition of each cable.
  - Installed improved protection devices in the refrigerated power supply system that can detect phase imbalance and provide residual current detection.

- Installed IP56 rated connections in the refrigerated power supply system.
- Revised the company's instructions to masters and its safety management system to emphasise the master's authority in emergency situations and the conduct of search and rescue operations.
- Rectified installation errors in the fire detection system.
- Modified the conduct of fire drills on all company vessels to include the use of the fire detection system.
- Fitted deck drain covers in accordance with the IMO circular MSC.1/Circ.1320 on all company vessels.
- Conducted table-top exercises with the port authorities and Fire and Rescue Services in Jersey and Guernsey to discuss how a similar incident might be dealt with in the Channel Islands.
- Removed the built in delay in the fire detection system (such that all fire alarms initially sounded only on the bridge and ECR if silenced within 30s) so that all alarms (but not system fault alerts) immediately sound throughout crew accommodation, thus alerting all crew to a potential problem.
- Organised in conjunction with HFRS a further joint exercise with HFRS, Jersey, and Guernsey MIRG teams that was held on board *Commodore Clipper* on 11 October 2011 to reinforce the lessons learned during the incident on 16 June 2010.
- Commissioned the development of an enhanced intact and damage stability computer system for *Commodore Clipper* and *Commodore Goodwill*, accessible to the company's crisis team.

Queen's Harbour Master Portsmouth has:

- Begun a review of the SOLFIRE emergency response procedures, together with the MCA and other stakeholders.
- Hosted a major SOLFIRE exercise in the autumn of 2010.
- Reviewed its requirements for pilotage with PIP and agreed that in future incidents, discussions will be held with PIP and Solent Coastguard to identify the most appropriate means of providing pilotage support to vessels in distress.

Portsmouth International Port has:

- Begun a review of the SOLFIRE emergency response procedures, together with the MCA and other stakeholders.
- Updated its risk register to include a vessel with a vehicle deck fire berthing in its port.
- Updated its contingency plans to reflect the level of support that the port can provide to support vessels that require emergency assistance.

Det Norske Veritas has:

- Clarified the requirements in the society's rules regarding the required ingress protection rating for electrical equipment in special category spaces.

Hampshire Fire and Rescue Services has:

- Conducted an internal review of the lessons learned from fighting a fire on board a ferry with densely packed cargo, and has promulgated these lessons to other fire services which could face similar incidents.

The **Maritime and Coastguard Agency** has:

- Conducted an internal review of the coastguard response and the management issues associated with responding to a vessel in distress as it enters harbour and berths.

- Undertaken to implement the following recommendations from the internal review:

  – SAR Operations Branch should review all current high level Memoranda of Understanding (MOU), legislation and guidance and produce a definitive document which is clear and unambiguous regarding the jurisdictional and legislative responsibilities of the MCA/HMCG for the conduct of SAR. This should inform the rewrite of the SAR UK Framework and be passed to the SAR Strategic Committee for endorsement.

  – SAR Operations Branch should direct a review of all existing MOUs and Local Guidance relating to SAR to ensure that it is compliant with current policy, guidance and legislation and to remove ambiguity or doubt regarding precedence. Such plans should be available, electronically, for access by MCA duty officers. In this case, the East of England Regional Director should initiate a review of the SOLFIRE plan to ensure that it is consistent with the normal operating requirements, guidance, policies and practices of HMCG. In particular, the role of the CGLO.

  – New HMCG operational protocols are under development. The Operational Management System should contain guidance:

    - Regarding information gathering techniques used to develop a clear awareness of the situation and drawing on the deployment of liaison officers and Sitreps from other command groups.

    - On how to pass unambiguous information to masters to assist them in their decision making.

    - On how to develop a coherent plan of action that is not in conflict with existing regulations.

  – The SOSREP deputy/duty structure should be reviewed to remove any ambiguity about the authority of individuals. This should:

    - Provide for the formal delegation of SOSREP authority and powers to a nominated deputy during periods when the nominal SOSREP is unavailable (e.g during periods of leave, overseas travel or sickness absence).

    - Distinguish between advice that is being offered by SOSREP during evolution and requirements that result from the exercise of the powers of intervention.

SECTION 5 - RECOMMENDATIONS

The **Maritime and Coastguard Agency** is recommended to:

2011/140 Work with its stakeholders to produce industry guidelines for maritime emergency responders to consider when providing fire-fighting or other emergency support to ships in UK waters. The guidelines should include, inter alia:

- Best practice command and control principles
- Information gathering and liaison on scene
- Safety of passengers and crew
- Ship specific risks and considerations with particular emphasis on issues associated with passenger ro-ro vessels and vessels carrying hazardous cargoes
- Factors to be considered in deciding whether to bring a vessel into port/alongside
- Specialised equipment and other resources.

The **Port Marine Safety Code Steering Group** is recommended to:

2011/141 Provide advice in the guide to good practice on port marine operations regarding:

- The need for ports to identify and list the capabilities and limitations of the facilities they can offer to support vessels requiring emergency assistance once they are alongside.
- How support from cargo handling equipment and other port infrastructure might be provided to the principal vessel types that are trading in a port, in order to assist in dealing with an emergency on board a vessel that is alongside.

Det Norske Veritas is recommended to make a submission to IACS to develop a unified requirement to:

2011/142 Improve the standard of electrical fault protection on systems designed to provide electrical power to road freight units stored on vehicle deck, special category and ro-ro spaces. Such protection should include:

- Residual current detection to reduce the risk of electric shock
- Short circuit and overload detection
- Phase imbalance detection

The **Bahamas Maritime Authority** is recommended to:

2011/143 Make a submission to the IMO to consider a requirement for all existing ro-ro passenger vessels to be fitted with, or have ready access to, means of determining the effect of damage or entrained water from fire fighting on the vessel's stability.

2011/144 Develop a joint paper with the Maritime and Coastguard Agency for submission to the IMO to consider a requirement for all vessels, whose principal means of access is via a single ramp to a vehicle, special category or ro-ro space, to assess how an alternative means of pedestrian access to shore could be provided in an emergency.

Safety recommendations shall in no case create a presumption of blame or liability

Annex A

Classification society's report of the damage caused by the fire

DNV id. no.	Job Id.
21616	191416

Name of vessel	Name of owner	IMO no.
COMMODORE CLIPPER	Condor Limited	9201750

Survey, Following Main Vehicle Deck Fire

This is to confirm that the following has been carried out:

Surveys

Survey Code	Survey Name	Result
MISC.O	Miscellaneous item occasional - Survey, following main vehicle deck fire	Complete

Conditions and Memoranda – Given		Due Date
CC 40	Before the due date, No.20 void starboard bilge valve, remote control is to be repaired or renewed. Finding(s): **[Bilge handling control and monitoring system (Bilge Remote Control valves)]** No.20 void, starboard bilge valve, remote control valve was removed.	2010-10-02
CC 41	Before the due date, the starboard main engine, local telegraph is to be repaired. Finding(s): **[Engine telegraph]** Starboard main engine, local telegraph was found inoperable, due to an electrical fault.	2010-10-02

Station	Place of survey	Survey started	Survey completed
Southampton	**Portsmouth, UK**	**2010-06-16**	**2010-07-02**

Lead surveyor's name
[redacted]

Survey team

Survey Observations and Findings

Events

Fire was reported to have started at sea, in a freight trailer, on the port side of the main vehicle deck, at approx 03:00hrs on 2010-06-16.
The vessel came alongside Portsmouth Continental Ferry Port, No.2 Berth, the fire was reported extinguished by the Fire Brigade and passengers disembarked at 23:00hrs on 2010-06-16.
Four trailers, in total, were found to be damaged by fire.

The vessel was attended by Bahama Maritime Authority and UK Marine Accident Investigation Branch, for the purpose of incident investigation.

The vessel was also attended by the UK MCA, as port state control, who issued a "Prohibition Notice" with 10 deficiencies.
All deficiencies were dealt with before departure.

On completion of repairs and basin trials, the vessel was subjected to a sea trial.
All systems were found to be operating satisfactorily.


Fire damaged trailer


Fire damaged trailer


Fire damaged trailer


Vessel alongside, with the fire brigade in attendance


Fire damaged trailer

Findings
Fire damage was found in the following locations:

Main Vehicle Deck (deck 3), port side, between frames 71 and 89.
- Longitudinal and transverse frames on deckhead buckled.
- Pipework buckled.
- Electrical cables and equipment burnt out.

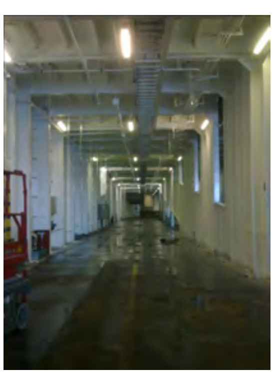
Upper Vehice Deck (deck 5), port side, between frames 74 and 86.
- Deck buckled.

Fire / water damage was found to the following systems:

- Drencher system pipework, on deck 3.
- Fire main pipework, on deck 3.
- Fresh water pipework, on deck 3.
- Fire detection system, on deck3, steering gear and engine control room.
- Public address system, on deck 3.
- CCTV system, on deck 3.
- Steering gear, remote and local, control and feedback systems.
- Forward switchboard supply (including anchor hydraulics, car deck fans and bow thrusters).
- Main and emergency lighting, on deck 3.
- Reefer sockets, on deck 3.
- Internal ramp control and indication electrics.


After fire

Repaired: Fire damage was repaired, as necessary, as detailed in the following report.
Smoke affected zones were washed down with fresh water.



After repairs

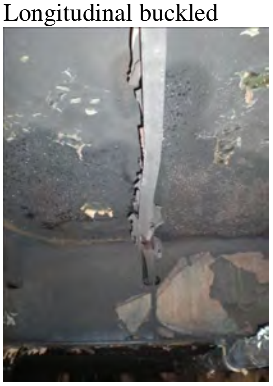
Decks

Findings
[Deck]
The Upper Vehicle Deck (deck 5) deck plating was found buckled, from frame 74 to frame 86, port side, outboard of the internal ramp.

The following damage was found to the Upper Vehicle Deck (deck 5) supporting structure, port side, outboard of the internal ramp:
- Between frames 71 and 74 - 3 longitudinals buckled.
- Between frames 74 and 77 - 6 longitudinals and 1 deep longitudinal buckled.
- Frame 77, web and lower flange buckled.
- Between frames 77 and 80 - 6 longitudinals and 1 deep longitudinal buckled.
- Between frames 80 and 83 - 6 longitudinals buckled.
- Between frames 83 and 86 - 4 longitudinals and 1 deep longitudinal buckled.
- Between frames 83 and 86 - 1 deep longitudinal buckled, just forward of ramp.
- Between frames 86 and 89 - 2 longitudinals buckled.


Longitudinal buckled


Section of cropped deep frame


Longitudinal buckled


Upper Vehicle Deck buckled

Longitudinal buckled

Frame 77, web and lower flange buckled (buckled longitudinal deep frame already removed)

Repaired: The following repairs were carried out, by Testbank Ship Repair:
- Upper Vehicle Deck plating was cropped and renewed, from frame 73 to frame 88, 6 metres wide.
- Longitudinal frames were cropped and renewed, from frame 74 to frame 88, as required.
- Deep frames and deep longitudinals were cropped and inserted, as necessary.
Welding procedures, welder qualifications, materials and consumables certificates were reviewed and found in order.
AH 36 steel has been replaced with DH 36 or EH 36, due to availability.
12mm deck plating has been replaced with 14mm, due to availablity.

Ultrasonic thickness measurement and magnetic particle testing was carried out by DNV approved service supplier, Ultramag, on a representative number of welds.
100% visual inspection was completed by the undersigned Surveyor.
No defects were noted.

Shell doors water leakage detection alarm system

Findings
"Water on vehicle deck" alarms were noted damaged and inoperable.
Repaired: "Water on vehicle deck" alarms were repaired and satisfactorily function tested.

Anchoring arrangement

Findings
[Anchor winch hydraulic power system]
Electrical power supply was noted lost to the forward hydraulics, for anchoring and mooring equipment.
Repaired: Damaged cables were cropped, spliced and enclosed in approved heat shrink closures.
Anchoring and mooring equipment was satisfactorily function tested.

Steering gear arrangement P

Findings
The following power and control faults were found on the port steering gear:
- No.1 pump forced the rudder hard to starboard, in remote.
- No.2 pump auto-starting, unable to stop, no directional control, in remote or local.

The following power and control faults were found on the starboard steering gear:
- No.3 pump hunting, in remote.
- No.4 pump auto-starting, unable to stop, no directional control, in remote or local.

Repaired: The fire damaged 48 core steering control cable was cropped, a junction box was installed at each end and the cable was renewed.
Steering power and control was fully function tested and found in order.

Manoeuvring thruster arrangement A

Findings
Electrical power and control was noted lost to the aft bow thruster hydraulics.

Repaired: Damaged power supply cables to the forward swtichboard were cropped, spliced and enclosed in approved heat shrink closures.
The aft bow thruster was satisfactorily function tested.

Manoeuvring thruster arrangement F

Findings
Electrical power and control was noted lost to the forward bow thruster hydraulics.

Repaired: Damaged power supply cables to the forward swtichboard were cropped, spliced and enclosed in approved heat shrink closures.
The forward bow thruster was satisfactorily function tested.

Main electric power distribution

Findings
The following was noted on the electrical power distribution system:
-Main Vehicle Deck (deck3), port side main cable tray buckled and cable insulation destroyed, between frames 74 and 77.
- Forward switchboard, both power supplies fire damaged.
- Reefer socket, fuse boxes and breaker cabinets water damaged.

Fire damaged cable tray

Fire damaged cable tray

Repaired: Damaged cables were cropped, spliced and enclosed in approved heat shrink closures. Reefer socket circuit breakers were renewed and fuse boxes were taken out of service.

Fresh water generation, storage and distribution system

Findings
Main Vehicle Deck (deck3), port side domestic fresh water main buckled, between frames 74 and 77.
Repaired: The damaged section of pipework was renewed.

Bilge handling control and monitoring system (Bilge Remote Control valves)

Findings
The port forward engine room bilge valve, remote control was noted inoperable.
Repaired: The remote control valve was renewed.

Electronic chart display and information systems (ECDIS)

Findings
[Electronic chart display and information system (ECDIS) 1]
Software malfunctions were noted on the ECDIS.
Repaired: The ECDIS was repaired by the manufacturer's representative.

Navigation lights, shapes and signalling devices

Findings
[Navigation lantern]
Both lamps and alarm indication for the stern light were found to be inoperable, after fire damage to the cabling.
Repaired: Damaged cables were renewed.
Both lamps and the alarm indiciation were satisfactorily function tested.

Public address system

Findings
The following sections of the public address system were noted inoperable:
- Main Vehicle Deck (deck 3).

Repaired: Damaged cables and speakers were renewed.
The system was satisfactorily function tested.

Watch call alarm system

A Bridge Navigational Watch Alarm System was verified as fitted in accordance with MSC.128(75) and function tested, satisfactorily.

Fire detection system

Findings

The following sections of the fire detection system were found inoperable:
- Main Vehicle Deck (deck 3).
- Steering gear.
- Engine control room.
- Bow thruster room.

One section of the motherboard, in the control unit was also found burnt out.

Fire damaged, fire detector head

Repaired: Damaged cables and detector heads were renewed.
The motherboard was replaced in the control unit.
The system was satisfactorily function tested.

Fire water distribution arrangement

Findings

Main Vehicle Deck (deck3), port side fire main buckled, between frames 74 and 77.

Repaired: Fire main pipework, within the fire area, was renewed.
The system was satisfactorily pressure tested and no leaks were noted.

Deep-fat cooking device foam fire extinguishing system

In the main galley, an approved deep fat fryer, foam fire extinguishing system was noted as fitted in accoredance with SOLAS Ch.II-2, Reg.10, 6.4.

Vehicle, special category and ro-ro space water spraying fire extinguishing system

Findings
Main Vehicle Deck (deck3), port side drencher main (zone 4) buckled, between frames 74 and 77.


Buckled drencher main aft of frame 77


Buckled drencher main aft of frame 77

Repaired: Drencher main pipework, within the fire area, was renewed.
The system was satisfactorily function tested and no leaks were noted.

Other safety arrangements

Findings
Main Vehicle Deck (deck 3), CCTV was found fire damaged and inoperable.
Repaired: Damaged cables and cameras were renewed.
The system was satisfactorily function tested.

Ventilation systems for accommodation spaces
Main laundry dryer exhaust dampers and filters were fitted in accordance with the latest SOLAS amendments and function tested, satisfactorily.

Ventilation systems for hazardous cargo spaces

Findings
Electrical power supply was noted lost to all car deck fans.
Repaired: Damaged cables were renewed.
Fans were satisfactorily function tested.

Lighting arrangement

Findings
Main Vehicle Deck (deck3), main and emergency lights were found fire damaged and inoperable.

Fire damaged light

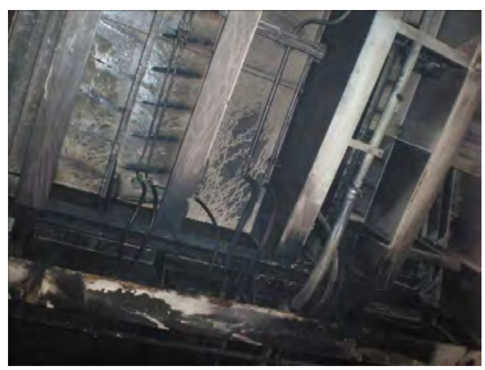
Repaired: Damaged cables and lights were renewed.
Main and emergency lighting system were satisfactorily function tested.

Internal moveable ramp arrangement

As a precautionary measure, the following maintenance was completed:
- Flexible hydraulic hoses renewed.
- Hydraulic rams overhauled.
- Hinge pins and locking mechanisms overhauled.
- Sheaves renewed, as necessary.
- Main lifting wire renewed.

The internal ramp was recommissioned, by the manufacturer's representative and then overload tested in operation, with 85 tonnes (10%+ in excess of the safe working load of 75 tonnes).

Internal ramp



Internal ramp hoses

Findings
[Internal moveable ramp control and monitoring system]
The internal ramp (main vehicle deck to upper vehicle deck), control and indication electrics were found fire damaged and inoperable.

Repaired: The control and indication electrics were renewed and the system was satisfactorily function tested.

Hydraulic pipework, outboard of the ramp, was found fire damaged.

Repaired: Hydraulic pipework was renewed, flushed and satisfactorily pressure tested.

Annex B

IMO Resolution A.123(V)

RESOLUTION A.123(V)

RECOMMENDATION ON FIXED FIRE EXTINGUISHING SYSTEMS FOR SPECIAL CATEGORY SPACES

The Assembly,

Noting Article 16(i) of the IMCO Convention concerning the functions of the Assembly,

Noting also that at this session it adopted a new Part H of Chapter II of the International Convention for the Safety of Life at Sea, 1960, in respect of fire protection, fire detection and fire extinction in passenger ships and, in particular, Regulation 108(c) which requires that each special

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* For guidance purposes, it is assumed that each ship would be fitted with a vertically polarized unity gain antenna at a nominal height of 30 feet (9.15 metres) above water, a transmitter R.F. power output of 10 watts, and a receiver sensitivity of 2 microvolts across the input terminals for 20 db signal-to-noise ratio.

category space shall be fitted with an approved fixed fire extinguishing system which shall protect all parts of any deck and vehicle platform, if any, in such spaces,

Recognizing that the adoption of specific requirements in respect of fixed fire extinguishing systems for the vehicle spaces of passenger ships having drive-on/drive-off facilities might inhibit the development of new fire extinguishing systems for use in such spaces,

Having considered the Recommendation on the fixed fire extinguishing system for special category spaces adopted by the Maritime Safety Committee at its fifteenth session (Annex II, MSC XV/22),

Recommends that Contracting Governments, when approving the fixed fire extinguishing system for special category spaces, should satisfy themselves that any such system is at least as effective in controlling a flowing petrol fire as a fixed pressure water-spraying system, complying with the requirements set out in the Annex to this Resolution,

Invites governments concerned:

(1) to put the measures recommended into effect as soon as possible and

(2) to inform the Secretary-General of this accordingly.

ANNEX

RECOMMENDATION ON FIXED FIRE EXTINGUISHING SYSTEMS FOR SPECIAL CATEGORY SPACES*

A fixed fire extinguishing system for special category spaces should be at least as effective in controlling a flowing petrol fire as a fixed pressure water-spraying system complying with the following:

(a) The nozzles should be of an approved full bore type. They should be arranged so as to secure an effective distribution of water in the spaces which are to be protected. For this purpose, the system should be such as will provide water application at a rate of at least 3.5 litres per square metre per minute (0.07 gallons per square foot per minute) for spaces with a deck height not exceeding 2.5 metres (8.2 feet)

---

* "Special category spaces" are those enclosed spaces above or below the bulkhead deck intended for the carriage of motor vehicles with fuel in their tanks for their own propulsion, into and from which such vehicles can be driven and to which passengers have access.

and a capacity of at least 5 litres per square metre per minute (0.1 gallons per square foot per minute) for spaces with a deck height of 2.5 metres (8.2 feet) or more.

(b) The water pressure should be sufficient to secure an even distribution of water.

(c) The system should normally cover the full breadth of the vehicle deck and may be divided into sections provided they are of at least 20 metres (66 feet) in length, except that in ships where the vehicle deck space is subdivided with longitudinal "A" Class divisions forming boundaries of staircases, etc., the breadth of the sections may be reduced accordingly.

(d) The distribution valves for the system should be situated in an easily accessible position adjacent to but outside the space to be protected which will not readily be cut off by a fire within the space. Direct access to the distribution valves from the vehicle deck space and from outside that space should be provided. Adequate ventilation should be fitted in the space containing the distribution valves.

(e) The water supply to the system should be provided by a pump or pumps other than the ship's required fire pumps which should additionally be connected to the system by a lockable non-return valve which will prevent a back-flow from the system into the fire main.

(f) The principal pump or pumps should be capable of providing simultaneously at all times a sufficient supply of water at the required pressure to all nozzles in the vehicle deck or in at least two sections thereof.

(g) The principal pump or pumps should be capable of being brought into operation by remote control (which may be manually actuated) from the position at which the distribution valves are situated.

25 October 1967
Agenda item 10

Annex C

Report of the examination of the electrical components

Commercial-in-Confidence

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Client Reference:	MAIB10010
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Report Checked by:

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Approved by:

[redacted]

August 2010

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Summary

A fire occurred on 16 June 2010 on the Commodore Clipper while on passage from Jersey to Portsmouth. The crew identified that a refrigerated trailer unit, powered from the ship's electrical supply, had caught fire.

Following an initial investigation by Marine Accident Investigation Branch (MAIB), Cobham Technical Services was asked to assist in the investigation. This assistance involved the examination of the electrical components relating to the refrigeration system on the trailer.

From the examination of the remains it has been concluded that the fire was initiated by arcing at an insulation displacement connector in the socket, on the ship's supply cable, which connected to a fixed plug on the trailer. The arcing was caused by a high resistance connection in the socket.

A second socket of the same design, from the *Commodore Clipper*, was found to have been incorrectly terminated. The error was that the insulation had been stripped back at the end of the cable cores before they were inserted into the IDC terminal. This error could lead to a high resistance connection. It is considered that incorrect assembly of the termination is the most likely cause of the high resistance connection that led to the fire. However the possibility that excessive tension on the cable had partially pulled the conductors out of the IDC terminations cannot be ruled out.

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Contents

Figures List

1. Introduction

At 0242 (BST) on 16 June 2010 while Commodore Clipper was on passage from Jersey to Portsmouth, a fire was detected on the main vehicle deck. The vehicle deck was loaded with unaccompanied freight trailers including a number of refrigerated, curtain-sided lorries containing potatoes in plastic trays. The crew identified that one of the refrigerated trailer units, powered from the ship's electrical supply, had caught fire.

Following an initial investigation by Marine Accident Investigation Branch (MAIB), Cobham Technical Services was asked to assist in the investigation. This assistance comprised an examination of the electrical components relating to the refrigeration system on the trailer.

This report gives details of the examination of the electrical components.

2. Background

Cobham was provided with the following information concerning the incident.

The trailer's 400 V, 3 phase refrigeration system can be powered from the tractor unit's engine, from a diesel driven generator within the trailer or from an external power source. The electrical control units for the refrigeration system and the supply intake are mounted under the bed of the trailer at one side. The burn pattern and damage to the supporting cargo pallets indicated that the fire started below the trailer bed in the immediate vicinity of the electrical controls.

It is known that the trailer was supplied from the ship's electrical 400 V, 50 Hz, 3 phase system via a 32 A circuit breaker, which had not operated. The trailer's electrical system was also protected by a miniature circuit breaker (MCB).

There was no obvious evidence of "beading" or "fusing" of the burned out wiring in the refrigeration control system.

3. Examination

3.1 On-site examination

The trailer that had been directly involved in the fire, CRF459, and a similar unit with no fire damage to the electrical components, CRF461, had been stored at Portsmouth ferry terminal. These units were examined, on site, by Cobham on 16 July 2010.

A general view of the location of the fire damage to the components under the bed of the trailer is shown in Fig. 1.

Figure 1 Location of electrical units

The layout of the electrical units on the damaged trailer was identical to that on the undamaged trailer, Fig. 2. All of the electrical controls were housed in plastic enclosures.

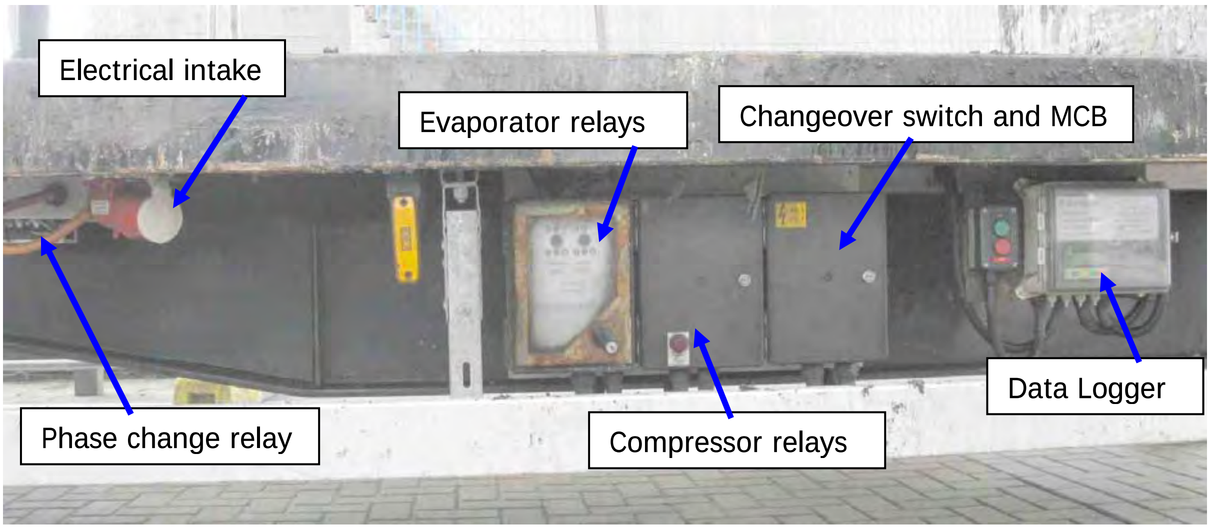

Figure 2 Layout of electrical units

The on site examination did not reveal any obvious signs of arcing between the fire damaged electrical components or between the electrical equipment and the body of the trailer.

The plug and socket arrangement at the power intake to the trailer was badly melted and was heavily carbonised at the free socket end, Fig. 3. The free socket had been on the end of the cable from the ship's power supply.

Figure 3 Supply socket

The damaged electrical units and some of the equivalent undamaged units from the second trailer were removed.

The items removed included:

1. Supply intake plug and socket from fire damaged unit, CRF459
2. Phase change relay from fire damaged unit
3. Assembly of three control boxes from fire damaged unit, Fig. 4
4. Assembly of three control boxes from undamaged unit, CRF461, Fig. 5
5. Supply intake plug from undamaged unit, Fig. 6

Figure 4 Control box assembly, fire damaged

Figure 5 Control box assembly, undamaged

Figure 6 Trailer mounted intake plug

The data logger unit from the fire damaged trailer was retained by MAIB.

Cobham was also provided with the flexible cable that had supplied the damaged trailer, a second complete lead and the plugs and sockets cut from a further two leads.

3.2 Examination at Cobham

The items collected by Cobham were examined on 4 August 2010 in the presence of representatives from BMA, Burgoynes, Geoffrey Hunt and Partners, Hawkins and MAIB.

Prior to the examination the MCB from the control assembly and the fire damaged intake plug and socket had been subjected to X-ray examination. It was not possible to determine the position of the contacts in the MCB from the X-ray examination. Prior to removing the MCB from the control box a continuity measurement across the poles indicated that the MCB could be in the 'on' position. After removal a continuity measurement showed the MCB to be in the 'off' position. Checking the wiring that had been disconnected from the MCB confirmed that all of the cables to the MCB were in contact, hence the erroneous 'on' indication.

The X-rays of the plug and socket revealed that the free socket had insulation displacement connectors, IDC, at the cable terminals whereas the fixed plug on the trailer had screw terminals, Fig. 7.

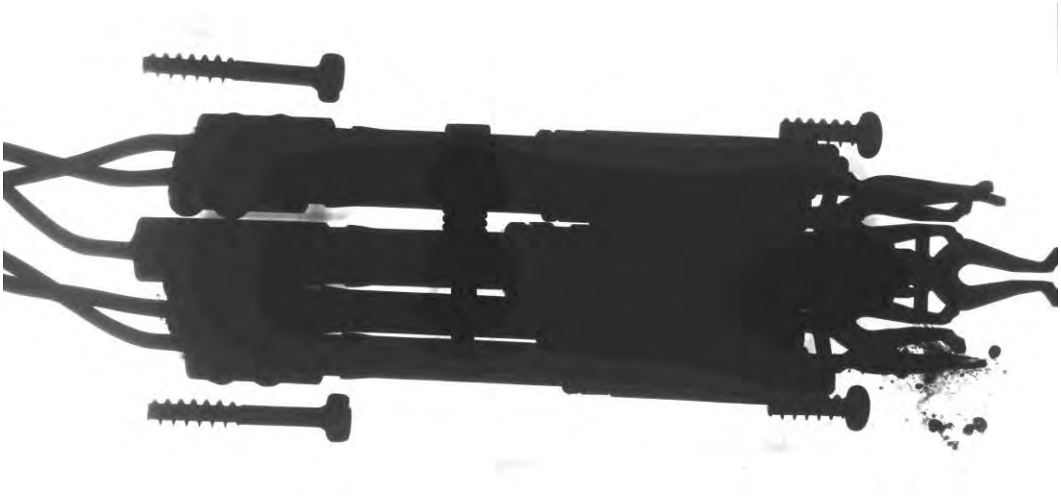

Figure 7 X-ray of plug and socket

The X-ray also revealed what appeared to be globules of metal around one of the IDC connectors. Prior to examining the connector the other items recovered from the trailer were examined.

The cut-away picture extracted from the manufacturer's catalogue shows the IDC connector arrangement, Fig. 8.

Figure 8 Insulation displacement connectors

The changeover switch on the side of the control unit was found to be in the correct position for taking a mains supply from the ship, Fig. 9

Fire damaged

Undamaged

Figure 9 Changeover switches

An examination of the MCB in the trailer control box showed that there was no evidence of arcing at its terminations and the condition of the MCB confirmed that the fire had not started at the MCB, Fig. 10.

Figure 10 Trailer MCB

Examination of the phase change relay and the cable from the trailer mounted plug to the relay did not reveal any evidence of arcing or other features that would indicate that they were the cause of the fire.

The wiring and the remains of the contactors in the three linked control units was examined in detail for evidence of arcing between cables, at contacts or at terminations, Figs 11 to 13. The middle unit was the most severely damaged with the main compressor contactor housing having been completely destroyed. The insulation had been burned away from most of the interconnecting wiring and the cases of the remaining relays and contactors were charred.

No evidence of arcing or other features that could have been the cause of the fire were found.

Figure 11 Fire damaged wiring

Figure 12 Terminal and spring contact

Figure 13 Contacts

The free socket at the trailer end of the cable from the ship's supply was a five-pin, 32 A, Mennekes 'Startop' socket. The trailer mounted plug and the socket were fused together by molten plastic. At the plug end the terminals were visible and did not show any evidence of arcing or severe overheating, Fig. 14. A large portion of the free socket had burned away, Fig. 15. The ends of one of the IDC connectors could be seen emerging from the charred plastic, Fig. 16.

Figure 14 Terminals in fixed plug

Figure 15 Damaged and undamaged free socket

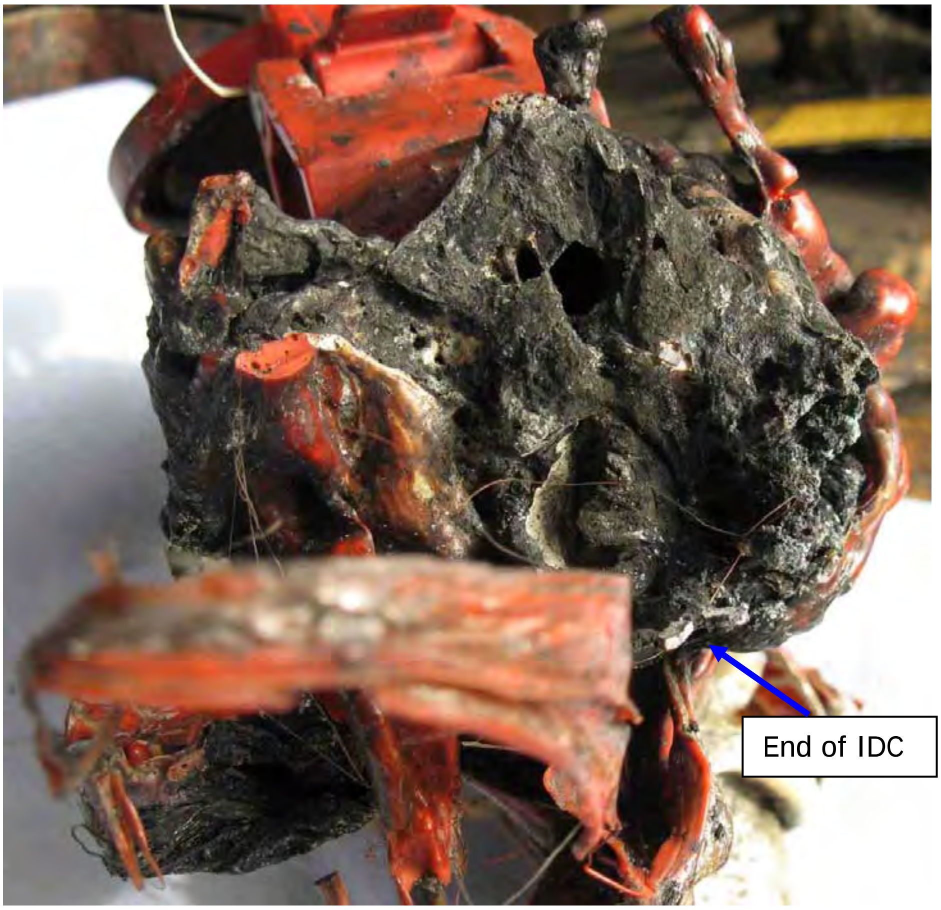

Figure 16 Charred free socket

The plug and socket were separated and the contact faces of the pins were examined. The corrosion and debris seen on the pins was light and probably partially due to the fire fighting activities, Fig. 17. There was no evidence of poor contacts between the plug and the socket and no arc damage at the ends of the pins to indicate that it may have been connected or disconnected ‘on-load’. From the condition of the socket it appeared that a grease may have been applied to the pins at some stage, Fig. 18.

Figure 17 Contact pins

Figure 18 Free socket

The carbonised plastic around the IDC terminals was carefully removed so that the condition of the five connectors could be examined. What appeared to be slight arcing damage was seen at the end of the Blue phase terminal, Fig. 19. Later examination showed this to be melted plastic.

Figure 19 Blue phase IDC

The brown phase terminal had severe arcing damage and the remains of some conductor strands were adhered to the back of the terminal, Figs 20 & 21.

Figure 20 Brown phase IDC

Figure 21 Conductor strands adhered to terminal

A number of conductor strands and globules of copper were found in the carbonised debris, Fig 22.

Figure 22 Conductor strands and copper globules

The remaining IDC showed no signs or arcing, Fig. 23

Figure 23 Undamaged IDC connector

The other plugs and sockets recovered from the *Commodore Clipper* were examined. Most of these had screw terminals all of which were found to be tight with no evidence of overheating. One of the free sockets, recovered from the *Commodore Clipper*, was a 'Startop' socket with IDC terminals. On examination of this unit it was noted that the ends of some strands could be seen in the connector, Fig. 24. On dismantling the connector it was noted that the insulation appeared to have been stripped from the ends of the cable cores before the cable was inserted into the IDC, Fig. 25. Cobham remade one connection into the IDC without stripping the insulation, Fig. 26.

Figure 24 Conductor strands in connector

Figure 25 Insulation removed before fitting

Figure 26 Correctly terminated core

It was also noted that the undamaged 'Startop' socket had a cable retaining gland marked with a minimum torque of 5 Nm.

The ends of the cable that had been fitted to the free socket were examined. The exposed conductors on two of the cores were the same length; the third core had some strands broken off shorter than the rest and on the fourth core all of the strands were shorter. The fourth core was the brown phase, Fig. 27. It was reported to Cobham that the cable had been pulled out of the connector during the fire fighting operation.

Figure 27 Cable cores

Close examination of the conductor strands of the brown core revealed several small globules of melted copper, Fig. 28.

Figure 28 Copper globule

A simple test was carried out to compare the burning properties of the red and white plastics used in the free socket. A small sample of each material was held in a Bunsen flame for a short time and then removed from the flame. Both materials continued to burn for a short time and dropped globules of burning plastic. However the red material appeared to burn more readily and continued to burn longer after removal from the flame.

No further examinations were carried out.

4. Discussion

The only evidence of arcing or other damage that could have cause a fire in the electrical equipment was the arcing at the brown phase IDC termination in the free socket that had been connected to the ship's cable. From the available evidence it is considered that this arcing would have ignited the plastic of the free socket. The resulting flames than ignited the curtain sides of the trailer and burning plastic from the curtains or the packaging of the trailer contents then set fire to the plastic electrical enclosures.

The arcing at the brown phase IDC would have been initiated by a high resistance connection. The heat generated by a high resistance connection would have degraded the surrounding insulation as well as oxidising the contact materials. The oxidisation of the contact would increase the contact resistance and hence increase the heating at the contact. This would have been an ongoing process until the condition of the contact deteriorated to the stage at which arcing occurred.

Because the arcing was 'in-line' rather than between two different phases the arc current would have been limited to the load current. The circuit breaker in the ship's supply circuit would not be expected to trip in these circumstances.

The plastic used in the construction of the socket would probably have been subject to a 'glow wire' test to demonstrate that it would not ignite if subjected to arcs and sparks. The energy available in a glow wire test and its duration is much less than that which would be present during in-line arcing. Thus it is not surprising that the plastic ignited.

The examination of the second 'Startop' socket recovered from the *Commodore Clipper* showed that it had been incorrectly assembled. The insulation had been removed from the ends of the cores before they were inserted into the insulation displacement connector. This would have removed some of the support from the conductor strands allowing then to splay out as they were inserted into the connector. This would have resulted in a poor quality connection that could further deteriorate when on load. An IDC termination is designed so that the blades of the termination push through the insulation and make firm contact with the conductor.

The cable is gripped in the body of the socket by a gland nut at the rear that is intended to be hand tightened. If this was not sufficiently tightened the pulling on the cable may cause the conductors to partially pull out of their IDC terminations.

During the examination it was found that the MCB at the trailer end of the circuit appeared to have operated. The MCB would have contained both a magnetic trip and a thermal overload trip. The thermal trip would have been a bimetallic element that would be expected to operate at somewhere between 150 and 200 °C. Thus it is most likely that the heat from the fire caused the MCB to trip rather than an electrical overload. Because no arcing damage was found on the wiring in the control boxes it is considered that the supply had been lost before the insulation on the wiring burned away.

5. Conclusions

From the examination of the remains of the components of the supply to the trailer refrigeration unit it is concluded that the fire was initiated by arcing at an IDC termination in the socket on the ship's supply cable to the trailer. The arcing was caused by a high resistance connection in the socket.

A second socket of the same design, from the *Commodore Clipper*, was found to have been incorrectly terminated. The error was that the insulation had been stripped back at the end of the cable cores before they were inserted into the IDC terminal. This error could lead to a high resistance connection. It is considered that incorrect assembly of the termination is the most likely cause of the high resistance connection that led to the fire. However the possibility that excessive tension on the cable had partially pulled the conductors out of the IDC terminations cannot be ruled out.

Reports on the reaction to fire testing

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[redacted]

12 November 2010

Dear [redacted]

Commodore Clipper fire investigation

Please find attached as appendix A to this letter a summary of the work undertaken to investigate a potential ignition scenario related to the fire incident on board the Commodore Clipper.

Yours sincerely

[redacted]

Appendix A

Introduction
Following a fire in June 2010 on a freight trailer on the main deck of the *Commodore Clipper*, the Marine accident Investigation Branch (MAIB) have commissioned BRE Global to undertake a test to simulate a potential ignition source to inform their investigation of the incident.

Description of the project
BRE Global at the request of the MAIB has undertaken a test to simulate a potential ignition source caused by a fault within the power supply to the 3 phase refrigeration system on the freight trailer.

The test set up consisted of a hollow section representing the side rail of the trailer, a profile representing the frame to which the electrical socket was attached and a section of the curtain side material incorporating samples of the webbing straps used on the trailer. Figure 1 shows the location of the socket on an identical trailer to the one involved in the incident while Figure 2 shows the experimental set up.

Figure 1 Location of socket on freight trailer

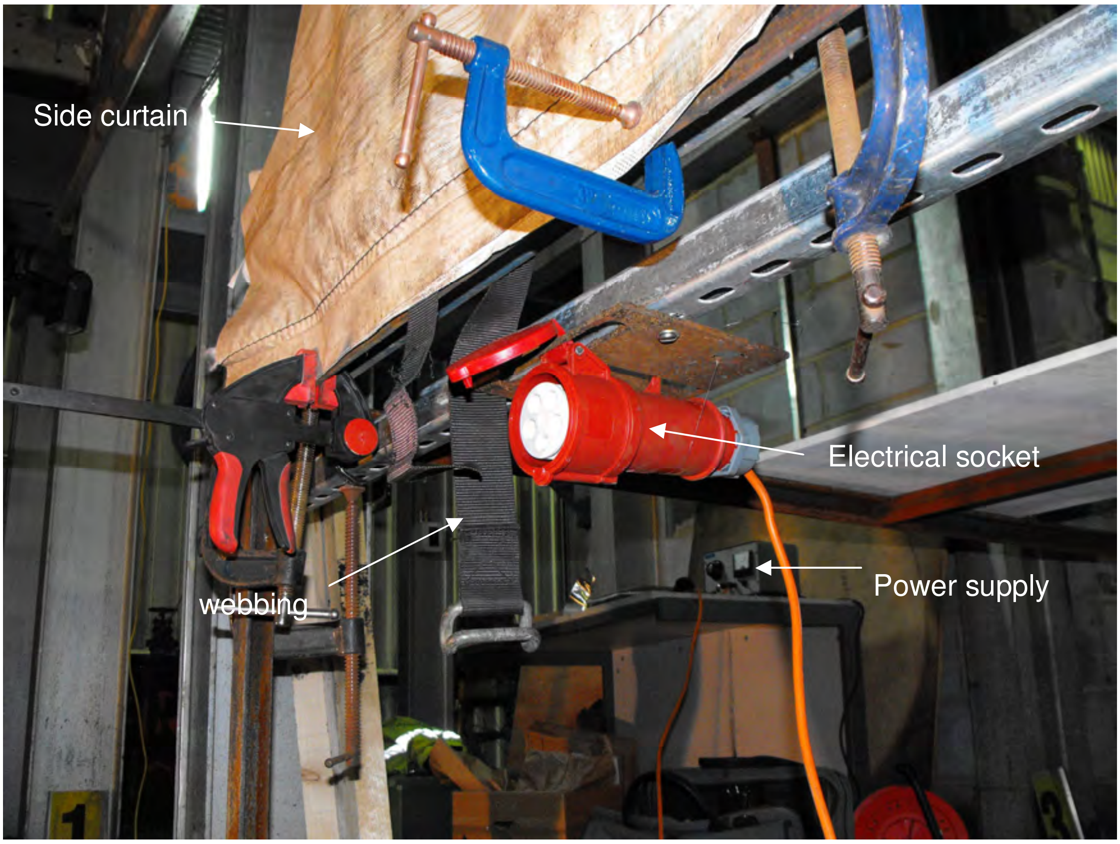

Figure 2 Experimental set up

A high temperature platinum alloy coil was placed inside one of the terminals in the 32 amp socket provided to BRE by the MAIB. The coil was heated using a variable voltage power supply with a maximum output of 100 Volts at a current of 10amps. The coil was placed in to the lowest (earth) terminal within the socket as shown in Figure 3.

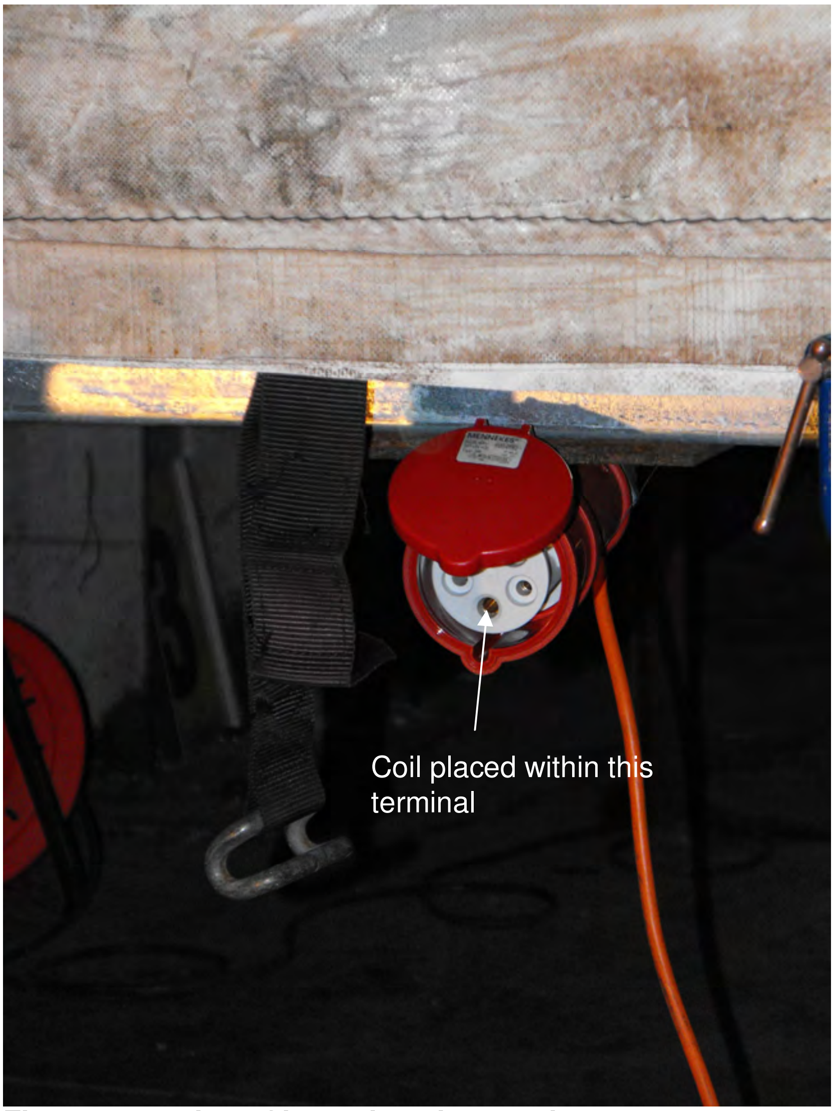

Figure 3 location of heated platinum coil

Findings

The coil was heated slowly until glowing red hot. Attempts to measure the temperature directly using a thermocouple probe were unsuccessful as the junction between the probe and the coil interrupted the circuit and cut the power to the coil. Spot readings were taken with a hand held infra red thermometer. The results indicated a temperature of 180℃ in the area around the coil and up to 120℃ on the white inner plastic of the socket. However, this was not an accurate measurement of the coil temperature. Subsequent testing in the laboratory has established that the coil temperature when glowing red hot is 980℃. After just a few minutes smoke could be seen from the socket and the white plastic inner core local to the heat source began to discolour and then to melt (Figure 4). At this stage the input to the coil was approximately 40Volts at 10Amps.

Figure 4 Localised damage to inner plastic core

Ten minutes into the test flames could be seen in the socket and the white plastic core began to melt away (Figure 5).

Figure 5 Initial flaming of plastic core

Approximately eleven and a half minutes into the test the flames had spread upwards to involve the red outer casing of the socket. Shortly afterwards the flame was extinguished. The damage to the outer casing is clearly visible in Figure 6.

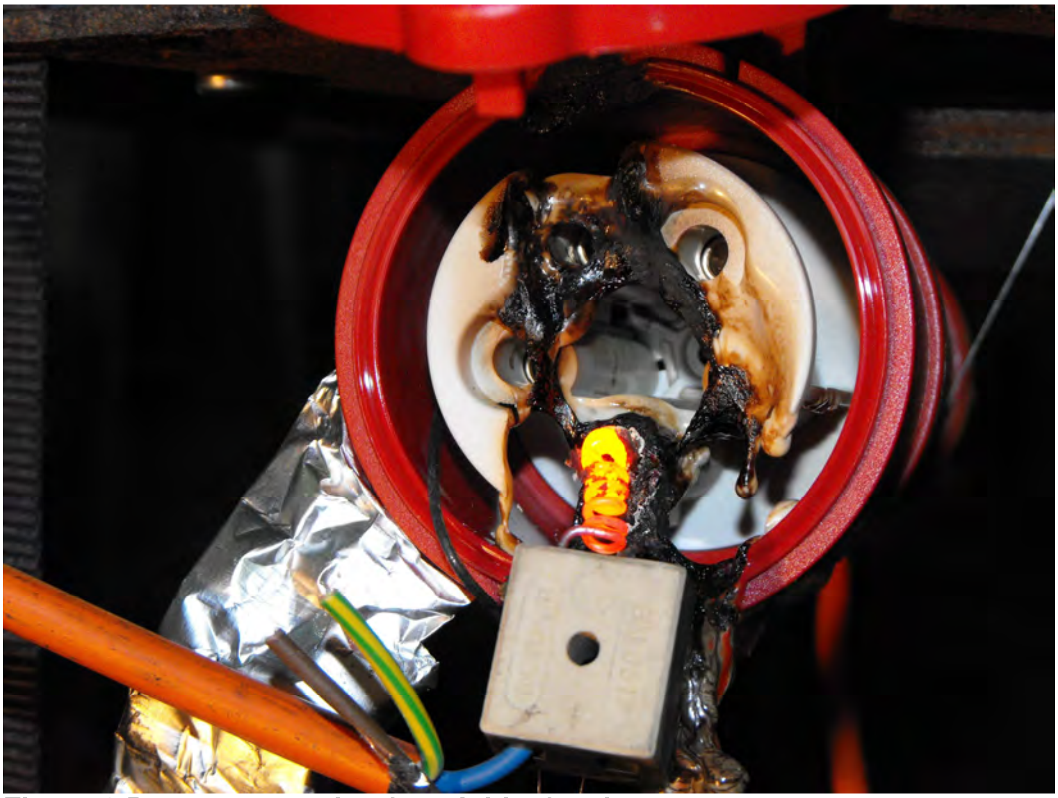

Figure 6 Damage to socket from initial flaming

The voltage was increased to 50V at 10 amps. Approximately 20 minutes from the start of the test smoke could be seen emanating from the rear of the socket. The material of the socket reignited and molten plastic was dripping onto the floor. The coil was moved into direct contact with the housing using tongs leading to immediate ignition of the material causing flash flaming sufficient to ignite any combustible material in the vicinity.

During the test no ignition of the webbing or the curtain material took place. Once the flaming had died down a piece of webbing was placed into contact with the coil and ignited immediately. The flame spread up the webbing strap and ignited the side curtain material though this did not lead to extensive fire spread and the flames self-extinguished after a few minutes.

Finally a direct flame source (gas burner) was applied to the webbing straps. This caused fire spread to the curtain material (Figure 7).

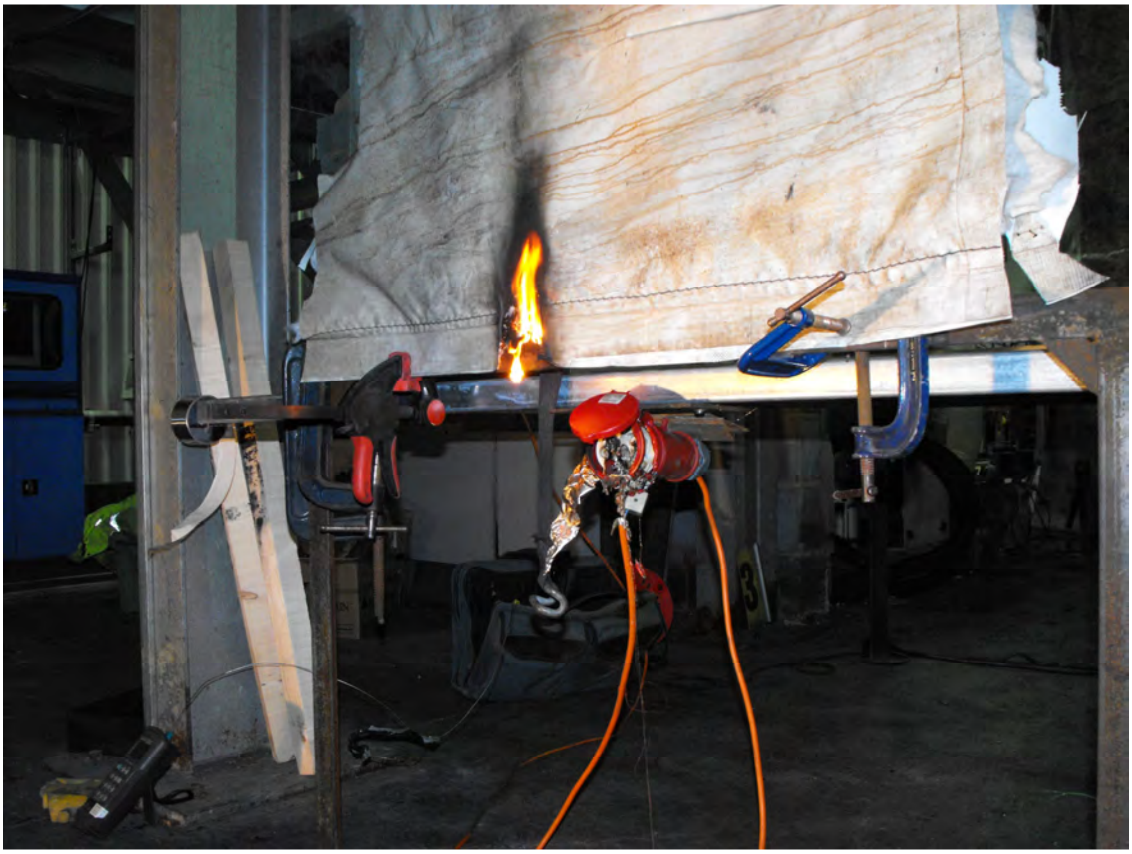

Figure 7 Ignition of curtain material following direct application of gas burner to webbing strap

Conclusions
BRE Global has undertaken a test to simulate an electrical short circuit within an electrical socket to investigate the feasibility of this being the initial source of ignition in the incident on board the *Commodore Clipper*. The heat source within the socket led to the development of flaming which could easily have ignited combustible materials such as the strapping webs used to secure the side curtain.

The tests have shown that a sustained source of heat is required to achieve ignition of the plastic material used to form the housing for the socket. Both the socket and the strapping web produce burning droplets when flaming.

bre global

Commodore Clipper Fire Investigation - Materials Tests

Prepared for: Marine Accident Investigation Branch

21 December 2010

Client report number 267389

Protecting People, Property and the Planet

Prepared on behalf of BRE Fire and Security by

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Approved on behalf of BRE Fire and Security by

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Executive Summary

On 16 June 2010 while *Commodore Clipper* was on passage from Jersey to Portsmouth, a fire was detected on the main vehicle deck. The vehicle deck was loaded with unaccompanied freight trailers including a number of refrigerated, curtain sided, lorries containing potatoes in plastic trays. The crew identified that one of the refrigerated trailer units, powered from the ship's electrical supply, had caught fire. Soon afterwards the fire spread to nearby units.

The vehicle deck was fully enclosed and smoke built up quickly. The crew contained the fire using the vehicle deck water drenching system and boundary cooling from above, but were not able to fully extinguish it. The vessel came into port and the local fire and rescue service extinguished the fire.

Two sets of standard small-scale tests have been carried out at the request of the Marine Accident Investigation Branch (MAIB). These are:

1. Cone calorimeter test to ISO 5660-1 & 2:2002. This involves taking 100mm square samples of a material and subjecting it to a range of set irradiance levels. Ignition is achieved using an electric spark ignition above the surface of the material. This test provides information on rate of heat release and time to ignition and can be used to calculate critical heat flux for ignition (the lowest heat flux at which a material will ignite).

2. Toxicity testing to NES 713. This test is used to ascertain the concentrations of gaseous species produced from burning materials. It is a Naval Engineering Standard test used to determine the concentrations produced per unit mass of material burnt. Gases measured are CO, CO_2, acid gases, nitrous oxides, sulphur dioxide, hydrogen cyanide and organic products of incomplete combustion (e.g. phenol, formaldehyde).

This report presents the data obtained from the testing and the findings/implications of this data with regards to safety during the incident.

Contents

Introduction

On 16 June 2010 while *Commodore Clipper* was on passage from Jersey to Portsmouth, a fire was detected on the main vehicle deck. The vehicle deck was loaded with unaccompanied freight trailers (i.e. no tractor units) including a number of refrigerated, curtain sided, lorries containing potatoes in plastic trays. The crew identified that one of the refrigerated trailer units, powered from the ship's electrical supply, had caught fire. Soon afterwards the fire spread to nearby units.

The vehicle deck was fully enclosed and smoke built up quickly. The crew contained the fire using the vehicle deck water drenching system and boundary cooling from above, but were not able to fully extinguish it. The vessel came into port and the local fire and rescue service extinguished the fire.

The Marine Accident Investigation Branch (MAIB) have commissioned BRE Global to carry out laboratory tests to assist their investigation into this incident, see BRE Global proposal number 127479, dated 14th July 2010, and MAIB acceptance dated 21st July 2010 (Contract Number: MAIB10011).

Two sets of standard small-scale tests have been carried out at the request of the MAIB. These are:

1. Cone calorimeter test to ISO 5660-1 & 2:2002. This involves taking 100mm square samples of a material and subjecting it to a range of set irradiance levels. Ignition is achieved using an electric spark ignition above the surface of the material. This test provides information on rate of heat release and time to ignition and can be used to calculate critical heat flux for ignition (the lowest heat flux at which a material will ignite).

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Samples provided by MAIB for the testing comprised sections of side curtain material from the freight trailers, straps for the side curtain material and crates used for transporting potatoes, as were present in the trailers involved in the fire.

Material Ignition and Burning Properties

Samples were exposed to a number of irradiances in the Cone Calorimeter apparatus (method as defined in ISO 5660 [1]) in order to obtain data for calculating ignition and burning properties. The summary data obtained from the Cone Calorimeter are given in Appendix A. Photos of the test runs (all at 35kW/m^2 are given in Appendix B. Keys to the symbols used in the summary data and the definition and calculation method for Maximum Average Rate of Heat Emission (MARHE) are given in Appendix C.

Critical Heat Flux

A critical radiant heat flux can be considered as the limiting criterion for pilot ignition of material i.e. the heat flux below which ignition is not possible. It is sensitive to heat losses from the surface and therefore the orientation and geometry of the surface. Many studies of ignition behaviour have been carried out which have yielded data on time to ignition as a function of incident heat flux. Based on heat transfer theory, assuming that incident heat flux is constant and ignoring heat losses, for thermally thick solid ($L>4\sqrt{(\alpha t)}$), the incident radiant heat flux can be plotted against $1/\sqrt{t_{ig}}$. An estimate of the critical radiant heat flux for pilot ignition can be found by extrapolating a line of best fit for the points plotted above. This is the point at which the line of best fit intercepts the incident radiant heat flux axis (y-axis on Figure 1 and Figure 2 below). However, it should be noted that non-linearities can occur in the data if extended to low heat fluxes and long ignition times. For more detailed information see Drysdale [2]. Note that the R-squared figures given on the critical irradiance plots are a statistical measure of how well the regression lines extrapolated approximate the distribution of their respective data points. R-squared values range from 0 to 1 and an R-squared value of 1 indicates a perfect fit.

Janssens [3] describes an approach of lowering the heat flux in small increments between subsequent tests (bracketing) until no ignition occurred during the thirty minute exposure period of the test. This methodology could not be used in this case as all of the components ignited at an irradiance level of 15 kW/m^2; the lowest irradiance employed.

The time to sustained flaming was recorded at five irradiance levels; the reciprocal of the square root of this time was then plotted against the irradiance level incident on the surface of the specimen, to estimate the minimum flux required to affect sustained ignition. According to ISO 5660, sustained flaming is deemed to have occurred if flaming is visible on or over the surface of the specimen for more than ten seconds. The results of this critical flux determination are shown below.

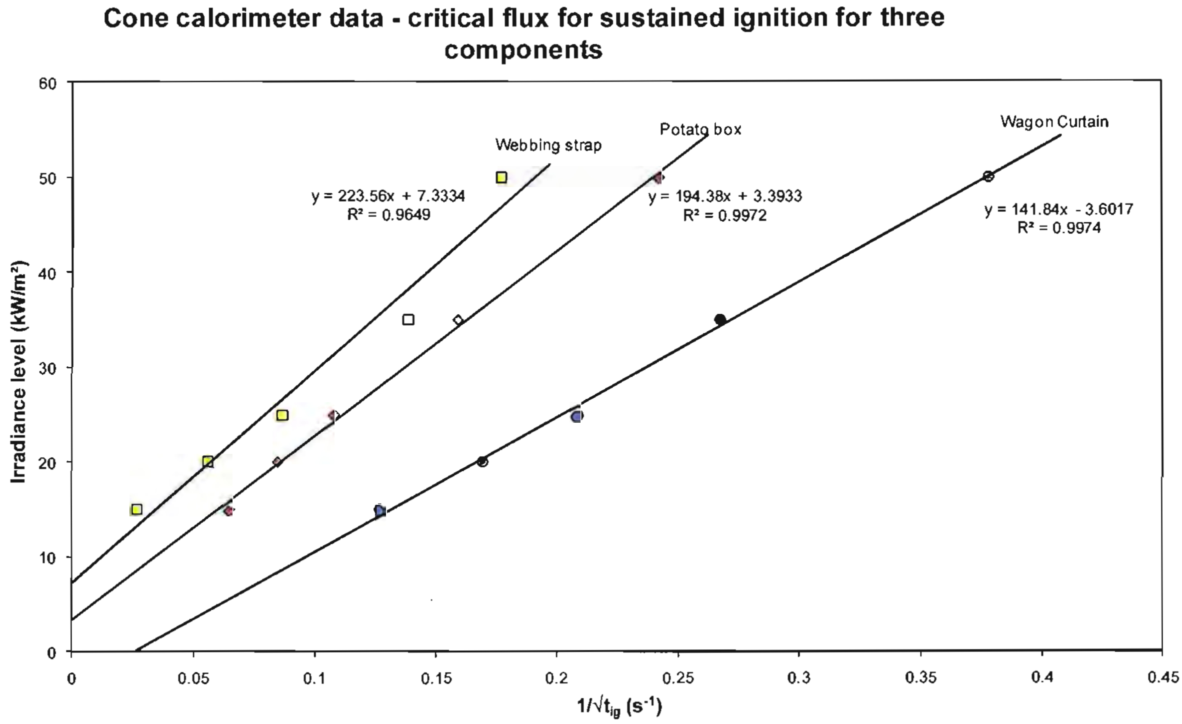


Figure 1 – Linear extrapolation of critical heat flux

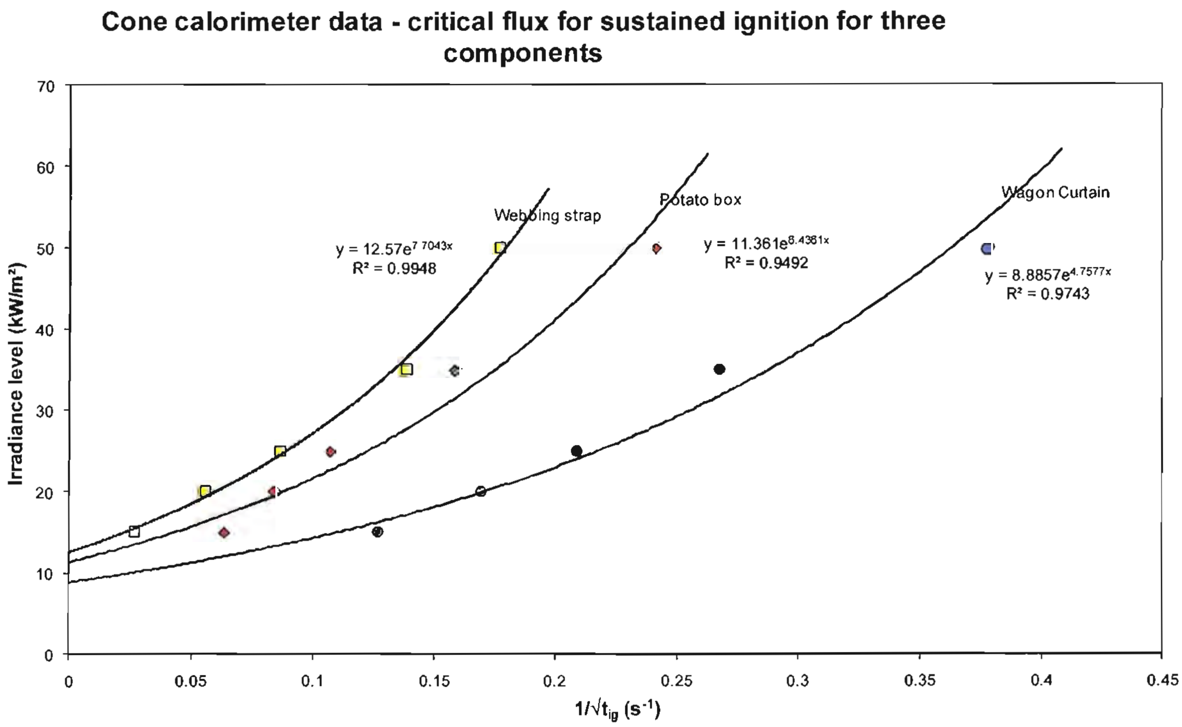


Figure 2 – Exponential extrapolation of critical heat flux

The values achieved from the extrapolation of the plots above are given in Table 1 below.

Component	Estimated critical heat flux, kW/m²	
	Linear extrapolation	Exp. extrapolation
Cream wagon curtain	-3.6 (R=0.997)	8.9 (R= 0.974)
Black webbing strap	7.3 (R = 0.965)	12.6 (R = 0.995)
Black potato box	3.4 (R=0.997)	11.4 (R = 0.949)

Table 1 – Estimated critical heat fluxes

The linear extrapolation method for the cream lorry curtain cannot be considered to be accurate as the value estimated is negative; in this instance the testing would need to be repeated at levels below 15 kW/m² to further refine the correlation. The data for the black webbing strap fits an exponential as opposed to linear trend line, as does the wagon curtain to a lesser extent. This may be because these materials were three millimetres or less in thickness and may not be considered to act in the same way as a thermally thick material.

Given that these materials appear to be thermally thin, their critical irradiance values cannot be compared directly with example values given in the literature [4] as these have been ascertained for thermally thick materials (where the combined material properties and sample thickness will have little or no impact upon the propensity of materials to ignite). However, some values for typical thermally thick materials are given below.

Material	Critical heat flux (kW/m^2)
Plywood, plain (1.27cm thick)	16
Polystyrene (5.08 cm)	46
Polycarbonate (1.52 cm)	30
PMMA polycast (1.59 cm)	9

Table 2 – Critical heat fluxes of known thermally thick materials

Maximum Average Rate of Heat Emission (MARHE)

The railway industry and associated fire laboratories are contributing towards the drafting of fire safety standards for rolling stock in the EU. DD CEN TS 45545-2: 2009 [5] defines a set of upper limits for the MARHE values of materials permitted on railway rolling stock seeking to comply with the standard (expected to be made mandatory in the EU).

The upper limits for MARHE values for some example materials listed in DD CEN TS 45545-2: 2009 for Hazard Level 1 (least stringent hazard level – trains not passing through extensive tunnels) are given below in Table 3. These values may be compared with the test results given in Appendix A.

Material	MARHE upper limit for Hazard Level 1
Interior components (structure and coverings) such as ceiling panelling as also flaps, boxes, hoods, louvers, insulation material and the body shell in this area. Interior components (structure and covering) such as side walls, front walls / end-walls, partitions, room dividers, as also flaps, boxes, hoods, louvers, in this area, interior doors, interior lining of the front-/end-wall doors and external doors, luggage compartment, windows (plastics, glazing with foils) also body shell in this area; kitchen interiors surfaces (except those of kitchen equipment)	If flaming droplets/particles are reported according to 6.3.6 during the test ISO 5658-2, or for the special case of materials which do not ignite in ISO 5658-2 and are additionally reported as unclassifiable, the following additional tests shall be added: **— MARHE maximum value for HL1,2,3 is 90 kw/m^2** (Assessed at 50 kW/m^2); — test according test method EN 11925-2 with the request 30 s flame application no spread > 150 mm within 60 s and shall not have burning droplets/particles.
Vertical parts of external structure of body shell and door leafs (including paint/coating systems, films)	If flaming droplets/particles are reported according to 6.3.6 during the test ISO 5658-2, or for the special case of materials which do not ignite in ISO 5658-2 and are additionally reported as unclassifiable, the following additional tests shall be added: **— MARHE maximum value for HL1,2,3 is 90 kw/m^2** (Assessed at 50 kW/m^2); — test according test method EN 11925-2 with the request 30 s flame application no spread > 150 mm within 60 s and shall not have burning droplets/particles.
External roof structure of the car body (including paint/coating systems, films)	No MARHE Limit Other Criteria (Critical heat flux at extinguishment; heat flux at which flame front ceases to advance)
Enclosure for electrical equipment	If flaming droplets/particles are reported according to 6.3.6 during the test ISO 5658-2, or for the special case of materials which do not ignite in ISO 5658-2 and are additionally reported as unclassifiable, the following additional tests shall be added: **— MARHE maximum value for HL1,2,3 is 90 kw/m^2** (Assessed at 50 kW/m^2); — test according test method EN 11925-2 with the request 30 s flame application no spread > 150 mm within 60 s and shall not have burning droplets/particles.
Surge arrester; isolators; switches; main circuit breakers	No MARHE limit Other criteria (smoke production, toxicity of fire effluents)

Table 3 – Example MARHE upper limits from DD CEN TS 45545.

Cone Calorimeter Temperature Data

Temperature profiles were collected for the cone calorimeter for each material at an irradiance of 35 kW/m^2. The summary cone calorimeter data for these runs are presented below in Table 4. (N.B. HRR = Heat Release Rate, MLR = Mass Loss Rate)

Specimen	Thickness	Time to ignition	Time to end of test	Test Duration	Total HRR	MARHE
	(mm)	(s)	(s)	(s)	(MJ/m²)	(kW/m²)
Wagon Curtain	3.00	15	600	585	30.5	95.74
Webbing Strap	1.4	34	672	638	21.2	99.12
Potato Box	3.0	44	714	670	56.2	233.97

Specimen	60s mean	180s mean HRR	300s mean HRR	Maximum HRR	Average	Average MLR between 10 and 90 % mass loss
	(kW/m²)	(kW/m²)	(kW/m²)	(kW/m²)	(MJ/kg)	(g/m²s)
Wagon Curtain	112.69	95.93	84.30	139.87	14.79	6.11
Webbing Strap	140.14	94.52	61.98	203.59	18.45	5.15
Potato Box	216.46	277.32	180.62	581.75	28.18	6.65

Specimen	Initial Mass	Mass at sustained flaming	Final Mass	Total mass Loss	Average rate of mass loss	Total of Mass Pyrolysed
	(g)	(g)	(g)	(g/m²)	(g/m²s)	(%)
Wagon Curtain	19.19	18.70	0.47	2063	3.49	98
Webbing Strap	12.21	10.30	0.17	1146	1.81	99
Potato Box	25.44	25.30	7.68	1995	2.97	70

Table 4 – Cone Calorimeter data for temperature measurement runs.

The temperature data and ignition times for each of these runs are plotted below in Figure 3.

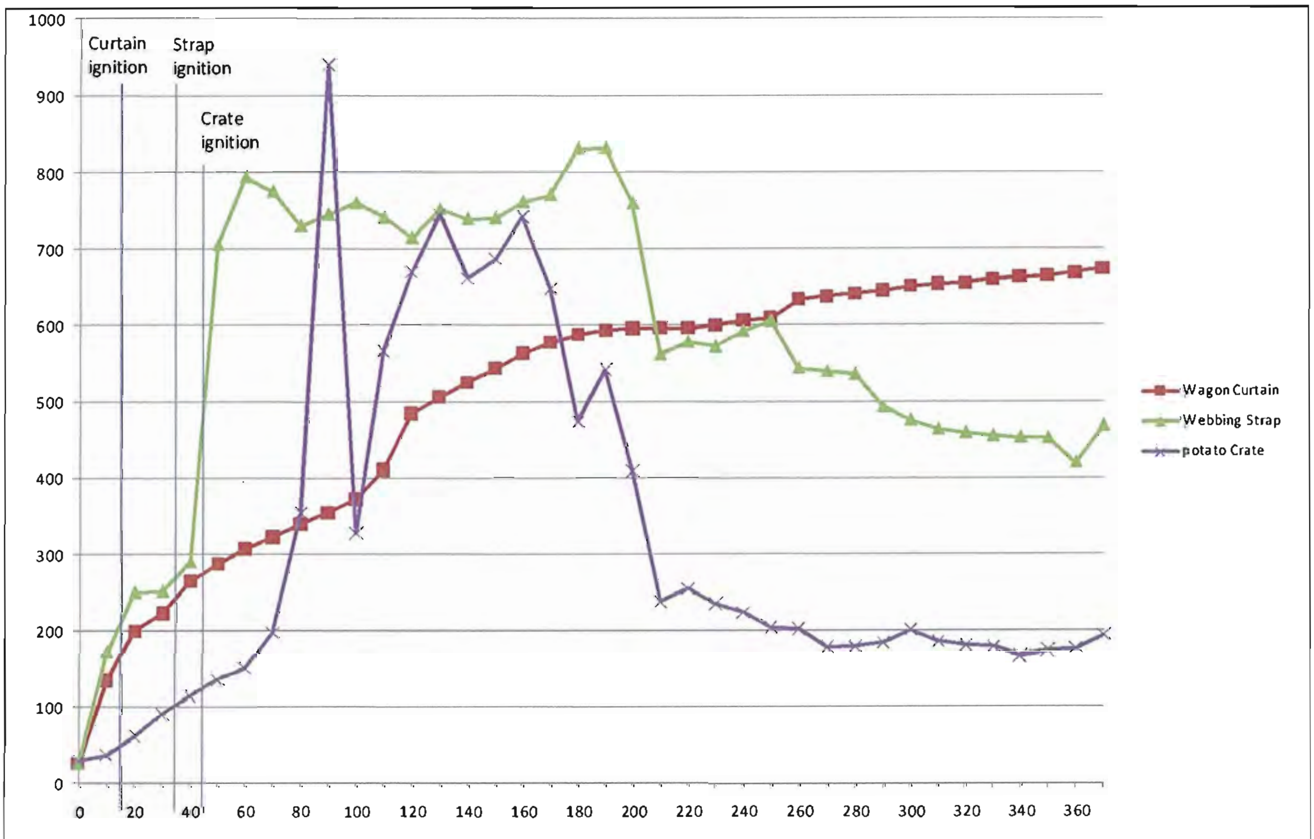


Figure 3 – Temperature data collected from 35 kW/m^2 Cone Calorimeter runs

Toxicity Properties

The materials were tested for the concentration of toxic effluents they were capable of producing using NES 713. Data from these tests have been submitted separately to MAIB as standard test reports (BRE Global report numbers 266462, 266463 and 266464, all dated the 11th October 2010).

The following information has been received from MAIB regarding the compartment into which toxic effluents were released.

- 2287m^2 area
- 5.7m height
- 13035.9 m^3 volume
- 4935m^3 occupied by vehicles

From the NES 713 test reports (BRE Global test report numbers 266462, 266463 and 266464), the following species production data have been obtained for the materials tested.

Wagon Curtain			
	Concentration calculated per 100g sample in 1m^3, parts per million		
Species	Sample 1	Sample 2	Average
CO	0.97	0.49	0.73

Webbing Strap			
	Concentration calculated per 100g sample in 1m^3, parts per million		
Species	Sample 1	Sample 2	Average
CO_2	1.99	0	0.995
CO	0.12	0.12	0.12
NO_X	1.19	1.19	1.19

Potato Crate			
	Concentration calculated per 100g sample in 1m^3, parts per million		
Species	Sample 1	Sample 2	Average
CO_2	0.99	0.48	0.735
CO	0.25	0.36	0.305

Calculations for total compartment filling

These calculations have been made for homogenous dispersal of the toxic products of combustion throughout the entire free volume of the cargo deck of the Commodore Clipper. For these calculations the following assumptions have been made:

- The cargo deck is a sealed compartment.
- There are no objects reducing the free volume of the cargo deck other than those reported by MAIB.
- Toxic species are homogenously mixed throughout the atmosphere of the cargo deck.
- Burning conditions in the cargo deck are yielding toxic species in the same quantities (mass of effluent per unit mass of material burnt) as in the NES 713 test.

Wagon Curtain			
Species	Concentration per 100g sample in $1m^3$, parts per million	Compartment concentration per kg sample burnt, ppm	Compartment concentration per 1000kg sample, ppm
CO	0.73	0.00056	0.559992

Webbing Strap			
Species	Concentration per 100g sample in $1m^3$, parts per million	Compartment concentration per kg sample burnt, ppm	Compartment concentration per 1000kg sample, ppm
CO_2	0.995	0.000763	0.763277
CO	0.12	0.000092	0.092053
NO_X	1.19	0.000913	0.912864

Potato Crate			
Species	Concentration per 100g sample in $1m^3$, parts per million	Compartment concentration per kg sample burnt, ppm	Compartment concentration per 1000kg sample, ppm
CO_2	0.735	0.000564	0.563828
CO	0.305	0.000234	0.233969

Calculations for 1m smoke layer

MAIB have indicated that approximately 10 minutes following the first signs of smoke appearing on CCTV footage of the incident, a smoke layer approximately 1 metre deep developed beneath the ceiling of the compartment. As such the following calculations have been made for concentrations within a 1m smoke layer at the top of the compartment. It has been assumed that no part of the trailers is occupying the volume of the uppermost 1m of the cargo deck compartment.

Wagon Curtain			
Species	Concentration per 100g sample in 1m^3, parts per million	1m smoke layer concentration per kg sample burnt, ppm	1m smoke layer concentration per 1000kg sample, ppm
CO	0.73	0.003192	3.191955

Webbing Strap			
Species	Concentration per 100g sample in 1m^3, parts per million	1m smoke layer concentration per kg sample burnt, ppm	1m smoke layer concentration per 1000kg sample, ppm
CO_2	0.995	0.004351	4.350678
CO	0.12	0.000525	0.524705
NO_X	1.19	0.005203	5.203323

Potato Crate			
Species	Concentration per 100g sample in 1m^3, parts per million	1m smoke layer concentration per kg sample burnt, ppm	1m smoke layer concentration per 1000kg sample, ppm
CO_2	0.735	0.003214	3.213817
CO	0.305	0.001334	1.333625

Conclusions

Material Ignition and Burning Properties

The critical irradiance determination has shown that, of the three materials tested, the wagon curtain has the lowest critical irradiance and is also the quickest material to ignite at higher irradiances. All three materials, regardless of the extrapolation method employed, have critical irradiances less than or equal to 12.6 kW/m^2. For comparison, Approved Document B (Fire Safety) to the Building Regulations sets out requirements for space separation of buildings based on the assumption that materials on the outside of buildings can withstand heat radiation up to 12.6kW/m^2.

The MARHE determination has shown that, of the three materials tested, the potato crate has the greatest potential for heat emission once it becomes involved in fire. Given that the potato crate accounted for the majority of the combustible mass involved in the incident (apart from the potatoes themselves, although these contain 90% water, significantly reducing their calorific value in fire) the heat emission of this material would have been the greatest contributing component to the overall heat emission of the fire.

When considered in combination, the ignition and burning data obtained for the materials, and their respective locations within the incident, indicates the following:

- The wagon curtain, providing the external face of the wagons, would have been most susceptible to incident radiation being received from an external burning object. Once ignited, the wagon curtain would have provided a pilot ignition source for the potato crates and potatoes.
- The webbing strap material, given the low mass involved and its resistance to ignition relative to the other materials tested, is unlikely to have played a significant part in the start or development of the fire during the incident.
- The potato crate, accounting for the greatest proportion of combustible mass apart from the potatoes themselves and possessing the highest MARHE of the three materials tested, is likely to have been principally responsible for the amount of heat and combustion products given off during the fire.

Toxicity Properties

The toxicity testing of the materials has indicated that none of them has an unusually great propensity for producing toxic combustion products. However, this assumes that the combustion conditions during the incident were analogous with those of the toxicity test itself. If the fire became oxygen starved during the incident (if the cargo hold was well sealed and there wasn't sufficient oxygen within its volume to allow complete combustion of all the materials that burned during the incident) then it is possible that more toxic combustion products would have been produced per unit mass of material burned than has been indicated by the standard testing.

References

1. International Standards Organisation. ISO 5660-1: 2002. Reaction-to-fire tests -- Heat release, smoke production and mass loss rate -- Part 1: Heat release rate (cone calorimeter method). ISO 2002.

2. Drysdale, D. An Introduction to Fire Dynamics, Section 6.3.1, second edition. Published by J.Wiley & Sons, England, 1999.

3. Janssens, M. 'Development of FDMS Tools to Generate Data for Fire Safety Engineering and Modeling', NIST SP 998, NIST, Gaithersburg, MD, May 2003.

4. Quintiere, J. G. Principles of Fire Behaviour. Delmar Publishers, Albany, 1998.

5. British Standards Institution. DD CEN TS 45545—2: 2009. Railway applications — Fire protection on railway vehicles. Part 2: Requirements for fire behaviour of materials and components. BSI 2009.

Appendix A – Cone Calorimetry Data

Wagon Curtain

Client	Sample ref	level
Fire safety/MAIB Cream Wagon Curtain	E3030	15 - 50 kW/m²

Specimen number	Thickness	Time to ignition t_{ig}	Time to end of test	Test Duration	Total HRR $Q_{A,tot}$	MARHE
	(mm)	(s)	(s)	(s)	(MJ/m²)	(kW/m²)
1 - 50 kW/m²	3.00	7	864	857	32.1	110.18
2 - 35 kW/m²	3.00	13	992	979	34.9	91.12
3 - 25 kW/m²	3.00	23	644	621	20.0	66.84
4 - 20 kW/m²	3.00	35	794	759	23.9	57.36
5 - 15 kW/m²	3.00	58	824	766	34.0	57.48
6 - 15 kW/m²	3.00	67	870	803	32.5	52.86
Mean Value	**3.00**	**34**	**831**	**798**	**29.6**	**72.64**

Specimen number	60s mean $\dot{q}_{A,60}$	180s mean HRR $\dot{q}_{A,180}$	300s mean HRR $\dot{q}_{A,300}$	Maximum HRR $\dot{q}_{A,max}$	Average $\Delta h_{c,eff}$	Average MLR between 10 and 90 % mass loss $\dot{m}_{A,10-90}$
	(kW/m²)	(kW/m²)	(kW/m²)	(kW/m²)	(MJ/kg)	(g/m²s)
1 - 50 kW/m²	124.76	101.10	87.69	168.92	16.29	5.70
2 - 35 kW/m²	111.55	90.06	80.23	151.46	18.35	4.59
3 - 25 kW/m²	72.22	72.51	57.27	102.53	10.22	4.83
4 - 20 kW/m²	77.94	68.30	57.15	108.31	12.90	3.74
5 - 15 kW/m²	79.32	73.87	66.96	112.94	19.70	3.27
6 - 15 kW/m²	77.21	71.33	63.02	109.32	18.87	3.33
Mean value	**90.50**	**79.53**	**68.72**	**125.58**	**16.06**	**4.24**

Specimen number	Initial Mass m	Mass at sustained flaming m_s	Final Mass m_f	Total mass Loss Δm	Average rate of $\dot{m}$	Total of Mass Pyrolysed
	(g)	(g)	(g)	(g/m²)	(g/m²s)	(%)
1 - 50 kW/m²	19.37	19.37	1.99	1967	2.29	90
2 - 35 kW/m²	19.35	19.30	2.47	1905	1.94	87
3 - 25 kW/m²	19.35	19.00	1.71	1957	3.14	91
4 - 20 kW/m²	19.13	18.70	2.35	1851	2.46	88
5 - 15 kW/m²	19.29	19.29	4.05	1725	2.25	79
6 - 15 kW/m²	19.17	19.20	3.99	1722	2.15	79
Mean value	**19.28**	**19.14**	**2.76**	**1854**	**2.37**	**86**

	Length	Width
1 - 50 kW/m²	100	100
2 - 35 kW/m²	99.6	99.7
3 - 25 kW/m²	100	100
4 - 20 kW/m²	100	100
5 - 15 kW/m²	100	99
6 - 15 kW/m²	99.86	99.63

Webbing Strap

Client	Sample ref	level
Fire safety/MAIB Black Webbing strap	E3031	15 - 50 kW/m²

Specimen number	Thickness (mm)	Time to ignition t_{ig} (s)	Time to end of test (s)	Test Duration (s)	Total HRR $Q_{A,tot}$ (MJ/m²)	MARHE (kW/m²)
1 - 50 kW/m²	1.38	32	380	348	19.0	139.69
2 - 35 kW/m²	1.38	52	1852	1800	24.5	109.96
3 - 25 kW/m²	1.38	133	450	317	13.8	60.16
4 - 20 kW/m²	1.38	320	516	196	11.6	28.82
5 - 15 kW/m²	1.38	1423	1676	253	9.3	7.24
Mean Value	**1.38**	**392**	**975**	**583**	**15.6**	**69.17**

Specimen number	60s mean $\dot{q}_{A,60}$ (kW/m²)	180s mean HRR $\dot{q}_{A,180}$ (kW/m²)	300s mean HRR $\dot{q}_{A,300}$ (kW/m²)	Maximum HRR $\dot{q}_{A,max}$ (kW/m²)	Average $\Delta h_{c,eff}$ (MJ/kg)	Average MLR between 10 and 90 % mass loss $\dot{m}_{A,10-90}$ (g/m²s)
1 - 50 kW/m²	211.39	95.23	62.55	414.11	15.01	6.42
2 - 35 kW/m²	200.82	83.72	54.04	320.24	19.44	2.95
3 - 25 kW/m²	182.91	75.15	45.62	314.43	13.42	9.99
4 - 20 kW/m²	164.13	59.83	0.00	250.75	14.13	15.67
5 - 15 kW/m²	139.83	49.04	0.00	270.86	14.55	11.06
Mean value	**179.82**	**72.59**	**32.44**	**314.08**	**15.31**	**9.22**

Specimen number	Initial Mass m (g)	Mass at sustained flaming m_s (g)	Final Mass m_f (g)	Total mass Loss Δm (g/m²)	Average rate of $\dot{m}$ (g/m²s)	Total of Mass Pyrolysed (%)
1 - 50 kW/m²	12.14	11.90	0.70	1268	3.64	94
2 - 35 kW/m²	11.82	11.60	0.47	1259	0.70	96
3 - 25 kW/m²	12.21	11.50	2.45	1024	3.22	80
4 - 20 kW/m²	12.14	11.30	4.03	823	4.19	67
5 - 15 kW/m²	12.11	11.50	5.88	636	2.48	51
Mean value	**12.08**	**11.56**	**2.71**	**1002**	**2.85**	**78**

	Length	Width
1 - 50 kW/m²	99.9	99.9
2 - 35 kW/m²	100	100
3 - 25 kW/m²	100	100
4 - 20 kW/m²	100	100
5 - 15 kW/m²	100	100

Black Potato Box

Client		Sample ref	Irradiance level
Fire safety/MAIB Black Potato box		E3032	15 - 50 kW/m²

Specimen number	Thickness (mm)	Time to ignition t_{ig} (s)	Time to end of test (s)	Test Duration (s)	Total HRR $Q_{A,tot}$ (MJ/m²)	MARHE (kW/m²)
1 - 50 kW/m²	3.00	17	864	847	104.7	472.04
2 - 35 kW/m²	3.00	35	1835	1800	50.1	171.78
3 - 25 kW/m²	3.00	86	1668	1582	56.9	113.52
4 - 20 kW/m²	3.00	140	1342	1202	59.5	116.14
5 - 15 kW/m²	3.00	239	812	573	56.8	87.52
Mean Value	**3.00**	**103**	**1304**	**1201**	**65.6**	**192.20**

Specimen number	60s mean $\dot{q}_{A,60}$ (kW/m²)	180s mean HRR $\dot{q}_{A,180}$ (kW/m²)	300s mean HRR $\dot{q}_{A,300}$ (kW/m²)	Maximum HRR $\dot{q}_{A,max}$ (kW/m²)	Average $\Delta h_{c,eff}$ (MJ/kg)	Average MLR between 10 and 90 % mass loss $\dot{m}_{A,10-90}$ (g/m²s)
1 - 50 kW/m²	287.79	488.58	325.82	1086.71	35.71	8.89
2 - 35 kW/m²	205.04	164.29	116.12	326.51	32.01	6.14
3 - 25 kW/m²	103.44	165.32	139.11	299.36	31.17	2.35
4 - 20 kW/m²	107.59	195.62	163.51	349.96	39.48	12.05
5 - 15 kW/m²	97.04	176.62	152.55	275.23	41.72	3.83
Mean value	**160.18**	**238.09**	**179.42**	**467.55**	**36.02**	**6.65**

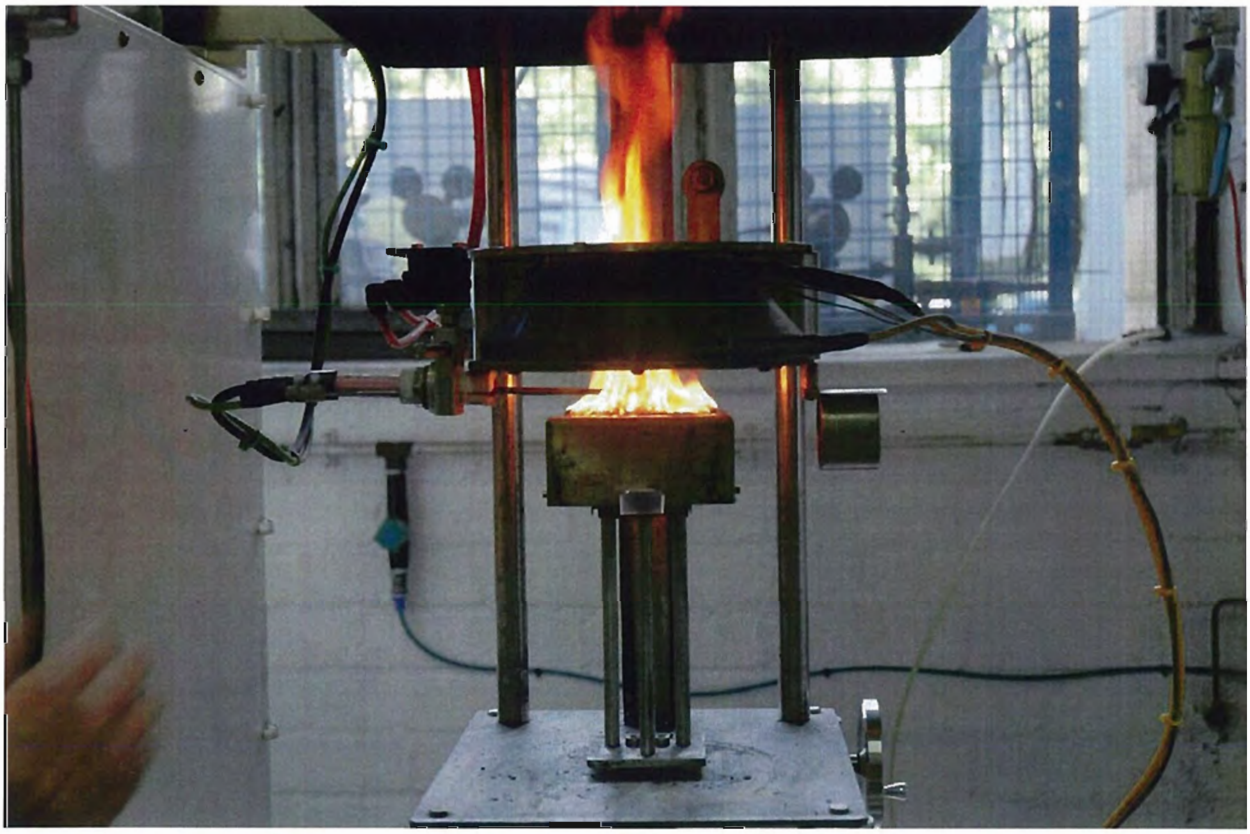
Specimen number	Initial Mass m (g)	Mass at sustained flaming m_s (g)	Final Mass m_f (g)	Total mass Loss Δm (g/m²)	Average rate of $\dot{m}$ (g/m²s)	Total of Mass Pyrolysed (%)
1 - 50 kW/m²	25.05	25.05	-0.86	2932	3.33	103
2 - 35 kW/m²	19.72	19.40	5.57	1565	0.87	72
3 - 25 kW/m²	25.73	25.70	9.58	1824	1.15	63
4 - 20 kW/m²	25.91	25.40	12.09	1506	1.24	53
5 - 15 kW/m²	25.03	24.50	12.48	1361	2.38	50
Mean value	**24.29**	**24.01**	**7.77**	**1838**	**1.79**	**68**

	Length	Width
1 - 50 kW/m²	99.81	99.87
2 - 35 kW/m²	99.97	99.63
3 - 25 kW/m²	99.77	98.95
4 - 20 kW/m²	99.48	99.35
5 - 15 kW/m²	100	100

Appendix B – Test Photos

Wagon Curtain

Webbing Strap



Black Potato Box

Appendix C – Key to symbols

t_{ig} Time to ignition (onset of sustained flaming), expressed in seconds.

$Q_{A,tot}$ Total heat released per unit area during the entire test, expressed in mega joules per square metre.

ARHE The average rate of heat emission at time t, expressed in kilowatts per unit area. Calculated as the cumulative heat emission from t = 0 to t = t divided by t and given by the following equation (reference DD CEN/TS 45545-2:2009[2]).

$$ARHE(t_n) = \frac{\sum_{2}^{n} (t_n - t_{n-1}) X \frac{\dot{q}_n + \dot{q}_{n-1}}{2}}{t_n - t_{n-1}}$$

Where $\dot{q}$ is the heat release per unit area and t is the time.

MARHE The maximum value of ARHE, expressed in kilowatts per unit area.

$\dot{q}_{A,60}$, $\dot{q}_{A,180}$ and $\dot{q}_{A,300}$ Average heat release rate per unit area over a period starting at t_{ig} and ending 60 s, 180 s or 300 s later respectively, expressed in kilowatts per square metre.

$\dot{q}_{A,\max}$ Maximum value of the heat release rate per unit area, expressed in kilowatts per square metre.

$\Delta h_{c,eff}$ Effective net heat of combustion expressed in mega joules per kilogram.

$\dot{m}_{A,10-90}$ Average mass loss rate per unit area between 10 % and 90 % of mass loss, expressed in grams per square metre seconds.

m_s Mass at sustained flaming, expressed in grams.

m_f Mass remaining after the test, expressed in grams.

Δm Sample mass loss, expressed in grams per square metre.

$\dot{m}$ Average rate of specimen mass loss calculated between t_{ig} and the end of the test, expressed in grams per square metre seconds.

Reference

1. DD CEN/TS 45545-2:2009. “DRAFT FOR DEVELOPMENT. Railway applications - Fire protection on railway vehicles. Part 2: Requirements for fire behaviour of materials and components”, CEN, Brussels, Belgium.

MAIB Safety Bulletin 3/2010

MAIB SAFETY BULLETIN 3/2010

Vehicle deck fire on board the ro-ro passenger ferry *Commodore Clipper*

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MAIB SAFETY BULLETIN 3/2010

This document, containing safety lessons, has been produced for marine safety purposes only, on the basis of information available to date.

The Merchant Shipping (Accident Reporting and Investigation) Regulations 2005 provide for the Chief Inspector of Marine Accidents to make recommendations at any time during the course of an investigation if, in his opinion, it is necessary or desirable to do so.

Stephen Meyer
Chief Inspector of Marine Accidents

NOTE

This bulletin is not written with litigation in mind and, pursuant to Regulation 13(9) of the Merchant Shipping (Accident Reporting and Investigation) Regulations 2005, shall not be admissible in any judicial proceedings whose purpose, or one of whose purposes, is to apportion liability or blame.

As the flag state, the Bahamas Maritime Authority has agreed the content of this Bulletin.

This bulletin is also available on our website: www.maib.gov.uk
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BACKGROUND

At 0242 (BST) on 16 June 2010, while the ro-ro ferry *Commodore Clipper* was on passage from Jersey to Portsmouth, a fire was detected on the main vehicle deck. The vehicle deck was loaded with unaccompanied freight trailers and crew identified that a refrigerated trailer unit, powered from the ship's electrical supply, had caught fire.

The vehicle deck was fully enclosed and smoke built up quickly. The crew contained the fire using the vehicle deck water drenching system and boundary cooling from above, but were not able to extinguish it.

The vessel came into port and the crew assisted the local fire and rescue service in attempts to fight the fire. Freight trailers were packed closely on the vehicle deck and firefighters found it extremely difficult to reach the seat of the fire. Trailers had to be towed off before the fire, which had by now burned for about 18 hours and spread to four trailers, was finally put out.

Firefighters preparing to attack the fire from the stern door

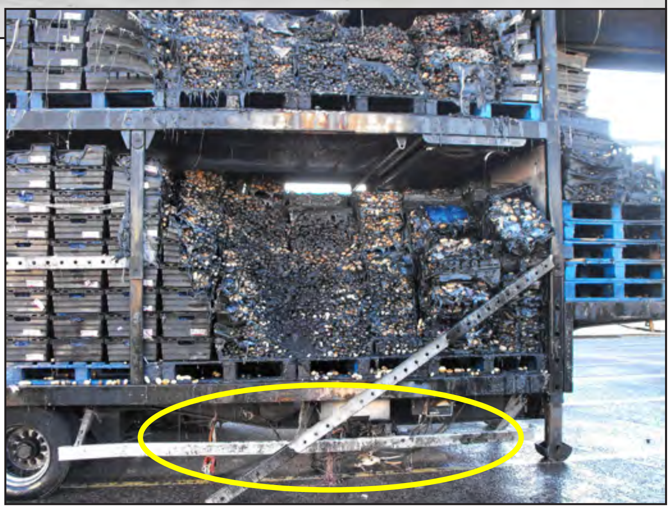
ANALYSIS

Preliminary findings of the subsequent accident investigation indicate that the fire was caused by an electrical fault involving the power supply from the ship and the trailer's refrigeration control system. The resultant sustained overheating led to the curtain-side of the trailer igniting. Although the ship's electrical breakers were found to be working correctly, they did not trip before the fire started.

MAIB has also received other reports of power supply cables to refrigerated trailers becoming very hot while in use.

Damage to one of the refrigerated trailers and its cargo of potatoes

Electrical power connection



Damaged refrigeration control units

RECOMMENDATION

S2010/118M Operators of vessels carrying refrigerated trailer units should:

- Take immediate action to ensure that all power supply cables and fittings provided for refrigerated trailer units are in good condition and that electrical protection devices will activate at an appropriate level.
- Until such time as the exact causes of this fire have been established, make additional checks of refrigerated trailers powered by ships' electrical systems to provide early warning of any overheating.

Issued July 2010

MAIB flyer to ro-ro vessel operators and the ports industry

MAIB

MARINE ACCIDENT INVESTIGATION BRANCH

FLYER TO RO-RO VESSEL OPERATORS AND THE PORTS INDUSTRY

Commodore Clipper – Fire on the main vehicle deck due to an overheating reefer cable connection

Commodore Clipper

During an overnight passage from Jersey to Portsmouth on 16 June 2010, a fire was detected on the main vehicle deck of the ro-ro passenger vessel *Commodore Clipper*. The officer of the watch and duty engineer initially thought the alarm was due to a fault with the fire detection system, and the vehicle deck water drenching system was not started until 20 minutes later.

The fire developed in an unaccompanied curtain-sided refrigerated trailer that was carrying a load of potatoes. The trailer roof shielded the flames from the drenchers and the fire continued to burn. The trailers were tightly stowed; crew had great difficulty gaining access to the fire and were unable to extinguish it.

Unprotected cables and pipework running above the fire were soon damaged in the high temperatures that were generated by the burning curtain-side and cargo packaging materials. The vessel lost power to forward mooring deck winches and bow thrusters, control of the rudders was disrupted and the port rudder suddenly moved hard to starboard. Loose cargo partially blocked the deck drains and drencher water caused *Commodore Clipper* to list. Drenching was stopped while water drained to prevent further risk to the vessel's stability, but each time it was stopped, the fire grew in intensity.

With tugs standing by, *Commodore Clipper* entered harbour and berthed alongside. The control circuits for the ro-ro hydraulics had been burnt out, but the engineers managed to bypass the system and were able to open the stern door. Few foot passengers were carried on the route and *Commodore Clipper* never used a gangway. Although the port was able to provide a gangway, it was difficult for personnel to move through the tightly stowed vehicles on the upper vehicle deck to get from the gangway into the accommodation. It was decided that it was safer to leave the 62 passengers on board rather than risk evacuating them by the gangway, lifeboat or marine evacuation system.

The local fire and rescue service (FRS) attempted to gain access to the seat of the fire, but struggled to get past the vehicles and make their way through the cargo debris. Firefighters, crew and stevedores worked together to contain the fire, unlash and remove undamaged trailers. As they got deeper into the main vehicle deck, the smoke became thicker and it was no longer possible to work without wearing breathing apparatus (BA). Firefighters could not reach all the seats of fire without the trailers being removed from the main vehicle deck. The vessel's supply of spare BA cylinders had been used up and the stevedores had no previous experience of working in BA. There was a pause in fighting the fire while it was decided what to do next.

Commodore Clipper's crew had previously trained with the local FRS on exercises and managers had developed a good relationship. Fortunately, their BA sets were compatible and the FRS agreed to lend the crew additional cylinders so that they could continue to unlash the trailers and guide the firefighters. As senior fire officers and company managers were considering how they could get the remaining trailers off the vessel, one of the stevedores volunteered to drive his tugmaster while wearing BA. The stevedore was familiarised with the equipment and a number of firefighters stood by to monitor his safety and assist him if necessary. He carried on towing the trailers off the vessel until he reached the five units that were on fire. Still alight, the trailers were towed off the vessel and finally extinguished. Once a route through the main vehicle deck had been cleared the passengers were escorted off, nearly 20 hours after the fire had first been detected.

Subsequent investigation found that the fire was due to one of the ship's reefer cables being assembled incorrectly. The reefer cable plugs used 'insulation displacement connectors' (IDC) that are meant to speed up assembly by avoiding the need to strip insulation from cable ends. However, the insulation had been stripped away, and as the design relied on the insulation to help secure the cable in place, the connection became loose. This led to a local high-resistance fault and then arcing in one of the phases. The electrical protection in the vessel's circuit breakers was not able to detect this fault and heat built up inside the plug until the plastic casing ignited. The socket on the trailer was mounted close to the load-bed where the curtain-side was secured. In tests, the material ignited readily and flames spread quickly.

Fortunately, no-one was hurt on *Commodore Clipper* and the accident is a good illustration of how a vehicle deck fire can affect many different aspects of the vessel's operation. The total constructive losses of the ferries *Und Adriyatik* and *Lisco Gloria* show what can happen in similar circumstances if vehicle fires develop out of control.

The MAIB has also published a detailed report, **24/2011** about the accident which identifies all the safety issues raised by the case.

Safety Lessons

Ro-ro ferry operators

1. Check their vessels' vehicle decks for critical and vulnerable systems, and take action as necessary to improve their resilience to fire damage.

2. Check all reefer trailer power cables regularly. Consider upgrading existing electrical protection to a system that can detect in-line phase faults and provides residual current detection.

3. React quickly and positively to early indications of fires on vehicle decks. Fires in densely packed vehicle spaces can grow very quickly and, once they are established, can be very difficult to put out.

4. Existing vehicle deck drenching systems may not be able to extinguish the fire; there is not always a requirement for structural fire protection between vehicle decks, heat can transfer through decks and spread the fire very quickly. Boundary cooling is essential.

5. Review emergency response plans and identify the most effective options for vessels that trade on regular routes to obtain assistance from external authorities.

Port operators

1. Consider which berths in the port are best suited to supporting a vessel that needs assistance to deal with an emergency incident. Identify and record the capabilities and limitations of berths.

2. Work with vessel operators to identify and record how passengers could be evacuated and cargo moved to assist the emergency services in responding to an incident involving a vessel in the port.

3. Identify and record how other aspects of the existing port infrastructure and resources could be used to best effect in supporting a vessel that is alongside and needs emergency assistance.

4. Liaise with local emergency services to ensure that they understand the capabilities or limitations of the port's resources and infrastructure and what it is able to provide to help support vessels in distress.

This flyer and the MAIB's investigation report are posted on our website:
www.maib.gov.uk

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