Bundesstelle für Seeunfalluntersuchung
Federal Bureau of Maritime Casualty Investigation
Federal Higher Authority subordinated to the Ministry of Transport
and Digital Infrastructure

Investigation Report 99/13

Serious Marine Casualty

Fire on the con-ro carrier ATLANTIC CARTIER on 1 May 2013 in the Port of Hamburg

9 October 2015

www.bsu-bund.de

The following is a **joint report** by the German Federal Bureau of Maritime Casualty Investigation, as lead investigating authority, and the marine casualty investigation authority of the flag State Sweden. The two bodies have conducted this investigation jointly and in accordance with the IMO Casualty Investigation Code (Resolution MSC.255(84)) and Directive 2009/18/EC of the European Parliament and of the Council of 23 April 2009 establishing the fundamental principles governing the investigation of accidents in the maritime transport sector. The working language used for this joint investigation was English.

The investigation was conducted in conformity with the Law to improve safety of shipping by investigating marine casualties and other incidents (Maritime Safety Investigation Act - SUG) of 16 June 2002, amended most recently by Article 16(22) of 19 October 2013, BGBl. (Federal Law Gazette) I p. 3836.

According to said Law, the sole objective of this investigation is to prevent future accidents and malfunctions. This investigation does not serve to ascertain fault, liability or claims (Article 9(2) SUG).

This report should not be used in court proceedings or proceedings of the Maritime Board. Reference is made to Article 34(4) SUG.

The German text shall prevail in the interpretation of this report.

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1 Summary

Heat and smoke emanating from an enclosed vehicle deck was detected on the Swedish-flagged con-ro carrier[1] ATLANTIC CARTIER, laden with containers and vehicles, at about 1925[2] on 1 May 2013. At this point, the ship was at her berth in the Port of Hamburg. Cargo handling did not take place.

After locating the fire inside vehicle deck 3 B, attempts were initially made to extinguish it from on board the ship. The action taken in this respect had to be aborted unsuccessfully after about 30 minutes because of the rapid spread of fire and huge build-up of smoke. After that, the master of the ship requested shore-based assistance immediately. The first operational units of the Hamburg fire services arrived at the ship at about 2012 and after receiving a briefing on the ship from the ship's command assumed control of the rest of the firefighting operation. In the course of the ensuing eight hours, additional extensive firefighting resources were mobilised and deployed ashore and on the water to cool the shell plating and later extinguish the fire. At the same time as what was initially the actual priority, the intense cooling efforts carried out mainly from the water, the time-consuming survey of the scene by the fire service and the manifold preparations for the primary firefighting operation, preparations were made to discharge the containers in the immediate vicinity of the seat of the fire, with priority given to those carrying dangerous goods, and gradually executed.

Activation of the shipboard CO2 extinguishing system and any measures necessary in this regard were discussed exhaustively between the ship's command and operational command of the fire service between 2200 and 2230.

The decision to use CO2 was finally taken immediately after the fire service's conventional extinguishing action in deck 3 had to be abandoned at about 2234 for reasons of safety. This had been ongoing since about 2119 and was implemented from the main deck via two access points. This involved the affected forward part of cargo hold 3 being completely sealed off by means of two hydraulic sliding doors installed on the ship – one of which was open when the fire broke out – in the interest of effective use of the CO2 extinguishing system. At 2258 and again at 2318, CO_2 was discharged from the system's two tanks into the burning vehicle deck. Use of the CO_2 combined with the external cooling efforts finally had the desired effect, meaning the conventional extinguishing action could begin at 0344. The fire was completely extinguished at 0410.

Neither crew members nor operational units of the fire services were injured as a result of the accident. The vehicles parked in the forward part of ro-ro deck 3 B, the area affected most by the fire, were destroyed. The extent of damage to the ro-ro cargo in other places on the ship varied depending on distance to the seat of the fire.

[1] Con-ro carrier: Special type of ship designed for the simultaneous carriage of **con**tainers and **ro**lling cargo (cars, lorries and trailers).
[2] Time according to the deck log book. All times shown in this report are local = CEST = UTC + 2 hours.

The ATLANTIC CARTIER was able to resume regular service for the charterer after an extensive repair.

2 FACTUAL INFORMATION

2.1 Photo of the MV ATLANTIC CARTIER

Figure 1: Photo of the MV ATLANTIC CARTIER

2.2 Ship particulars: MV ATLANTIC CARTIER

Name of ship:	ATLANTIC CARTIER
Type of ship:	Con-ro carrier
Nationality/Flag:	Sweden
Port of registry:	Gothenburg
IMO number:	8215481
Call sign:	SCKB
Owner:	Atlantic Container Line AB
Year built:	1985/1987 (lengthened)
Shipyard/Yard number:	Chantiers du Nord, Dunkirk/321
Ship lengthened by 42.5 metres:	Hyundai Mipo Dockyard, Ulsan
Classification society:	Lloyd's Register
Length overall:	292.02 m
Breadth overall:	32.39 m
Gross tonnage:	58,358
Deadweight:	52,880 t
Draught (max.):	11.60 m
Engine rating:	20,300 kW
Main engine:	1 x B&W – 6L90 GB two stroke diesel engine
(Service) speed (max.):	18 kts
Hull material:	Steel
Minimum safe manning:	14

2.3 Voyage particulars: MV ATLANTIC CARTIER

Port of departure:	Gothenburg, Sweden
Port of call:	Hamburg, Germany
Type of voyage:	Merchant shipping, international
Cargo information:	Container, ro-ro cargo (vehicles)
Draught at time of accident:	No details
Manning:	26
Number of passengers:	None
Other people on board:	6 (service technicians)
Pilot on board:	No

2.4 Marine casualty information

Type of accident:	Serious marine casualty, fire in cargo hold
Date, time:	01/05/2013, 1925[3]
Location:	Port of Hamburg, O'Swaldkai
Latitude/Longitude:	φ 53°31.8'N λ 010°00.0'E
Ship operation and voyage segment:	Made fast at berth
Consequences:	Damage to the cargo, material damage to ship; no injuries or harm to the environment

Excerpt from Nautical Chart 48 (INT 1455 – Plan B: Port of Hamburg), BSH[4]

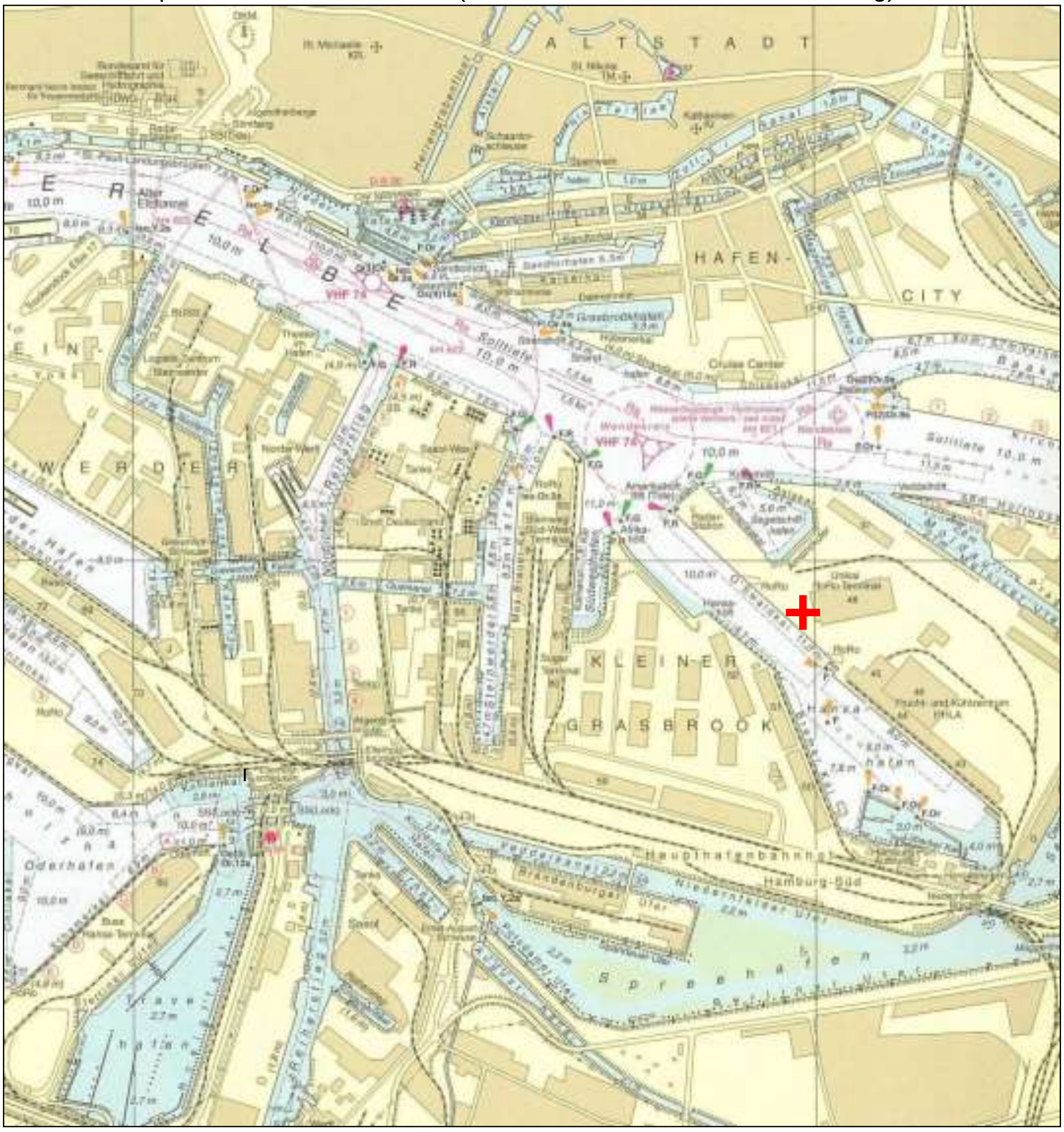


Figure 2: Scene of the accident

[3] Time fire detected according to entry in the deck log book.
[4] BSH: Federal Maritime and Hydrographic Agency

2.5 Shore authority involvement and emergency response

Agencies involved:	Hamburg fire services, Hamburg Port Authority, Hamburg Environmental Protection Agency, Waterway Police (WSP) Hamburg, Central Command For Maritime Emergencies (CCME)[5], Technical Relief (THW)
Resources used:	296 firefighters, two fireboats, three police boats, three tugs, 93 shore-based emergency vehicles, one fire support vehicle[6]
Actions taken:	Formation of an on-scene operational headquarters; deployment of firefighting units; co-ordination of the firefighting operation with the ship's command and assumption of operational command by the Hamburg fire services; cooling of the upper deck and shell plating from the water on the port side; cooling of the upper deck from the shore; preparation and execution of the primary firefighting operation (sealing off the seat of the fire, use of the shipboard CO_2 firefighting system, and conventional extinguishing action after the majority of the fire was contained); discharge of part of the ship's cargo
Results achieved:	Fire under control after the mission had proceeded for about nine hours; overall mission successfully completed after about 15.5 hours; no injuries or harm to the environment; fire-related material damage to the ship and cargo

[5] CCME: Joint institution of the Federal Government and the coastal States. Its purpose is to ensure joint management of accidents on the German coast. The CCME is responsible for planning, preparing, exercising, and implementing measures relating to the medical response, marine pollution response, firefighting, assistance, and security-related salvage in complex emergencies at sea. In the case at hand, the CCME initially assumed overall control of the operation but subsequently transferred it to the competent authority of the Free and Hanseatic City of Hamburg.

[6] Fire support vehicle (LUF 60): Unmanned, remote-controlled tracked vehicle with two rear water connections and a hydraulically driven turbine, which is used for cooling and ventilating and can produce an extensive water mist, inter alia.

3 COURSE OF THE ACCIDENT AND INVESTIGATION

3.1 Course of the accident

3.1.1 Events prior to fire detection

The ATLANTIC CARTIER sailed from Gothenburg to the Port of Hamburg and made fast at the intended ro-ro terminal, O'Swaldkai, on schedule at 1345 on 1 May 2013. She was then connected to the pier by means of a gangway and the required shipboard access control was established. The ro-ro ramp at the stern of the ship remained in the upright position.
Due to a national holiday, cargo-handling operations were arranged for the following day at 0700. Consequently, work on the ship was limited to ordinary maintenance duties of the ship's crew on deck and in the engine room, as well as general office duties of the ship's command.

Beyond that were the activities of the six-member welding team deployed on the ship, which did not form part of the regular crew and had been carrying out welding operations in different places on the ship both at sea and while she was laid up at port since it embarked in Liverpool or Gothenburg.[7]

3.1.2 Discovery of the fire

Due to the aforementioned welding operations, which were carried out in the Port of Hamburg in different places, including deck 3, and were still ongoing in the aft part of the ship at the time of the accident, the relevant sectors of the ship's smoke detection system were switched off prior to and at the time of the accident to prevent false alarms. Accordingly, an automated fire alarm was not triggered after the fire broke out on deck 3. Instead, recognition, most probably delayed, of the development of the fire on the deck was only by chance and initially indirect. At about 1900, a member of the welding team (referred to below as 'witness X') interrupted his work in the transformer room (aft section of deck 4) to make a phone call on a quieter part of the ship. To this end, he left the superstructure and went on the port side of the ship's main deck towards the bow. Level with bay 26 (frame section about N 50 to 217), the container slots of which were empty, the witness noticed a small amount of smoke apparently coming from inside the ship on the port side. Furthermore, heat-induced flaking of the paint on the floor of the deck was reportedly visible.

With regard to the further temporal and substantive course of events between the initial recognition of the fire described above and the second officer sounding the fire alarm at about 1930, witnesses of relevance to this provided various, partly contradictory items of information at different times.
owever, what is relatively certain is that witness X went back towards the superstructure to alert the ship's command after discovering the fire. While making his way back, he met a colleague (referred to below as 'witness Y') from the welding team and informed him about his observations. X then continued towards the bridge and met the chief officer in the underlying deck 10. The two individuals then hurried

[7] As regards the issue of welding operations and the resulting question as to whether these can be considered as having caused the fire, see the comments in sections 3.2.3.1 and 4.3 of the investigation report.

to the part of the ship in which X had discovered the smoke. The chief officer recognised the gravity of the situation and used his VHF radiotelephone to instruct the second officer, who was located on the bridge, to sound the fire alarm.

The deck log book contains corresponding entries:
'1925 Fire discovered by contractor, dk 3 B'
'1930 Fire alarm started'

3.1.3 Firefighting

3.1.3.1 Firefighting by members of the repair team

It was not possible to establish clearly the exact sequence of the initial shipboard firefighting activities after the smoke was discovered. However, it is reasonable to assume that while X was still making his way towards the bridge, the aforementioned witness Y went to bay 26 and on arriving immediately attempted to identify and also fight the seat of the fire. To this end, he reportedly entered deck 3 B in the area of bay 26 by means of a hold ladder via an emergency exit on the port side of the ship (see **Figure 3** below by way of example) and, in spite of smoke spreading on the forward part of the deck, which is only some 1.70 metres in height, reportedly identified a specific vehicle in flames limited to its engine compartment. It was reportedly a vehicle parked in the second row seen from the port side and third row seen from the forward bulkhead.

Figure 3: Emergency exit for ro-ro decks 3, 2 and 1 on the main deck

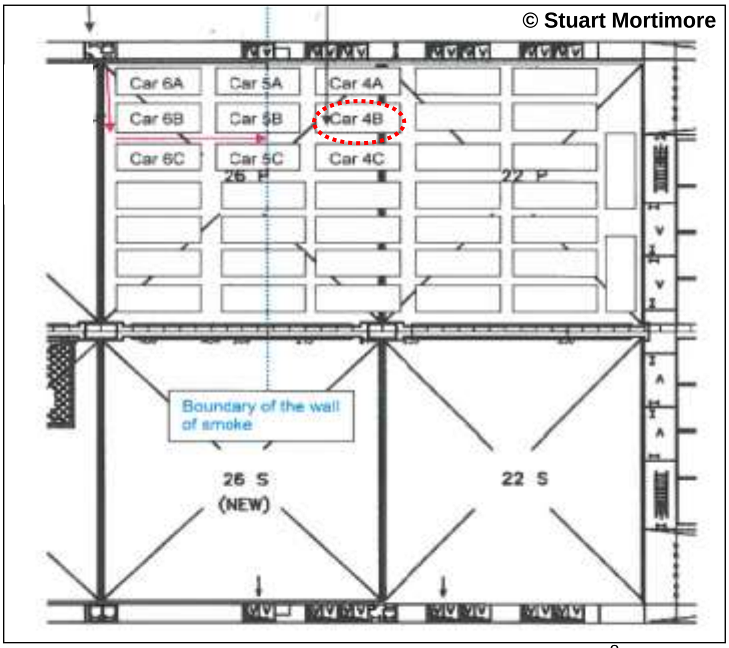


Figure 4: Witness Y's route on deck 3 B[8]

The route shown in **Figure 4** above and the marked boundary of the wall of smoke and fire source (car 4 B) correspond with the account of witness Y. The witness reportedly selected the route between the second and third role of vehicles, as it was claimed that its width was greater than between rows 1 and 2.

Stooping slightly, the some 6' 10" tall witness Y reportedly went to the aforementioned vehicle with a fire extinguisher that he had collected as a precaution in the deck access area and tried to extinguish it. The contents of the fire extinguisher were reportedly not sufficient for this, however.

After the unsuccessful use of the fire extinguisher, witness Y reportedly went back to the main deck, where he reportedly met another colleague from the welding team: witness Z. They both reportedly unrolled a firehose to start another extinguishing action. Accordingly, witness Y made his way back to vehicle deck 3 B with the firehose, while Z was reportedly tasked with connecting the hose to the hydrant and starting the water supply. Neither Y nor Z was apparently aware that the use of the hydrant requires previous actuation of the fire pumps from the bridge or the engine room of the ship. Consequently, the extinguishing action (as described by the witnesses and done on their own initiative) using the firehose was destined to fail from the outset for lack of actuated pumps at the time in question. Accordingly, the witnesses gave up their efforts in this respect.

[8] Source of figure: Expert opinion, Burgoynes (see Sources). Note by the BSU: Other sources of information do not verify whether the witness actually took this route.

3.1.3.2 Firefighting by the ship's crew

After the second officer sounded the fire alarm, the ship's crew took the necessary action for fighting the fire on board. The fire pumps were operational at 1937. The crew was mustered at 1941. The crew members on fire duty were ready to deploy from this point in time and began the conventional firefighting operation at 1954.
At the same time, the master of the ship alerted the Hamburg fire services at 2001 by phone on the emergency number 112. He then contacted Vessel Traffic Service (VTS) Hamburg at 2003 on VHF channel 14.

Shortly after the shipboard firefighting team first pushed forward towards the seat of the fire, subsequent firefighting on the vehicle deck had to be aborted at about 2005 because of the severe build-up of heat and smoke. The cooling operation on the main deck was continued, however.

3.1.3.3 Firefighting by the Hamburg fire services[9]

The first operational units of the fire services arrived at the ship at about 2012. Their operational command assumed control of the subsequent firefighting operation after a briefing by the chief engineer, who was responsible for shipboard firefighting operations according to the muster list. Here, the fire service, the ship's command and other public officials at the scene exchanged information constantly in the ensuing period.

At 2015, four firefighters accompanied by the chief engineer attempted to gain access to the burning vehicle deck 3 B via an emergency exit on the starboard side of the main deck. The rapid build-up of heat and smoke very quickly resulted in this action being aborted, however.
At 2020, the team leader of the fire services escalated the internal alert level to 'FEUWA2'. (Alert type: Fire on the water, resources include two fire tenders, one fireboat, and two small boats.) Due to the constantly increasing build-up of smoke and heat, the difficult access to the seat of the fire and thus the complex operational preparations, it was quickly recognised that the number of units available under Alert Level 2 would not be sufficient. Accordingly, the alert level 'FEUWA3' was initiated at 2038 and deployment of additional units and technical equipment started.

In preparation for further action, inter alia, a turntable ladder was used to establish direct access between the pier and main deck of the ship, seaborne water supply from a fireboat was set up, and potential access routes for fighting the fire on deck 3 B were explored. Here, special attention was given to the emergency exits on the main deck, each of which are not in the immediate vicinity of the presumed seat of the fire but give access to all ro-ro decks below deck via vertical ladders (see **Figure 3** above).

[9] Source: Inter alia, research of the expert appointed by the BSU, detailed article in the magazine 'Brandschutz' [fire protection] (see Sources).

Other operational units that were gradually arriving were tasked – in co-operation with certain members of the crew – with opening the stern ramp. Furthermore, the possibility of approaching the presumed seat of the fire from the stern of the ship, which was at a distance of about 150 metres, was explored for the purpose of conventional firefighting.

At 2119, an extinguishing action was initiated from the main deck via two access points after completion of the preparations necessary in this regard. However, this action did not achieve absolute success due to the structural conditions, smoke, and heat.

During the wide-ranging activities mentioned above, a thorough exchange of information was maintained between the operational command of the fire services and the ship's command. The fire and safety plan and the loading plans of the ship were requested and discussed.

In spite of the continuation of high-intensity external cooling efforts carried out from the water and ashore by means of, inter alia, a telescopic mast vehicle equipped with water cannon, high temperatures emanating from the fire spreading below deck resulted in deformation of the hull. Several detonations in the lower deck area were heard on the main deck. Moreover, since the lines of approach via the emergency exits proved inappropriate and the risk to the firefighters working on the main deck was increasing, a withdrawal was ordered.

During a briefing on the mission bus of the fire service on the pier, which started at about 2200, it and the ship's command used the existing plans to review exhaustively the possibility of using the shipboard CO2 installation and to that extent the necessary cordoning off of the affected area, and ultimately decided to use CO2 at about 2230.

To isolate the forward part of vehicle deck 3, which was primarily affected by the fire and was to be flooded with CO_2, from the aft part of the deck, it was necessary to close the starboard sliding door, which had been opened in the meantime, in addition to the port sliding door[10], which had remained closed since arrival at the Port of Hamburg, inter alia. To this end, firefighters made their way towards the sliding door at about 2230 accompanied by the second engineer. The control panel for the hydraulic ram operated to close the sliding door is located directly adjacent to the sliding door on deck 3. Access to the area in question was initially impossible due to the severe build-up of heat and smoke. Only after the fire services deployed an oscillating water cannon and a remote-controlled fire support vehicle was it possible to reach the control panel of the sliding door and establish watertight integrity at about 2250.

After a final check to ensure everybody was accounted for, the necessary operating steps were started in the CO_2 tank and control room for the CO_2 extinguishing operation. In the process, an unintentional CO_2 outflow occurred in the control room. It was quickly established that a leaking flange in a line in the CO_2 pipe system

[10] See the comments in section 3.2.2 below for details about the structural conditions.

caused this malfunction. Operational units of the fire services sealed the flange and then immediately started to flood the forward part of deck 3.

At 2258, approximately 15,000 kg of CO_2 was discharged into the cargo hold from the larger of the two low-pressure tanks installed on board. Initially, there was uncertainty as to the success of this action in the period that followed. Therefore, it was flooded with CO_2 again at 2318. Here, about 10,000 kg of CO_2 was discharged into the forward part of deck 3 from the smaller low-pressure tank.

Initial measures to salvage 33 containers carrying dangerous goods of different classes stowed in the vicinity of the vehicle deck affected by the fire were set in motion at 2308.[11] Here, partial discharge of the ship could only start at about 2330 and without a container gantry crane but rather just a mobile crane to begin with because cargo-handling operations were not being conducted in the Port of Hamburg due to a national public holiday.

Consequently, it was first necessary to mobilise the staff necessary for operating the shore-based handling equipment and the removal of the containers to be taken from on board the ship. At about 0335, the removal of the dangerous goods containers from those parts of the ship that were affected or at risk due to the fire was completed as far as possible.[12]

With regard to the use of the CO_2, it was initially unclear whether the fire had actually been extinguished even after the second CO_2 tank was emptied. The cooling efforts were continued. The temperatures of the hull wall and main deck were monitored permanently by means of a tele-thermometer.

At the same time as the aforementioned operational measures, the operational command requested the 'Coldcut Cobra (CCS)' cutting extinguisher systems held by the Brunsbüttel and Cuxhaven fire services as a precaution in case the extinguishing capability of the CO2 was insufficient. This is a special portable cutting extinguisher system made by a Swedish manufacturer. A cutting agent (so-called abrasive) is added to water through a special nozzle at high pressure (> 250 bar) and helps the water jet to cut very quickly through all known building materials when ejected. This makes it possible to combat smoke and fire safely from outside the fire location. Since only a very small opening has to be cut in the compartment in flames located behind the respective wall, no oxygen from outside reaches the fire, which significantly increases the extinguishing capability in the area.[13] According to the operating principle described, after its arrival the Cobra system of Brunsbüttel fire services was positioned inside the ATLANTIC CARTIER as a precaution, so as to be able to cut an opening in deck 3 and discharge water through it into the deck if necessary.

[11] On the issue of dangerous cargo on board, see the comments in section 3.2.3.6 below.
[12] Note: One flat container loaded with four uncleansed tanks contaminated with a residual amount of uranium could not be removed because it was located below the seat of the fire in the forward section of ro-ro deck 1, which was inaccessible due to the build-up of heat and smoke.
[13] See the manufacturer's information at http://www.coldcutsystems.de/about-coldcut-cobra-1.

As the night progressed, the continuous temperature readings increasingly indicated that use of the CO_2 had been successful. Between 0200 and 0300, the fire services decided to open the forward part of deck 3 and carry out an inside fire attack using C pipes. Accordingly, the sliding door preventing access was opened. Use of the Cobra system was not necessary. It was then possible to gain complete control of the fire using conventional extinguishing equipment.

At 0410, the fire services made a formal statement to the effect that the fire was reportedly extinguished. The ship's command was requested to start ventilating the cargo hold. Follow-up extinguishing and checks lasted several more hours. The operation of the fire services was brought to a successful conclusion at 1141 on 2 May, i.e. more than 15.5 hours after receiving the emergency call.

3.1.4 Consequences of the accident

3.1.4.1 Damage to the MV ATLANTIC CARTIER

Damage to the ship was essentially limited to fire and heat-related destruction within the forward section of vehicle deck 3, which was primarily affected by the fire, where cable routing that runs along the ceiling was destroyed, supports were deformed, and paint was ruined, in particular (see **Figure 5**).

Figure 5: Effect of fire on the cargo hold ceiling and cable routing

As a result of the immense heat radiation from the burning vehicle deck, parts of the floor of the main deck located above the seat of the fire were deformed (see **Figure 6** below). However, the cell guides installed on the main deck and also the ship's sidewalls were largely spared from the effects of the heat as a result of the cooling efforts, which were initiated immediately after the fire was detected and steadily intensified over the course of the other extinguishing activities.

Figure 6: Heat-induced discolouration and deformation on the floor of the main deck

3.1.4.2 Damage to the cargo[14]

A total of 69 new vehicles (cars) from the manufacturer VOLVO were stowed in the forward part of vehicle deck 3 B, which was primarily affected by the fire. The fire destroyed nine of these vehicles. The build-up of fire, heat, and smoke on the deck affected another 57 vehicles so extensively that they also had to be scrapped. One other car stowed on deck 3 B according to the cargo papers could not be found according to the transport insurer.[15]

[14] Source: Information from cargo interest (Volvo Car Corporation), inter alia.

[15] Note: Since all the other vehicles – those destroyed by the fire most severely, in particular – were identified after the accident, the BSU questions whether the untraceable vehicle was even on board.

Figure 7: Completely burnt out vehicles on deck 3 B

Figure 8: Cars damaged to varying degrees by the heat

A total of 22 new cars stowed in the aft part of deck 3 B or in the other ro-ro decks affected by the fire only secondarily were so severely damaged by the build-up of heat and/or smoke or fouled by soot that they also had to be scrapped. Due to the damage caused, 38 vehicles could only be used for spare parts. The use of 194 vehicles could be continued after in some instances very extensive cleaning or minor repairs.

Figure 9: Cars severely fouled by soot

Several commercial vehicles, including a road roller, were stowed directly beneath the forward part of deck 3 B (i.e. on deck 3). The heat radiation emanating from deck 3 B damaged the commercial vehicles to varying degrees.

Figure 10: Damaged commercial vehicles on deck 3[16]

The fire did not affect the container cargo stacked in up to four levels on the main deck of the ship significantly.

3.1.4.3 Injuries and environmental damage

The marine casualty and subsequent firefighting did not cause any injuries. A significant amount of pollutants did not escape as a result of the fire or extinguishing activities.

[16] Source: Expert opinion, Burgoynes (see Sources).

3.2 Investigation

3.2.1 Course, international co-operation, sources, and material particulars

The BSU in Hamburg was notified about the accident on the morning of 2 May 2013. Two investigators immediately went on board the ship. The fire was already extinguished at this point in time. Due to follow-up extinguishing and the continuing severe pollution of the breathing atmosphere immediately after the fire, it was not possible to inspect the vehicle deck affected by the fire at once. Instead, the investigation was initially limited to interviewing the master and examining various ship's papers.

After returning to the office, the BSU immediately contacted the Swedish body for accident investigation in Stockholm (SHK)[17]. The owner of the Swedish-flagged ship had already informed the staff there about the accident. The BSU, as investigative body of the coastal State affected, and the investigative body of the flag State agreed that the BSU would lead the joint investigation of the marine casualty. A constant flow of information prevailed between the BSU and SHK during the course of the investigation.

On 3 May 2013, more investigations took place on board the ATLANTIC CARTIER with the assistance of a fire expert appointed by the BSU. The expert's assessment of the possible causes of the fire and the firefighting operation carried out by the crew and fire services is an integral part of this investigation report.

In addition to the findings made by the BSU, the findings of the police were also examined during the course of the investigation. Audio recordings of the VDR[18] installed on board (Rutter VDR-100 G2) were not available for the investigation. Such recordings would have been able to deliver an objective understanding of the shipboard emergency management within the framework of the analysis of communication on the bridge after the fire was detected. The reason for this was that the ship's command did not carry out the necessary data backup within 12 hours of the fire breaking out; therefore, the data were overwritten after this period, as provided for by the system.

For the purpose of an all-embracing evaluation of the facts, and the possible causes of the fire open to consideration in particular, the BSU looked very closely at the ship owner's reasoning that the spontaneous combustion of a car was the most likely cause of the fire. This is based on a very extensive expert opinion submitted to the BSU, which was commissioned by the owner. In the course of the search for the causes of the fire breaking out, the BSU also analysed the assessment of the cargo interest that was particularly damaged, Volvo Car Corporation, which, also based on the assessment of an expert, is convinced that the causes of the fire were ship-based, in contrast to the owner.

[17] SHK = **S**tatens **h**averi**k**ommission (Swedish Accident Investigation Authority).
[18] VDR: **V**oyage **d**ata **r**ecorder.

3.2.2 MV ATLANTIC CARTIER

3.2.2.1 Type, history, structural characteristics

3.2.2.1.1 Overview

The ATLANTIC CARTIER forms part of a series of five con-ro ships operating in transatlantic service between Europe and North America that were built at three different shipyards in Europe and Asia in 1984 and 1985. The ships are capable of carrying containers and ro-ro cargo at the same time. While the handling of container cargo is carried out using only shore-based facilities, ro-ro cargo is loaded and unloaded via a stern ramp, which has a load-carrying capacity of 420 tonnes. Containers are stowed in cargo holds intended for this cargo in the forward section of the ship, as well as on the open main deck, the entire length of which is designed for container transport using cell guides[19].

3.2.2.1.2 Lengthening of the ATLANTIC CARTIER; location and features of the ro-ro decks of relevance to the investigation[20]

The ships from this series were built with partitioning into two cargo holds: the container and the ro-ro section. They were lengthened by 42.5 metres back in 1986 and 1987 to improve transport efficiency. The ATLANTIC CARTIER's conversion was carried out in 1987 at the Hyundai Mipo shipyard in Ulsan, South Korea. To achieve this, the ship's forward section (frame number 208) was separated and an additional section with frame designations N 1 to N 54 was inserted in the hull.

The ship's container capacity originally stood at 2,157 TEU, of which 424 TEU could be stowed in the container holds and another 725 TEU in the ro-ro section. Initially, 1,008 TEU could be transported on deck. Total capacity increased to 2,908 TEU after she was lengthened. Since then, 198 FEU and 28 TEU can be stowed in the container holds, 424 FEU and 636 TEU in the vehicle section, and another 1,000 TEU in the ro-ro section.

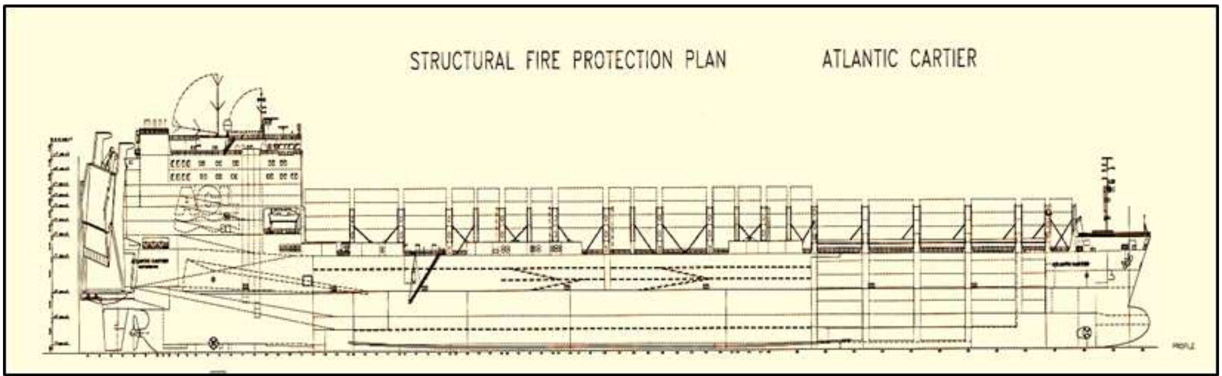


Figure 11: Schematic drawing of the entire ship after she was lengthened[21]

[19] Cell guides: Vertical steel guides that facilitate the proper stacking of containers and assist in securing them efficiently for transport.
[20] Note: The term 'vehicle deck' will be used synonymously below with the name ro-ro deck in accordance with this deck's main purpose.
[21] Source: Documents of the owner of the ship.

Figures 12 and 13 below are magnified sections of the schematic drawing of the ship (**Figure 11** above). In addition to marking the section inserted into the hull in 1987 (section between the red dotted lines), the excerpts also assist in defining the location of the vehicle decks of relevance to the investigation and providing – for now at this point of the report – a rough illustration of the location of the seat of fire on the port side of the forward section of vehicle deck 3 B (see dark red star).

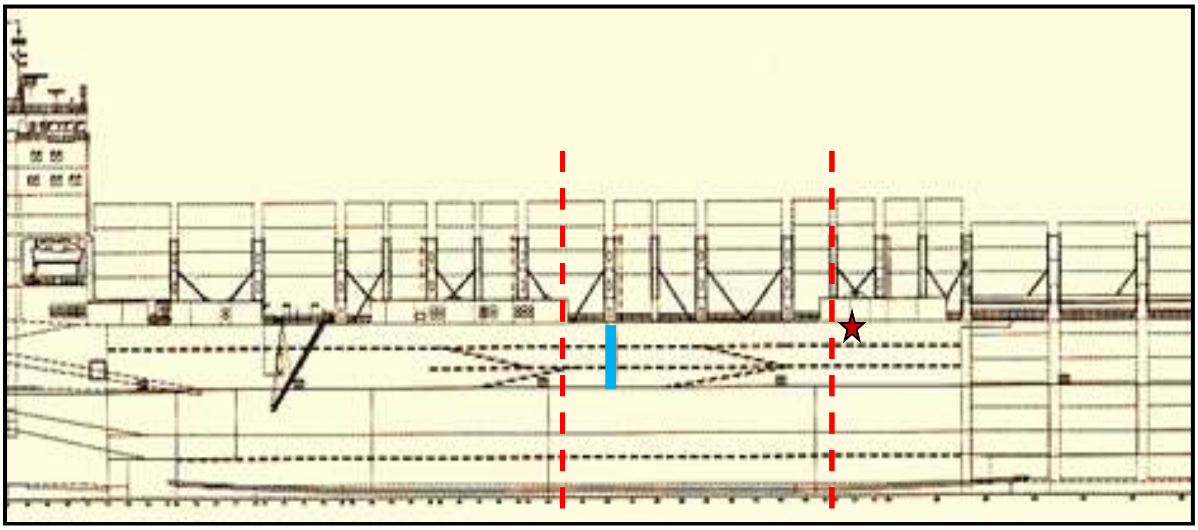


Figure 12: Location of the section inserted when the ship was lengthened

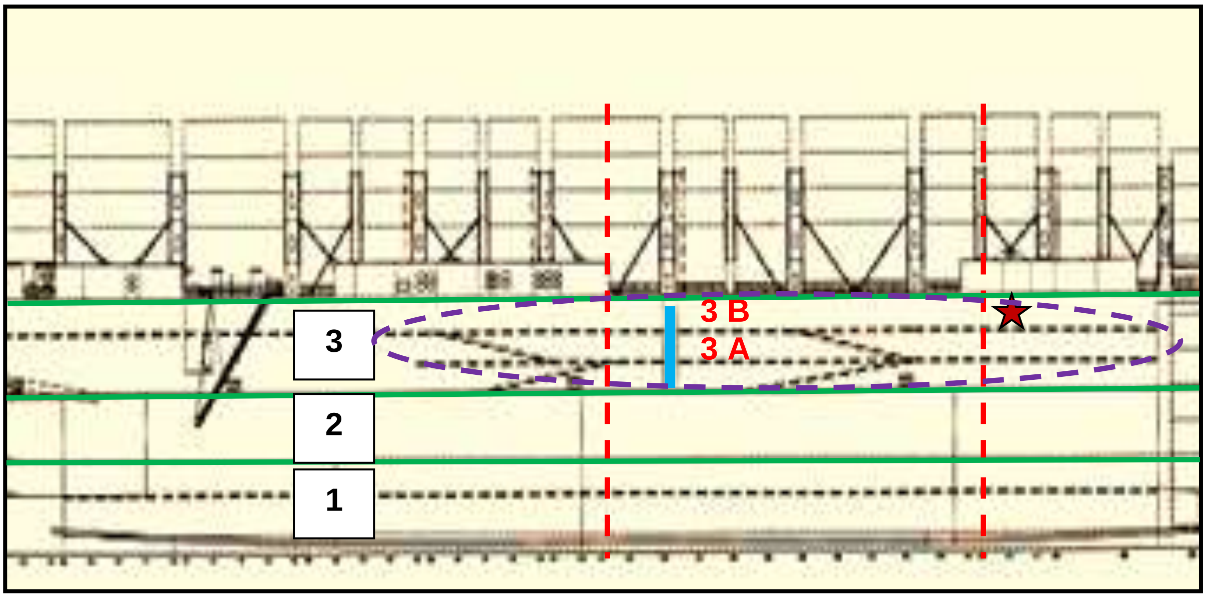


Figure 13: Location of ro-ro cargo holds 1 to 3 and vehicle decks 3 A and 3 B

Figure 13 illustrates that the forward and middle part of cargo hold 3 (see section surrounded by purple dotted line) – additionally partitioned amidships – can be partitioned vertically into a total of three vehicle decks, one above the other. This partitioning can be made independently of one another on the port side and on the starboard side of the ship's centreline.

Hence, depending on cargo volume and stowage height of the vehicles requiring transportation, two mobile intermediate levels can be raised or lowered inside the cargo hold independently of one another on each side of the ship by means of hydraulic ram. By this means, the vehicles to be stowed not only have space on one level in the cargo hold, but if necessary can also be stowed one above the other on two or even three levels on the port side or starboard side of the forward section of cargo hold 3 via mobile loading ramps.

It should also be noted here that each of the optional vehicle decks on the starboard side and port side of the ship do not consist of one homogeneous platform, but are individual segments of about 13 metres in length and 14.5 metres in width, which can be moved up and down independently of each other. This adds flexibility to cargo hold utilisation.

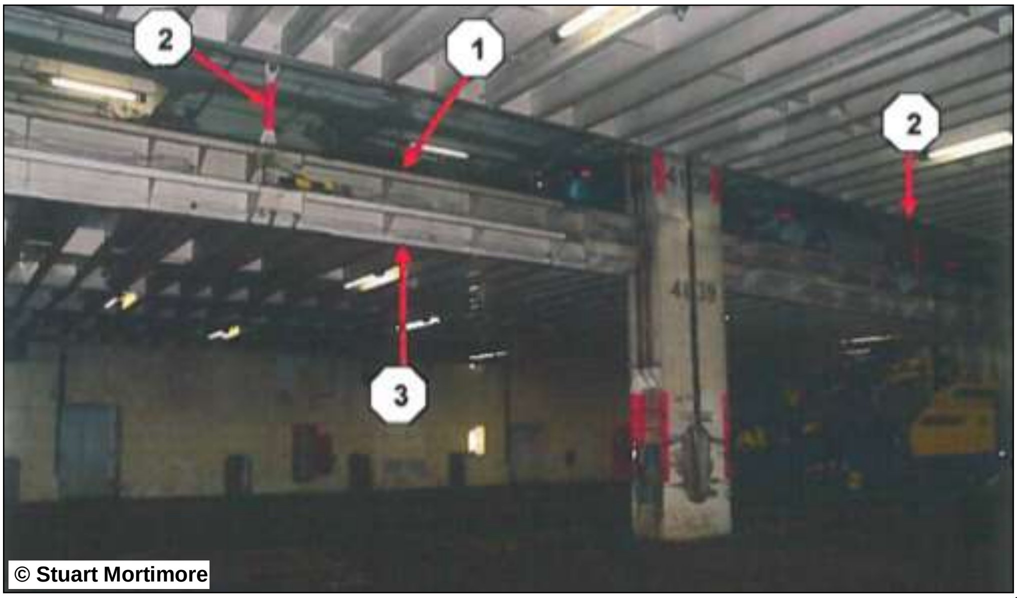


Figure 14: Example of possible configuration of the vehicle decks in cargo hold 3[22]

Figure 14 shows the same arrangement of the vehicle decks in cargo hold 3 on the port side of the ATLANTIC CARTIER as at the time of the accident.[23] Accordingly, the port side part of deck 3 B (see number 1) is in a lowered position for carrying cars. In contrast, deck 3 A (see number 3) has been raised up to the bottom edge of deck 3 B for lack of usage requirements. In contrast to the figure, which shows (or implies) that the sections of decks 3 A and 3 B are fully raised on the starboard side, vehicle deck 3 B on the starboard side – apart from a segment in the aft section of the cargo hold – was also lowered on the ATLANTIC CARTIER to the transport height for cars without carrying any cargo, however.

On **Figure 15** below, it can be seen that the two sliding doors (see also the blue marking above in **Figures 12** and **13**) located in the area of frame N 11 (boundary between bay 35 and bay 37 of the main deck), i.e. within the section of the ship inserted subsequently, are half-open. They are two hydraulically operated steel doors

[22] Source: Expert opinion, Burgoynes (see Sources).
[23] Note: The photo was taken in the aft section, i.e. the part of cargo hold 3 behind the sliding doors, at a later point in time; the photographer is looking to port.

that make it possible to partition the starboard side and port side of cargo hold 3 athwartships over its entire height and at about its half-length. When both the doors are closed completely, cargo hold 3 is divided into two separate watertight compartments.

The two sliding doors were supposedly closed during the ATLANTICS CARTIER's passage from Gothenburg to Hamburg. Accordingly, the starboard sliding door must have been opened at some point after she made fast in Hamburg and prior to the outbreak of fire, as establishing watertight integrity was one of the subsequent activities in connection with making ready for the CO_2 extinguishing action.

© Stuart Mortimore

Figure 15: Sliding doors in cargo hold 3[24]

3.2.2.1.3 Formation of cracks in the hull

Cracks have occurred repeatedly above the water line in different areas of the hull as early as when the ship had her original dimensions, and since the hull was lengthened, in particular. In all likelihood, these cracks were or are caused by faults in the ship's design and/or structural deficiencies, which in turn are likely to be due to the fact that this particular series was an entirely new type of ship.[25]

The owner has always accounted for this ongoing structural issue by frequent observation of the formation of cracks and arranging for repairs to be made immediately on detection. To organise the specific monitoring requirements systematically, a crack monitoring system (CMS) was introduced in 1997. The place and time at which all cracks occur are saved in a corresponding register. The CMS was expanded in co-operation with the classification society in the ensuing years to ultimately form a crack repair and monitoring system (CRMS), so as to include not

[24] Source: Expert opinion, Burgoyne; looking from aft.

[25] Note: The BSU has abstained from making a detailed investigation into the specific causes of the formation of cracks, since the issue in question was – if at all – only of very secondary importance to the ATLANTIC CARTIER's accident.

only the occurrence of cracks but also their repair. The CRMS was added to the ATLANTIC CARTIER's safety management system (SMS) in 2010 when there was a change of ship management and approved by the classification society.
A repair team is on board almost permanently specifically for the purpose of repairing cracks according to the state of the art and at short notice. The welders do not form part of the regular crew of the ship but are employed by a different company.

3.2.2.2 Crew and staff on board

The ATLANTIC CARTIER's crew, consisting of Swedish and Philippine nationals, as well as one Polish national, comprised 26 people at the time of the accident. The Swedish ship's command has many years of professional experience and is familiar with the specific circumstances of the ships from this series.

As stated above, due to the recurring formation of cracks in the ATLANTIC CARTIER's hull, one anomaly is that a repair team is on board in addition to the regular crew when the necessity arises. From a procedural point of view, members of this team are entered in the ship's papers as passengers. One such team consisting of five Polish welders and a Swedish supervisor was on board the ship at the time of the accident.

3.2.2.3 CO_2 extinguishing system

3.2.2.3.1 General notes

In addition to the causes of the fire, the fire expert appointed by the BSU also considered the action taken to fight the fire in the course of his assessment, and in this context specifically the fire-extinguishing appliances available on board the ship and, in particular, the CO_2 extinguishing system. Inter alia, in an editorially revised form, the following comments are based on the opinion submitted by the expert on 14 February 2014, who gained his findings from his local surveys and two technical documents. One was the technical description of the CO_2 installation by the manufacturer, sides GROUPE, dated 1985, which the owner of the ship made available in French with an English translation. In the case of the other, extracts of another technical description of the CO_2 installation in English were submitted to the BSU, which – without any indication of an originator or creation date – apparently take into account the modified structural conditions on the ship after she was lengthened and their effect on the CO_2 installation.

The ATLANTIC CARTIER has a so-called CO_2 low-pressure storage system installed on board, which is a key element to fighting cargo hold or engine room fires. This system meets the IMO's requirements for low-pressure CO_2 installations on lockable ro-ro decks. Unlike conventional high-pressure cylinder stores on seagoing ships, this system consists of two fully isolated pressure tanks with a capacity of 15,100 kg and about 10,600 kg of CO_2, which is stored in a liquefied form (by means of pressure and temperature) at a temperature of about -17°C and a pressure of about 21 bar.

Figure 16: CO_2 low-pressure tank

Figure 17: CO_2 system line with gas nozzle in the cargo hold

Activation of the CO_2 installation or the selection of zones for flooding with CO_2 is made either by means of remote-controlled pneumatically operated control valves from the bridge (see **Figure 18 f.** below) or in the CO_2 tank and control room (see **Figures 21 f.**) on deck 4. Direct system operation by opening and closing the relevant CO_2 valves is also possible in the CO_2 control room.

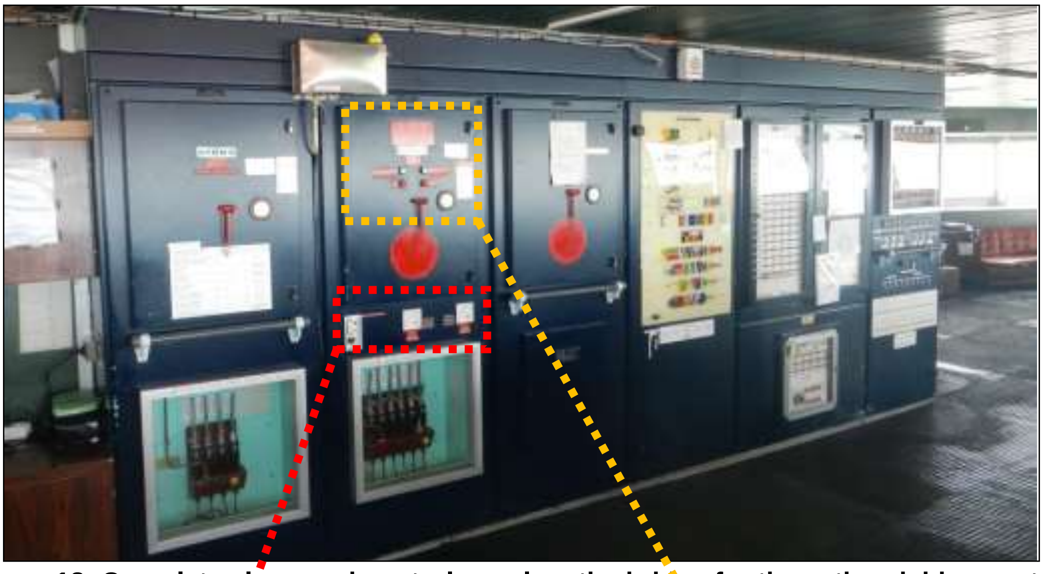


Figure 18: Complete alarm and control panel on the bridge for the extinguishing system

Figure 19: Extract showing the CO_2 installation controls

Figure 20: Extract showing the flood amount reading and levels of the two CO_2 tanks

The release valves for the individual CO_2 extinguishing zones (with regard to zones, see **section 3.2.2.3.2** below) are located in separate, specially secured control boxes (**Figures 21 f.**) in the CO_2 control room. Signs in English and French that provide information about the associated flooding zone and, pro tanto, required CO_2 flood quantity are affixed to each control box (see **Figure 23** below by way of example).

Figure 21: Control boxes for controlling the individual flooding zones (left)[26]

[26] Note: The large CO_2 tank with the main stop valve at the front is visible in the background.

Figure 22: Control boxes for zone 6 (left) and zone 3 A (right)

Figure 23: Close-up of the signs on the control box for zone 3 A

3.2.2.3.2 CO_2 extinguishing zones

Since she was lengthened, places on the ATLANTIC CARTIER intended for a CO_2 extinguishing action consist of nine zones that are structurally separate or detachable from each other with the following capacities[27]:

Zone designation	Place on the ship	Volume
Zone 1	Containers hold	23,870 m³
Zone 2 A	Ro-ro spaces under deck 2	21,392 m³
Zone 2 B	Ro-ro spaces under deck 3	20,632 m³
Zone 3 A	Ro-ro spaces deck 3 middle	20,033 m³
Zone 3 B	Ro-ro spaces fore	17,190 m³
Zone 4	Ro-ro spaces deck 3 on the aft and deck 4	13,850 m³
Zone 5	Ro-ro spaces decks 5, 6, 7, 8	14,240 m³
Zone 6	Pump room fore port and starboard	316 m³
Zone 7	Engine room[28]	15,281 m³ 12,504 m³

It is evident from the table above that for fighting a fire on deck 3, flooding the horizontally consecutive zones 3 A, 3 B and 4 (either alone, combined or altogether) with CO_2 comes into question. Zones 4 und 3 A are isolated from one another by closing the two bulkhead doors M1 and M2 in the vicinity of frame number 115 below the foreside of the superstructure. Zones 3 A and 3 B are isolated from one another by means of the two sliding doors in the vicinity of frame N 11 already mentioned above. Starting from the seat of the fire in the forward area of zone 3 B, the colours red, yellow and green assigned to the zones by the author of this report indicate the graduated requirement for flooding the inside of deck 3 with CO_2 in relation to the day of the accident.

The figures below illustrate the position of the relevant zones in the ship in the event of a fire on deck 3, after which information about the quantity of CO_2 needed to flood each of these zones is then given in tabular form.[29]

---

[27] Data source: Above technical descriptions of the CO_2 installation. The zone designations were also taken from the technical descriptions. It should be noted that the horizontally adjacent zones 3 A and 3 B, each of which span the height of deck 3, only have the same designation as the vertically adjacent decks 3 A and 3 B by coincidence.

[28] The original technical description of relevance already contains two different volumes for the engine room, which was not affected by the lengthening of the ship.

[29] The quantities (in kg) are based on the specification that 45% flooding with CO_2 is required for ro-ro decks, where the underlying value for the average density of the gas is 0.56 m³/kg.

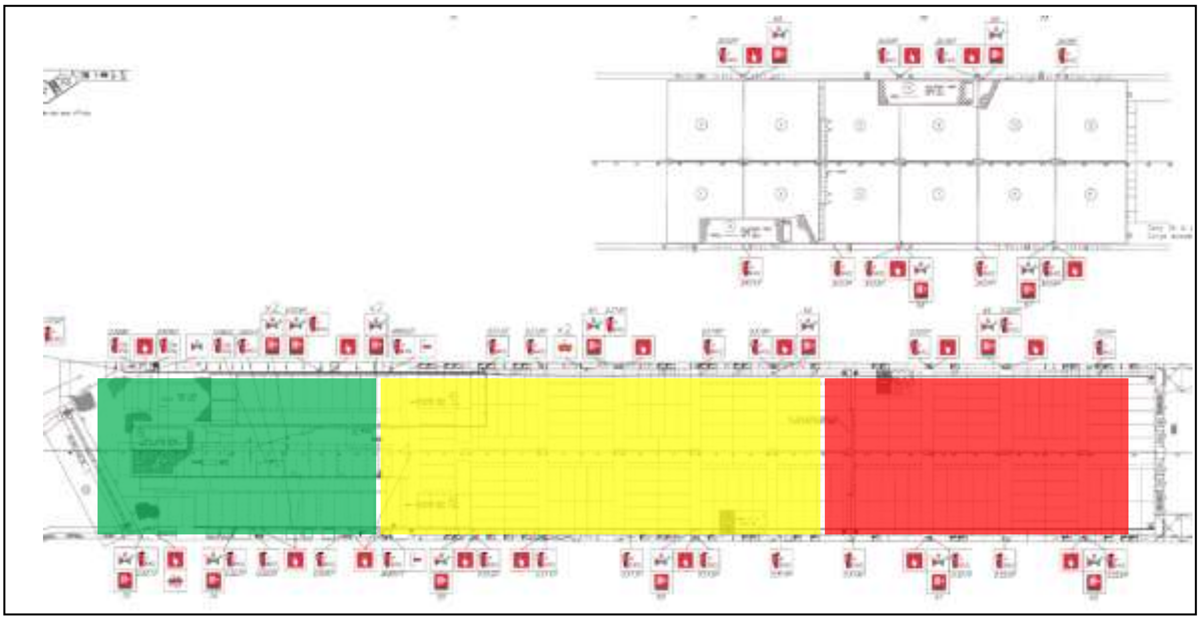


Figure 24: CO_2 zones, deck 3 (view from above)

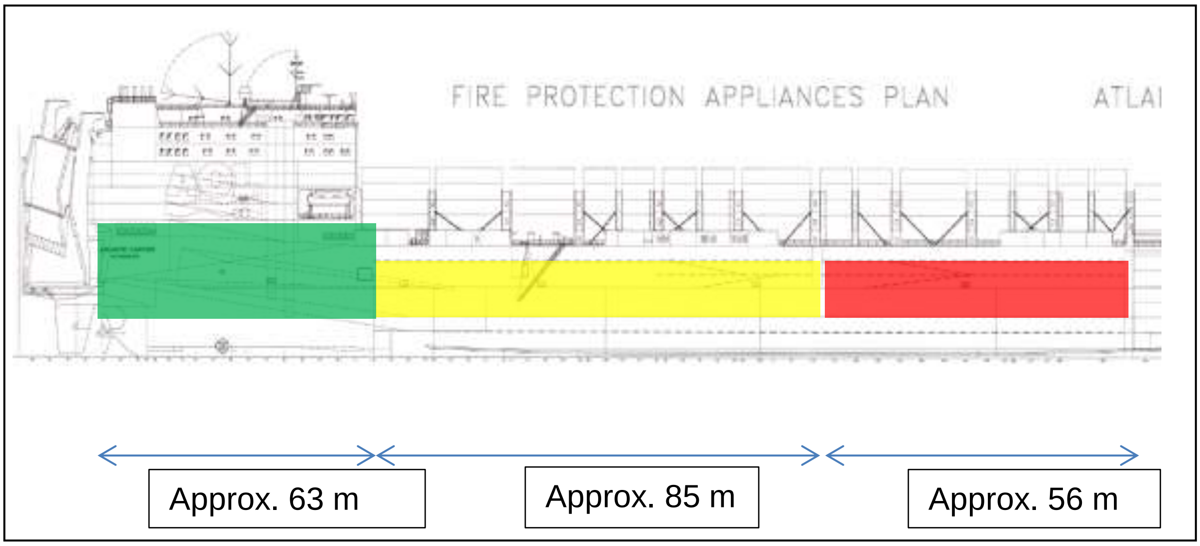


Figure 25: CO_2 zones, deck 3 (view from the side)

Zone	4 (deck 3 aft and deck 4)	3 A (deck 3 middle)	3 B (deck 3 fore)
Volume	13,850 m^3	20,033 m^3	17,190 m^3
Flood quantity (45%)	11,129 kg	16,098 kg	10,923 kg (?) 13,813 kg (?)
Position	Aft - frame 115	Frame 115 - N 11	Frame N 11 - 235
Termination	Stern ramps and doors to deck 5 – door M1/M2	Door M1/M2 – sliding doors	Sliding doors – LO/LO shot

While reviewing the technical documents for the CO_2 installation, it was noted at various points that they contain incorrect or partially difficult to understand information with regard to certain volumes and computations, inter alia (see the areas highlighted in red in **Figures 26 f.** below, for example). For example, according to the information given at the top of page 9 of the technical description created after the ship was lengthened, the volume of zone 4 is 18,850 m³. However, as regards the important computation of the CO_2 quantity needed to flood this zone, page 10 of the description specifies a volume of 13,850 m³. Another error is at the bottom of page 9 in the important computation of the CO_2 quantity necessary for zone 3 B. The result of this calculation (17,190 x 45% ÷ 0.56) is actually 13,813.39 kg, and not the 10,923 kg specified.

~~the drawing~~

- 9 -

CAPACITY OF THE PLANT

1°) zone 1 : Containers hold Volume 23.870 m3

2°) zone 2A : Ro-Ro spaces under deck 2 Volume 21.392 m3

3°) Zone 2B : Ro-Ro spaces under deck 3 Volume 20.632 m3

4°) Zone 3A : Ro-Ro spaces deck 3 middle (frame 115 to N11) Volume 20.033 m3

5°) Zone 3B : Ro-Ro space fore (frame N11 to 235) Volume 17.190 m3

6°) Zone 4 : RO-RO space deck 3 on the aft frame 113 and deck 4 Volume 18.850 m3

7°) Zone 5 : RO-RO space decks 5,6,7 and 8 Volume 14.240 m3

8°) Zone 6 : Pump room fore port and starboard Volume 316 m3

9°) Zone 7 : Engine room : Volume 12.504 m3

According to the rules of the BUREAU VERITAS, the quantity of gas available must enable to obtain one minimum of free gas, calculated on the basis of 0,56 m3/kg, équal to the higher of one or the other follower values :

- 40% of the gross volume of the bigger space to protect, this volume including the casing until the level where the horizontal surface is at most équal at 40% of the surface of the considered room.
- 35% of the gross volume of the bigger space to protect, including the whole volume of the casing.
- For the containers holds, the quantity of CO2 is calculated on the basis of 30% of the volume in less of 10 mn.
- For the cars holds, the quantity of CO2 is calculated on the basis of 45% of the volume in less of 10 mn.

1°) Containers holds : Zone 1

Weight of CO2 : 23.870 x 30 % / 0,56 = 12.788 Kg

2°) RO-RO spaces under deck 2 : Zone 2A

Weight of CO2 : 21.392 x 45 % / 0,56 = 17.190 Kg

3°) RO-RO spaces under deck 3 : Zone 2B

Weight of CO2 : 20.632 x 45 % / 0,56 = 16.580 Kg

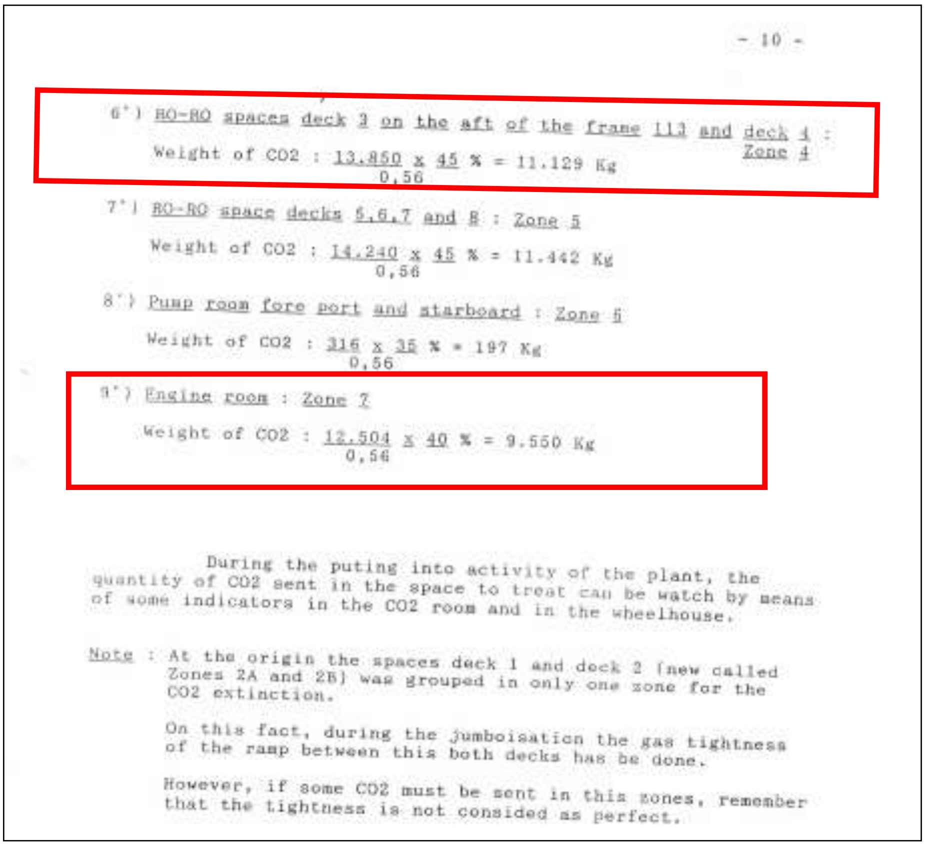
4°) RO-RO space from frames 115 to N11 : Zone 3A

Weight of CO2 : 20.033 x 45 % / 0,56 = 16.098 Kg

5°) RO-RO spaces deck 3 from frames N11 to 235 : Zone 3B

Weight of Co2 : 17.190 x 45 % / 0.56 = 10.923 Kg

Figure 26: Extract from the technical description of the CO_2 installation after the ship was converted (page 9)



- 10 -

6°) RO-RO spaces deck 3 on the aft of the frame 113 and deck 4 : Zone 4

Weight of CO2 : 13.850 x 45 % = 11.129 Kg
0,56

7°) RO-RO space decks 5,6,7 and 8 : Zone 5

Weight of CO2 : 14.240 x 45 % = 11.442 Kg
0,56

8°) Pump room fore port and starboard : Zone 6

Weight of CO2 : 316 x 35 % = 197 Kg
0,56

9°) Engine room : Zone 7

Weight of CO2 : 12.504 x 40 % = 9.550 Kg
0,56

During the puting into activity of the plant, the quantity of CO2 sent in the space to treat can be watch by means of some indicators in the CO2 room and in the wheelhouse.

Note : At the origin the spaces deck 1 and deck 2 (new called Zones 2A and 2B) was grouped in only one zone for the CO2 extinction.

On this fact, during the jumboisation the gas tightness of the ramp between this both decks has be done.

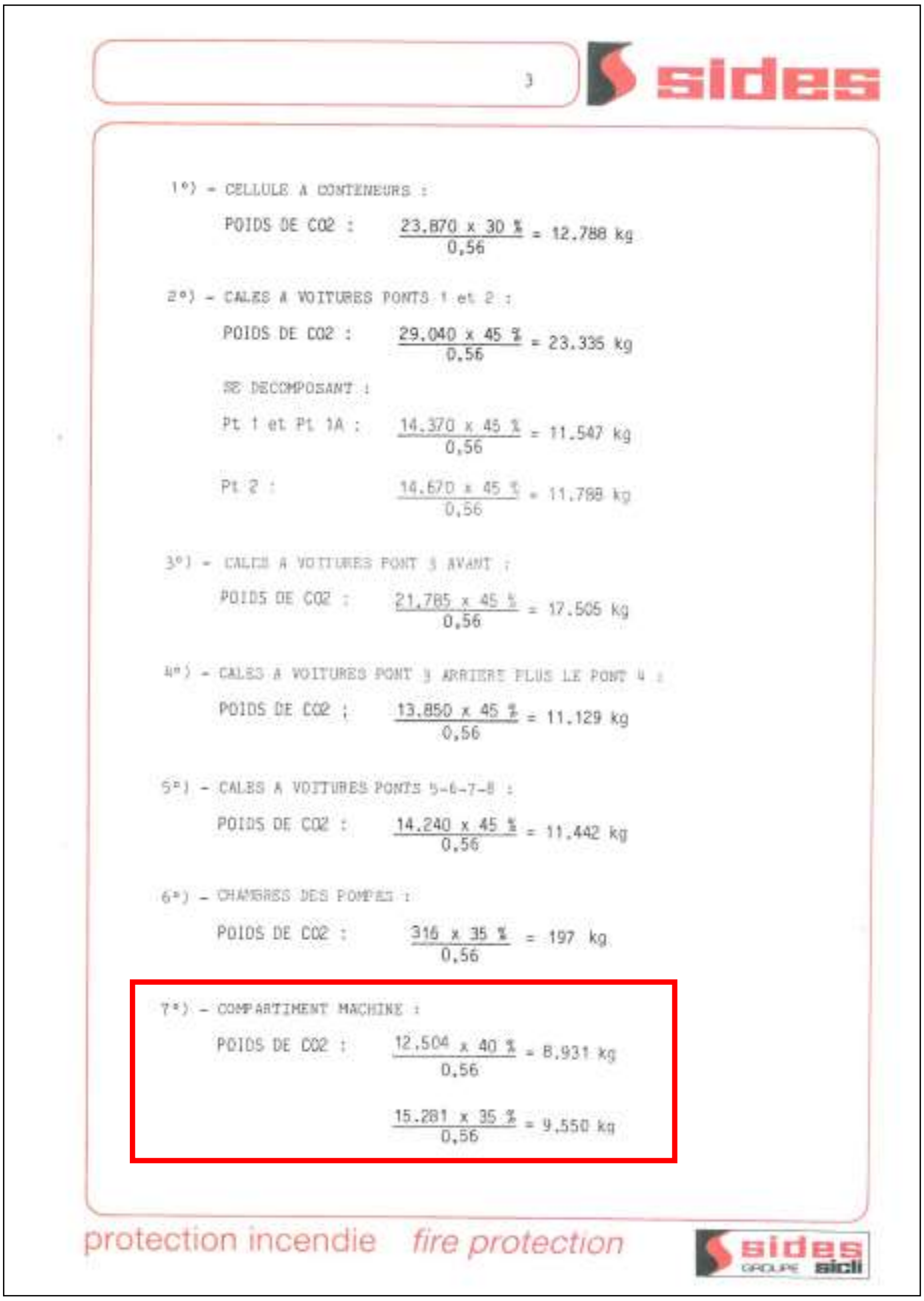
However, if some CO2 must be sent in this zones, remember that the tightness is not consided as perfect.

Figure 27: Extract from the technical description of the CO_2 installation after the ship was converted (page 10)

The CO_2 quantity 'calculated' in the technical description for zone 3 B (10,923 kg) is shown on an information panel in the CO_2 control room, which contains details – in French – of the CO_2 flood quantities necessary for the various zones (see **Figure 28** below).

Figure 28: Overview of the CO_2 flood quantities (CO_2 control room)

The calculation of the CO_2 quantity for the engine room on page 10 of the above technical description is also incorrect, as the result of this calculation (12,504 x 40% ÷ 0.56) is actually 8,931.4 kg and not 9,550 kg. In reality, the calculation for the engine room at the bottom of page 3 of the original technical description of the system manufacturer arrives at the latter result when based on a (alternate?) volume of 15,281 m³ and a 35% flooding requirement (see **Figure 29**).



3 sides

1°) - CELLULE A CONTENEURS :

POIDS DE CO2 : $\frac{23.870 \times 30\,\%}{0,56}$ = 12.788 kg

2°) - CALES A VOITURES PONTS 1 et 2 :

POIDS DE CO2 : $\frac{29.040 \times 45\,\%}{0,56}$ = 23.335 kg

SE DECOMPOSANT :

Pt 1 et Pt 1A : $\frac{14.370 \times 45\,\%}{0,56}$ = 11.547 kg

Pt 2 : $\frac{14.670 \times 45\,\%}{0,56}$ = 11.788 kg

3°) - CALES A VOITURES PONT 3 AVANT :

POIDS DE CO2 : $\frac{21.785 \times 45\,\%}{0,56}$ = 17.505 kg

4°) - CALES A VOITURES PONT 3 ARRIERE PLUS LE PONT 4 :

POIDS DE CO2 : $\frac{13.850 \times 45\,\%}{0,56}$ = 11.129 kg

5°) - CALES A VOITURES PONTS 5-6-7-8 :

POIDS DE CO2 : $\frac{14.240 \times 45\,\%}{0,56}$ = 11.442 kg

6°) - CHAMBRES DES POMPES :

POIDS DE CO2 : $\frac{316 \times 35\,\%}{0,56}$ = 197 kg

7°) - COMPARTIMENT MACHINE :

POIDS DE CO2 : $\frac{12.504 \times 40\,\%}{0,56}$ = 8.931 kg

$\frac{15.281 \times 35\,\%}{0,56}$ = 9.550 kg

protection incendie fire protection sides GROUPE sicli

Figure 29: Calculation of the CO_2 quantity for the engine room

3.2.2.3.3 Signs and information panels in the CO_2 control room

Deficiencies were found during the survey of the CO_2 control room with regard to the signs for the release components and other components of the CO_2 installation. The combination of the original French designations and information in English, as well as the attachment of handwritten notices and signs, some of which can only be placed with difficulty, constitute a problem in relation to a system as relevant to safety as the CO_2 extinguishing system.

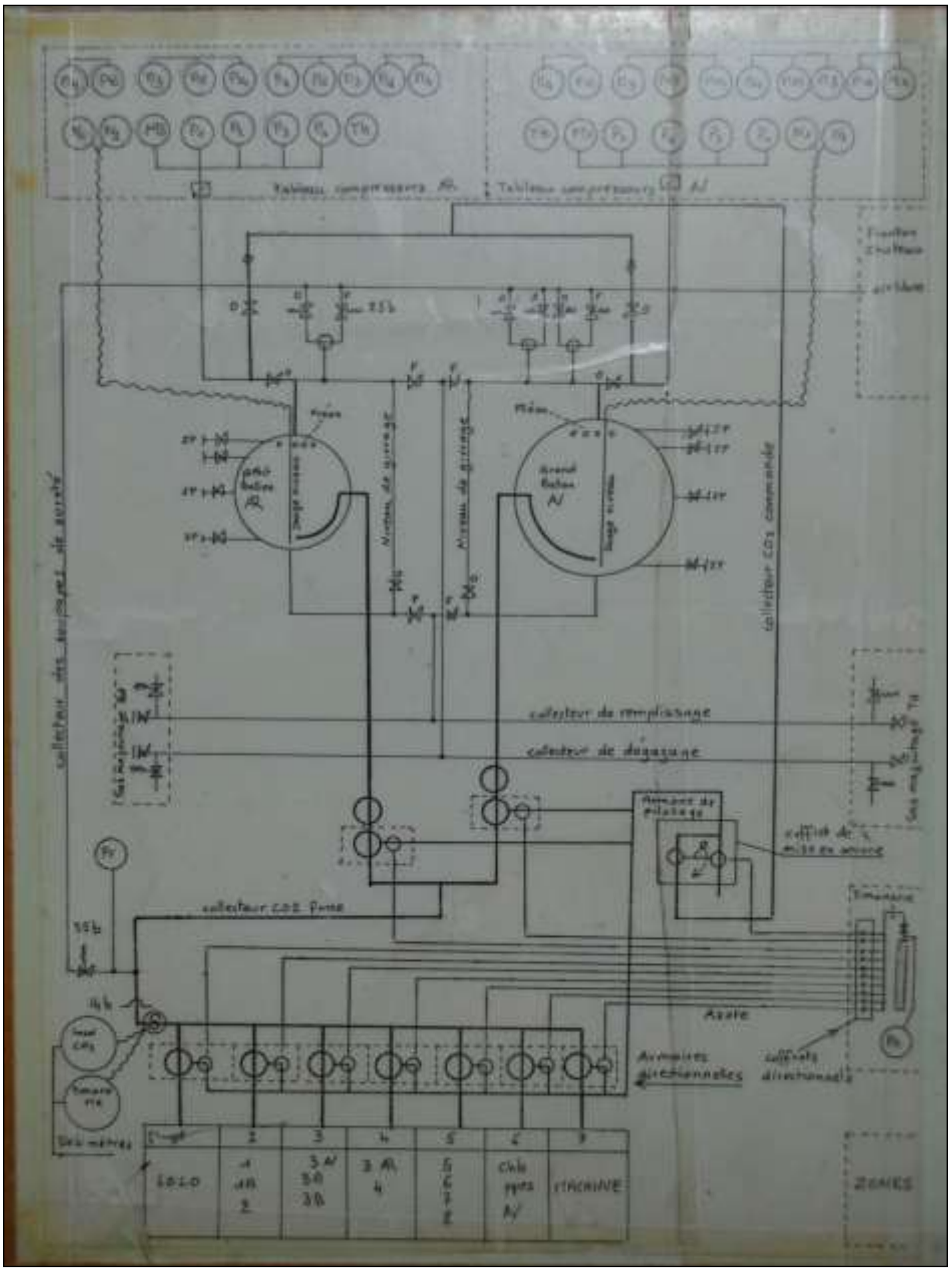


Figure 30: Handwritten functional diagram of the CO_2 installation

Figure 31: Operating instructions for the manual release of CO_2 flooding in French

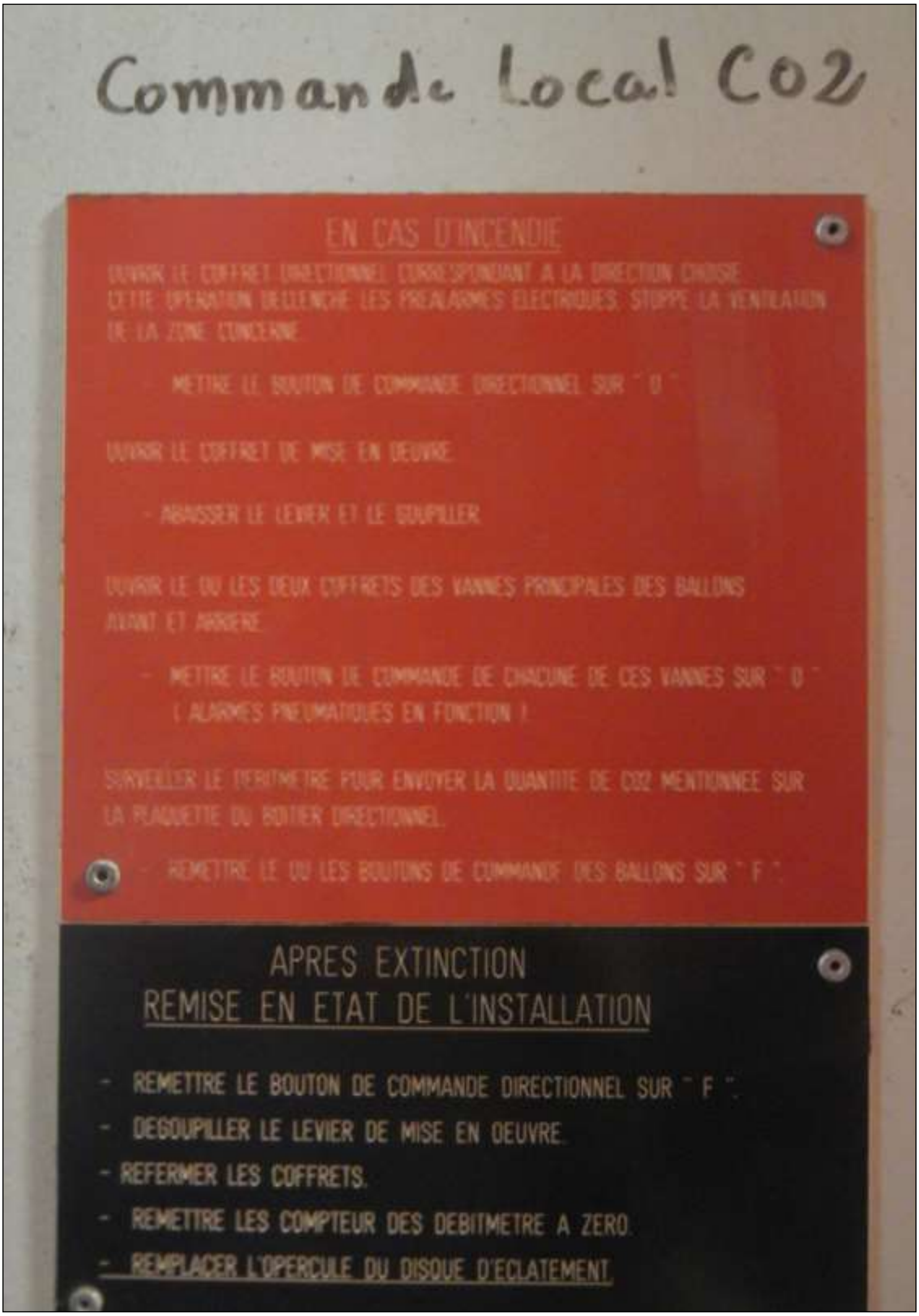


Figure 32: Operating instructions for the local pneumatic release of CO_2 flooding in French

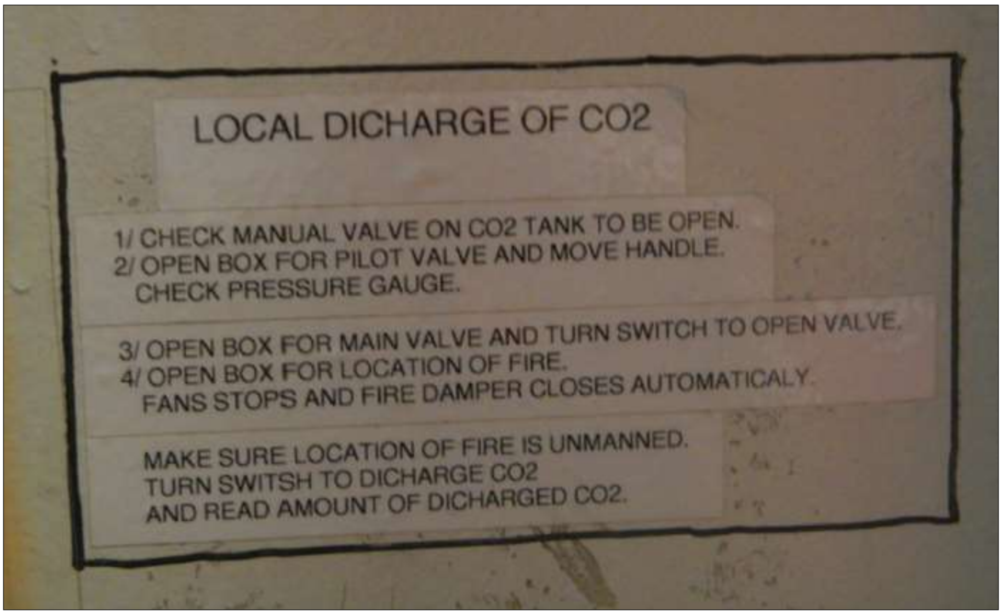


Figure 33: Operating instructions for the local pneumatic release of CO_2 flooding in English

Figure 34: Main tank valve with handwritten operating instructions

3.2.2.4 Mobile extinguishing equipment

French jet nozzles (manufactured in 1985 and earlier) that can be supplied from the water fire-extinguishing system via hydrants are available on the ATLANTIC CARTIER for mobile firefighting. Use of the hydrant system by external personnel using their own equipment fails due to the incompatibility of the French system with the standard Storz C system.

Figure 35: Example of the storage position of a firehose with extinguisher nozzle and coupling spanner on one of the ship's walls

Figure 36: Example of the storage position of a firehose beneath the ceiling

Innovative rapid response systems for fighting fires inside containers or vehicles, such as the Fognail, were not available.[30]

[30] Note: A corresponding carriage requirement does not exist.

3.2.3 Investigation into the cause of the fire

3.2.3.1 Welding operations on board the ship

3.2.3.1.1 Preliminary notes

Welding operations were carried out on board the ship during the voyage from Gothenburg to Hamburg and in the Port of Hamburg. The team of six welders, who do not form part of the crew, carried these out. The works were executed on the basis of the crack repair and monitoring system (CRMS) implemented in the ship's safety management system and approved by the classification society in 2010.

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BIBBY SHIP MANAGEMENT LIMITED
Att: Matt Thomas
105 Duke Street

LIVERPOOL L1 5JQ
United Kingdom

Date 23 June 2010
Your ref Matt Thomas
Our ref RSM/hau

Re: ATLANTIC CONTAINER LINE SHIPS:

ATLANTIC COMPANION	**LR 8214152**
ATLANTIC COMPASS	**LR 8214176**
ATLANTIC CONCERT	**LR 8214164**
ATLANTIC CARTIER	**LR 8215481**
ATLANTIC CONVEYOR	**LR 8215534**

CRACK MONITORING SYSTEM

Further to our London office approval 7 November 2001 of Edition 6 of the ACL Crack Monitoring System and with reference to your revised proposals for crack monitoring system as outlined in the following document:

Title:	Revision Number	Date
Container Ro-Ro Vessel Operations Manual Section 7 – Crack Repair & Monitoring System (CRMS)	1	**24 May 2010**

1. Review of revised Crack Repair & Monitoring System (CRMS)

Would advise that we have reviewed the contents of Bibby Ship Management proposals, as outline in the above document. The revised proposals are of minor editorial nature and found acceptable.

2. LR Approval of Revised Crack Repair & Monitoring System (CRMS)

The Crack Repair & Monitoring System (CRMS), Revision 1, 24 May 2010 has been duly approved as submitted. Two approved copies of revised pages are enclosed herewith.

Figure 37: Classification society's approval of the current CRMS (p. 1/2).

This approval is on the basis of the above review, our earlier survey and repair experience with the ACL vessels, and our London office approval letter dated 7 November 2001.

Yours faithfully
Lloyd's Register EMEA, Gothenburg

Roland Malmberg
Port Manager

Figure 38: Classification society's approval of the current CRMS (p. 2/2).

The CRMS forms part of the ship's ISM manual, where it is described in detail on seven pages in Chapter 7 (see extract in **Figure 39** below).

BIBBY SHIP MANAGEMENT
CONTAINER RO-RO VESSEL OPERATIONS MANUAL
SECTION 7 – Crack Repair & Monitoring System (CRMS)

Revision Number: 2
Page Number : 1 of 7
Revision Date : 23.06.11

Purpose
Section 7 of this Container Ro-Ro Vessel Operations Manual (CROM) is tailored to address any specific operational requirements of each container Ro-Ro vessel or a specific fleet within the Company's management.

In this instance this section addresses the specific requirements for the implementation of a Crack Repair and Monitoring System (CRMS) on the ACL Fleet.

All five vessels within the ACL fleet were lengthened with the addition of a mid-body during 1986-87. Four of the vessels were lengthened at the Hyundai Mipo Shipyard in Ulsan, Korea and the Atlantic Conveyor was completed at Scott Lithgow Ltd, Glasgow.

Atlantic Container Line vessels have been operating for many years with a formal crack monitoring system, as designed by ACL Ship Management AB hereinafter called ASM and approved by Lloyd's Register (LR), for all five ships in the fleet. Atlantic Companion, Atlantic Compass, Atlantic Concert have been operating under this specific system since 1995, and the Atlantic Conveyor, Atlantic Cartier since 1997. In January-February 2001, ASM implemented a plan, under the supervision of Lloyd's Register, to repair every crack that has been identified on each vessel.

This section "CRMS" re-establishes these uniform procedures that are intended to intensify the inspection and monitoring of the structural condition of the five ACL vessels, ensuring that they are duly integrated into the Bibby Management System whilst maintaining the full content and structure of the ASM document as approved by Lloyd's Register.

Responsibilities
The Master and all officers must ensure that they are familiar with, and are complying with, the requirements of the details contained within this section.

The specific responsibilities of the Company, Master, officers and other personnel associated with the implementation of the CRMS are as described below.

Details
1. **Introduction**
Atlantic Container Line vessels have been operating for many years with a formal crack monitoring system, as designed by ACL Ship Management AB hereinafter called ASM and approved by Lloyd's Register (LR), for all five ships in the fleet. Atlantic Companion, Atlantic Compass, Atlantic Concert have been operating under this specific system since 1995, and the Atlantic Conveyor, Atlantic Cartier since 1997. It has become apparent that ASM needs to keep pace with technological developments and to further clarify and tighten procedures to ensure that the ACL fleet is maintained to the highest safety and environmental standards. As a result, in January-February 2001, ASM implemented a plan, under the supervision of Lloyd's Register, to repair every crack that has been identified on each vessel.

The core elements of this updated system were implemented onboard all ACL vessels as they called Gothenburg in their port rotation, beginning with the MV Atlantic Conveyor on January 31, 2001. The last vessel, MV Atlantic Compass implemented the system on February 26, 2001. The system is continually updated and modified and this will continue to happen so that it remains current with up to date technology and standards. As a result the CMS was renamed to Crack Repair & Monitoring System (CRMS) forming edition 8.

Basically, CRMS re-establishes uniform procedures that are intended to intensify the inspection and monitoring of the structural condition of the five ACL vessels. Fortunately, the programme benefits from the fact that most of the Masters and many of the officers, have been involved with the ACL vessels since they were built. As a result, all already have a very clear understanding of the crack situation, the physical locations that need special observation and the structural modifications that have proven to be successful. However, in order to ensure that all vessel commands are working under the same, consistent understanding of the situation from vessel to vessel, specialized training for all Masters, Chief Engineers and Chief Officers has been and will continue to be provided on a regular basis.

Figure 39: Extract of Chapter 7 of the ISM manual

In the CRMS, cracks are separated into the five categories 1a, 1b, 2a, 2b, and 3, where within this range the most severe damage is assigned to group 1a and deficiencies affecting the safety of the ship least to group 3. In addition to the safety-related classification, the CRMS provides a second six-stage graduation according to the particular type of crack. This grading is independent of safety aspects and differentiates between various cracks according to position and applicable repair method.

In addition to the aforementioned grading criteria, the CRMS describes, inter alia, the shipboard responsibilities and the requirements for reporting and repair management. Finally, the CRMS also contains requirements for selecting the external service companies for repairs on board.

Seagoing ships in the Port of Hamburg need a regulatory permit for the performance of work involving heat or an open flame, i.e. welding operations in particular. The ATLANTIC CARTIER was in possession of such a permit for the period 7 March 2013 to 15 March 2014.

3.2.3.1.2 Welding operations on the day of the accident

Responsibility on the ship for monitoring welding operations to be performed by the repair company rested with the bosun of the ATLANTIC CARTIER. He attended the briefings for the pending works and prior to the works beginning asked the chief officer to disable those zones of the smoke detection system in which welding was to take place to avoid false alarms. During the welding operations, he reportedly carried out safety inspections of the relevant areas of the ship at 30-minute intervals. At about 1830, his last inspection of deck 3 B reportedly finished at its aft end.

With regard to the welding operations carried out on board at sea and then in the Port of Hamburg on the day of the accident, a list of the repairs that needed to be made on 28 April 2013 was submitted for the ship (see **Figures 40 f.** below).
As regards the repairs actually carried out on the day of the accident, a separate list (see **Figure 42** below) was handed over. Statements given by the relevant workers and inspections on board confirmed this.

Vessel: Atlantic Cartier — Remaining cracks 2013-04-28

Number	Type	Category	Location					Description	Crack length, mm.	Direction relative vsl.
			Frame	Bay	Row	Tier	Deck			
1806	5	2B	125	57	03		3B	Crack in old welding thru deck 4, in cable gland	150+ 50	T
1813	5	2A	226	23	09		3B	Crack under Deck 4 in valve for the fireline 20 RW 1/5	70	T
1944	6	3	N10	37	03		3B	Crack in bulkhead at battening penutration	120	V
1945	6	3	N10	37	03		3B	Crack in bulkhead at battening penetration	60	V
1951	2	3	273	10	01		4	crack at bracket between cellguide and hatch coaming	270	t
1955	6	3	N11	37	05		3B	Crack in Long 10	50	t
1981	5	2B	N42	29	9		3B	Crack in long 16 in recess	50+20	v
1998	6	3	273	10	6		4	Crack in doubler on the hatch	400	v
2009	2	2B	165	47	05/07		4	Crack btw floor plate and cellguide frame 46/50	30	t
2015	2	3	208	26	5/7	82	4	Crack in support for movable cell guide	180	t
2016	5	2B	253	18	1	82	4	Crack in cellgate on deck fwd bay 18	100	v
2030	5	2B	N12	35	07		3B	Crack in trans and bulkhead		
2058	6	3	199	38/42	12		4	Crack in bracket next to EM-exit 100 RW.	20	
~~2086~~	~~5~~	~~2B~~	~~N18~~	~~35~~	~~07~~		3B	Crack in long 6 and deck 4	100	
2105	6	3		61			2	Crack in bulkhead in D-ring recess (ramp to Dk 3)	70	
2107	6	3	N29	31	09		1	Crack in bracket outside em. exit	40	

Figure 40: CRMS repair list (scheduled work) of 28 April 2013 (p. 1/2)

Vessel: Atlantic Cartier — Remaining cracks 2013-04-28

Number	Type	Category	Location					Description	Crack length, mm.	relative vsl.
			Frame	Bay	Row	Tier	Deck			
2111	6	3	129	55	08		1	Crack in aft bulkhead at lashing recess	50	
2124	6	3	235	21	07		3B	Crack btw. Fwd. Bulkhead and bracket	80	
2150	5	2B	209	25	4		3B	Crack in long 8	150	
2151	6	3	N12	35	5		3	Crack in frame of sliding-door 300 1/5 GR	100	
2153	6	3	109	63	5		3	Crack in bulkhead to Engine 60 1/5 GR	30	
2166	6	3	79	66	04		1A	Crack in ER bulkhead on rabbit ramp	140	v

Figure 41: CRMS repair list (scheduled work) of 28 April 2013 (p. 2/2)[31]

Hot work carried out on board Atlantic Cartier at 1st May 2013.

Nr.

1813 1. Deck 3B bay 23 row 09 (stbd side), frame 226 welding small crack, all hot work finished at 0930

1906 2. Transformer room frame 125 on deck 4 and 3B bay 58 stbd side. Carried out when fire occurred.

3. Stbd gangway 1600-1700. Gangway was lowered on the quay and welding was carried out from shore side on two lowest steps from the groud.

4. Ramp to deck 2-3 hot work completed at 1000

058 5. Frame 199 row 12 deck 4 bay 42 about 1700

Figure 42: List of the welding operations actually carried out on 1 May 2013

[31] Note: Crack number 2150 is located in close proximity to the seat of fire. However, it was apparent during the inspection of the scene that the scheduled welding operations had yet to be carried out at the time of the accident.

As regards the cause of the fire, crack numbers 1813, 1806 and 2058, listed in both the planning list and the list of welding operations carried out on the day of the accident, can be eliminated because of their distance from the fire. Although crack number 1813 is located on the deck primarily affected by the fire (3 B), it is on the starboard side of the deck. No vehicles were stowed there and the horizontal distance to the place at which the fire subsequently broke out was about 25 metres.

The BSU noted during a comparison of the two lists that on the day of the accident welding operations took place in two areas (see numbers 3 and 4 in **Figure 42** above), which were not listed in the plan of required works. The additional welding operations carried out on the gangway (number 3) and the ramp to decks 2/3 (number 4) cannot be connected with the accident, either, because of the large distance to the seat of fire.

However, viewed generally the discrepancies between the aforementioned lists in respect of numbers 3 and 4 appeared to indicate that with regard to welding operations, deviations from predetermined plans were made from case to case. Nevertheless, the owner made clear in its statement to the draft investigation report that the list of required welding operations (**Figures 40 and 41**) concerns only those carried out within the framework of the CRMS and on file. By contrast, the list of the welding operations actually carried out on the day of the accident (**Figure 42**) reportedly includes such (all) welding operations as those done routinely, which have no relation to the CRMS.

This explanation for the observed discrepancy is understandable and credible. However, for lack of production of a separate list, from which, analogously to the CRMS repair list, the planning of welding operations that do not form part of the CRMS could be derived, the BSU is unable to rule out with absolute certainty that welding operations were carried out in the immediate vicinity of the seat of the fire in addition to the works on file that were scheduled and carried out on the day of the accident.

3.2.3.2 First opinion of the expert appointed by the BSU

3.2.3.2.1 Fundamentals of the investigation, objectives, initial situation, and limits

Important sources of information for the BSU's fire investigator were his own observations and in this connection the photos taken during two shipboard surveys on 3 and 6 May 2013. In addition, the analysis of witness testimonies and inspection of technical documents and recordings made on board were considered in the assessment. With regard to the assessment of the action taken to fight the fire, which in addition to determining the cause of the fire was the focus of the deliberations of the expert, the expert appointed by the BSU analysed mission reports or confirmations and statements of the Hamburg fire services.

After the accident event, several hours had already passed before the expert did the first survey. Initial investigations on the deck and of the cars took place during this period. Moreover, the upper deck was unloaded in the course of the operation. Due to that, but in particular due to the extremely high temperatures over a very long period on the affected deck, any traces pointing to the seat of fire directly on a single car were completely destroyed.

Consequently, it was impossible for the expert to obtain a precise image of the original condition immediately after the initial accident event during his survey. One must assume that the status found was affected significantly by the action taken hitherto, as well as the long period for which the fire event persisted and the extinguishing action.

Consequently, the expert was forced to limit his investigation into the cause of the fire to the assessment of certain characteristic phenomena, so as to describe the possible processes involved in the outbreak and spread of the fire. Special attention was given here to the spatial extent and localised severity of the damage.

3.2.3.2.2 Extent of the damage[32]

The damage on deck 3 B stretches to below the ceiling in the port area of the slots at bay 22 to bay 38. The area is limited on the port side up to the ships centreline. The starboard side was not loaded. The propagation of heat to the overlying deck 4 was apparent. When considering the extent of the damage, it is particularly striking that there was apparently no substantial fire damage outside the closed deck to the cargo on the upper deck, despite the fire developing rapidly.

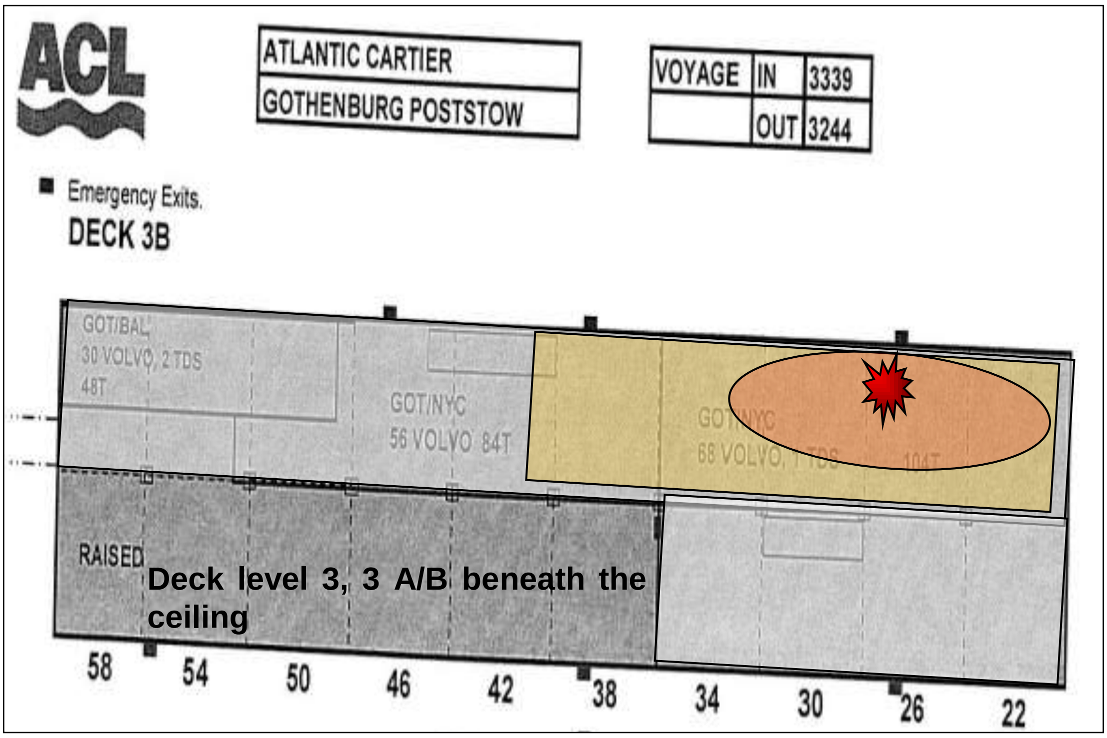

Figure 43: Area of fire development (ro-ro loading plan)

[32] Note: Verbatim or edited parts of the expert opinion are shown in italics.

The fire damage on deck 3 B varies, spreading from the apparent seat of the fire in a circular pattern. Despite the relatively long and unimpeded spread of fire, the damage is extremely localised. From that it can be concluded that the fire reaches extreme thermal proportions over time in an affected car; however, the structural condition of new cars stops it from crossing to the adjacent vehicle for an extremely long period, even though the stowage distance is very low (less than 30 cm in places).

Figure 44: Apparent position of the seat of the fire (bay 26)

Figure 45: Position of the seat of the fire

***Figure 45** above reveals that the second car seen from the port side (i.e. in front in the image) exhibits heavier damage than the outer. Therefore, it must be assumed that this was the first vehicle to burst into flames.*

Rather than from the front of the vehicle, the fire spread from its side panels. It is apparent that each engine compartment acted as a firewall. Indeed, the fire raged beneath the ceiling, which is visible from the severe damage to the deck. However, an indication that the fire crossed from the boot of the car to the engine compartment of the next adjacent vehicle or through the front/rear window to the passenger compartment is not so clearly visible.

Figure 46: Damaged vehicle in the second row from the front

(1) Cargo damage
*When considering the severity of the damage, it is evident that no effective action was taken to fight or contain the fire in the affected deck over a period of hours. Consequently, the fire was able to spread unhindered. That the entire cargo on the affected deck was not destroyed is thanks only to the specifics of the cargo, i.e. the fire resistance of the cars loaded. It is apparent that leaking fuel did not cause an extensive spread of fire, either. Most of the tyres survived at least partially even on the burnt out vehicles (see **Figure 48** below).*

It is remarkable that the fire evidently stayed within a confined area in spite of the considerable intensity. It would seem that the accumulation of gases caused the formation of convective currents in the lower area, too. Due to extreme temperatures, most of the plastic parts on the vehicles and deck installations melted even in areas some distance away (distance of two to three cars), however.

Figure 47: Thermal stress on the deck's ceiling

Figure 48: Spread of fire from above by heat radiation

Figure 49: Spread of fire by convection (not depending on the position of the seat of fire)

Figure 50: Various traces of damage to adjacent vehicles

Figure 51: Destroyed plastic parts (in this case the rear lights) on the vehicles

Figure 52: Plastic casing of a ceiling light melted by heat radiation

In summary, with regard to the extent and severity of the damage throughout the affected vehicle deck 3 B, it is noted that the damage sustained by the cargo was localised but comparatively severe. Even vehicles on the periphery aft were rendered largely unusable due to being fouled by soot.

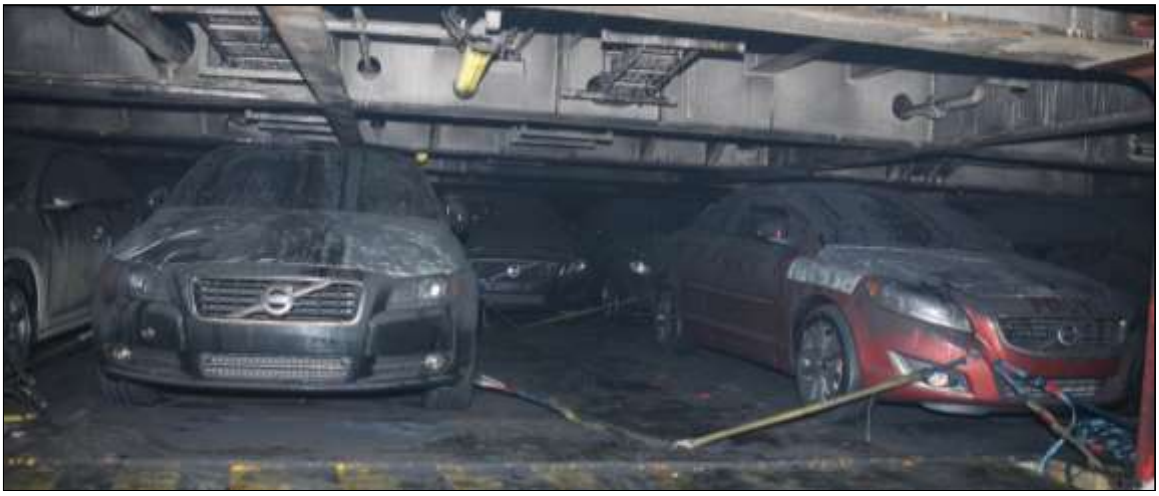

Figure 53: Vehicles in the outer area fouled by soot

(2) Ship damage
When considering the damage to the ship, a differentiation must be made between the consequences of the fire on the deck primarily affected (3 B) and the main deck (upper deck). Damage was sustained by the deck structure and installed technical equipment in the affected deck. The heaviest damage is on the cable routing beneath the ceiling. However, the deck structure was also heavily deformed in places due to the long period for which the fire persisted unimpeded.

Figure 54: Destroyed cable routing and deformed girders beneath the ceiling

*Metal fires occurred on vehicles in the main fire zone. Occurring at extreme temperatures in excess of 1,000°C, these fires caused the damage found (see **Figure 55** below). Parts of the permanently installed* CO_2 *low-pressure system were also destroyed in the main fire zone.*

Figure 55: Engine compartment of a car destroyed by metal fire

On the main deck, warping occurred on the floor in the main fire zone. The paint is burnt in places (see ***Figure 56****). It is apparent that there was no significant heat conduction vis-à-vis the cell guides on deck, however.*

Figure 56: Warped deck and fire damage in the area of bay 26

Thermal traces can only be demonstrated up to the actual edge of the cargo hold. The deck area above the void space and the ventilation ducts sustained hardly any thermal stress (see ***Figure 57*** *below).*

Figure 57: Damage threshold (cargo hold/void space)

Furthermore, no thermally induced damage was found on the shell plating – not even in the main fire zone.

Figure 58: No thermally induced damage to the hull wall in the area of bay 26 (port side)

3.2.3.2.3 *Investigation into the causes of damage – preliminary notes*

As mentioned above, the investigations of the expert appointed by the BSU were complicated by the preceding extinguishing work on the deck, the build-up of smoke and thus extensive fouling of all the cars with soot, and the fact that the fire had raged unimpeded for a prolonged period. Traces that may have been present originally or other externally visible evidence as to the seat of fire were covered or destroyed for the reasons given. Therefore, a reliable investigation to determine the actual cause of the fire was impossible for the expert. However, it was possible to reconstruct the probable fire process and then deduce possible fire causes from that based on the pattern of damage.

According to the statement given by the person who discovered the fire (witness Y), a car in the vicinity of the bay 26 emergency exit on the port side caught fire. This statement is consistent with the fire traces found. On initial questioning by the investigators, the witness was unable to state whether the fire issued from the engine compartment or passenger compartment. Since the new vehicles had been firmly lashed on board since the passage from Gothenburg (about 1.5-2 days), mechanical overheating in the vicinity of the chassis and/or engine can be ruled out as the cause of the fire. With a probability bordering on certainty, a fuel leak can also be ruled out as the cause of the fire for lack of an acute source of ignition. A technical fault in the electrical system of a vehicle as a result of an overload or short circuit and partial overheating resulting from that is conceivable.

It cannot be ruled out that the fire was caused by arson with absolute certainty. In particular, based on the assumption that only about 30 minutes had actually passed between the last safety inspection on the deck, which was uneventful, and the first identification of a car enveloped in flames, and given that the source of the fire was in the direct vicinity of an emergency exit, it would appear that negligent or even malicious arson is within the realms of possibility. Remarkable in this context is the fact that on the very day of the fire, the Port of Hamburg was 'in public holiday mode', meaning there was no cargo handling and as a result the number of personnel working on board, and in the area of the ro-ro deck in particular, was low.

3.2.3.2.4 *Fire process*

Given the extent and severity of the fire damage, the prevailing determinants (little ventilation on the deck and no immediate detection) and considering the nature and extent of the initial action to fight the fire, it is reasonable to assume that a comparatively large amount of heat must have been released within a short period. This means that the process that unfolded must have taken place with a high heat release rate. This assumption is supported by the extreme destruction of nine vehicles in the immediate vicinity of the location of the seat of fire, as listed below:

- *full and complete combustion of all inner and outer plastic parts, such as dashboard, seat cushions, steering wheel, indicators, headlights;*
- *exterior paint burnt off completely;*
- *complete destruction (metal fire) of the engine compartments, engines, bonnets, and large parts of the chassis;*
- *complete destruction of all the tyres and wheels, and*
- *complete destruction of all the windows, including rubber seals*

Figure 59: Completely burnt out vehicles

The extent and acutely localised isolation of the damage on deck 3 B permits the conclusion that for the most part the transfer of heat released by the fire must have taken place through convection and heat radiation. Here, the shielding effect of the individual cars is apparent.

There is no evidence to suggest a spread of fire due to an accumulation of fluids on the floor of the deck. Given the overall patterns of damage, the location of the seat of fire could be in the area of the passenger compartment, the engine compartment or the chassis (tyres) of the first car to catch fire. To define the actual position that led to ignition inside or outside this car and what this was caused by is practically impossible for the reasons already mentioned, however.

Witness statements to the effect that thorough fire inspections were reportedly carried out on the deck due to the disabling of the fire alarm system, during which no indication of any irregularities was found an estimated 30 minutes before the fire broke out, oppose a lengthy smouldering fire inside a vehicle, however.

Experience has shown that even a fuel-induced initial fire inside a closed vehicle develops for up to 15 minutes before windows burst and a fully-fledged fire thus ensues. According to the statement given by the person who discovered the fire, there was a heavy build-up of smoke on the deck and the upper deck felt warm only some 30 minutes after the previous safety inspection, however. On the other hand, this fact supports the possibility of a spontaneous event. The presumed detonations or even explosions cannot be substantiated, however. Rather, the noises repeatedly heard during the extinguishing activities can be attributed to burst tyres and triggered air bag systems.

Figure 60: Fragments of a triggered air bag inside a car

3.2.3.3 Expert assessment on behalf of the insurer of a cargo interest

3.2.3.3.1 Preliminary notes

Inter alia, a total of 321 new Volvo cars were stowed on decks 3 B, 5, 7, and 8 of the ATLANTIC CARTIER at the time of the accident. As described above, various vehicles in the decks referred to were either completely destroyed or destroyed in economic terms due to the fire or its effects. By its own account, the vehicle manufacturer suffered damage amounting to some 3 million euro. The insurer of the cargo interest, Volvo Car Corporation, commissioned the British BMT Group Ltd's inspection agency with the preparation of a fire report for the purpose of asserting any damage claims. The BSU was advised, initially verbally, on the main findings of this assessment in summarised form by the insurer's law firm on 23 September 2014. The aspects discussed during the conversation and submitted documents and photos were provided to the BSU in electronic form on 25 September 2014. Part of these sources are included in the BSU's investigation report in a moderately edited form in places with the kind permission of the contracting entity or rights holder.

To the extent possible based on the information provided by the law firm, extracts taken from the findings of the assessment and condensed to the key statements are shown below. **Whether and to what extent the BSU concurs with the findings of the experts shall remain open for now and is the subject of section 4.3.**

3.2.3.3.2 Cause of the fire[33]

In the opinion of the cargo insurer's expert, all the electric wiring on board the ship was defective and fire prone to an unusually high degree. According to that, evidence of inadequate wiring was revealed by cable loops protruding from the protective sheath, traces of corrosion on cables, cable connections of inconsistent strength, existing damage to cables due to welding operations, damage due to abrasion caused by metal cables, forcibly bent cables inside the insulation, damage to the insulation due to overheating, and traces of several earlier fires on deck 3 B. Indicative of the cable routing was numerous cable splices originating for the most part from the lengthening of the ship (see ***Figures 61 f.****).*

Figure 61: Cable splices on the ceiling of vehicle deck 3 B[34]

Figure 62: Cable splices on the ceiling of vehicle deck 3 B (close-up)[35]

[33] Note: Verbatim or edited extracts/information from the documents provided by the cargo interest's law firm are shown in italics in this and the following items.
[34] Source: Expert opinion, BMT Surveys (see Sources).

*There were about 200 cable spices in the area above vehicle 4 B alone at the time of the fire. **Figure 63** below is a schematic drawing showing the cars stowed in the forward part of deck 3 B. The nine vehicles affected by the fire most severely are highlighted in red.*

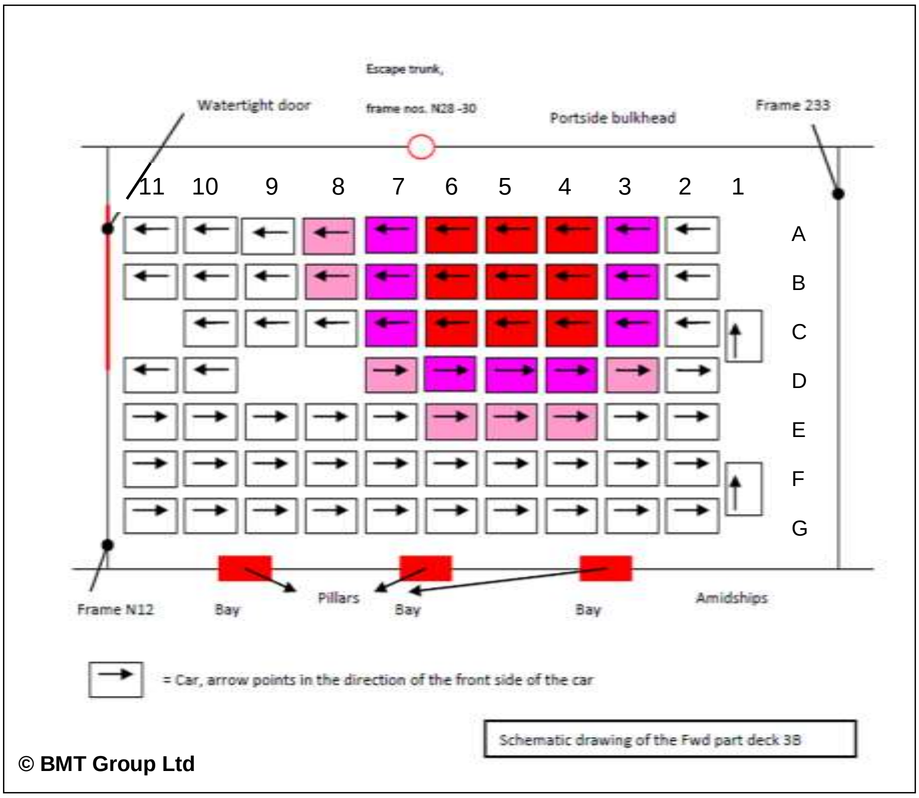

Figure 63: Schematic drawing showing the cars stowed on deck 3 B (port side)[36]

***Figure 64** below illustrates a fact that the experts regarded as significant, which was that the fire broke out in the very section that was inserted into the ATLANTIC CARTIER after she was lengthened in 1987.*

[35] Source: Expert opinion, BMT Surveys.
[36] Source: Expert opinion, BMT Surveys. (Figure moderately edited.)

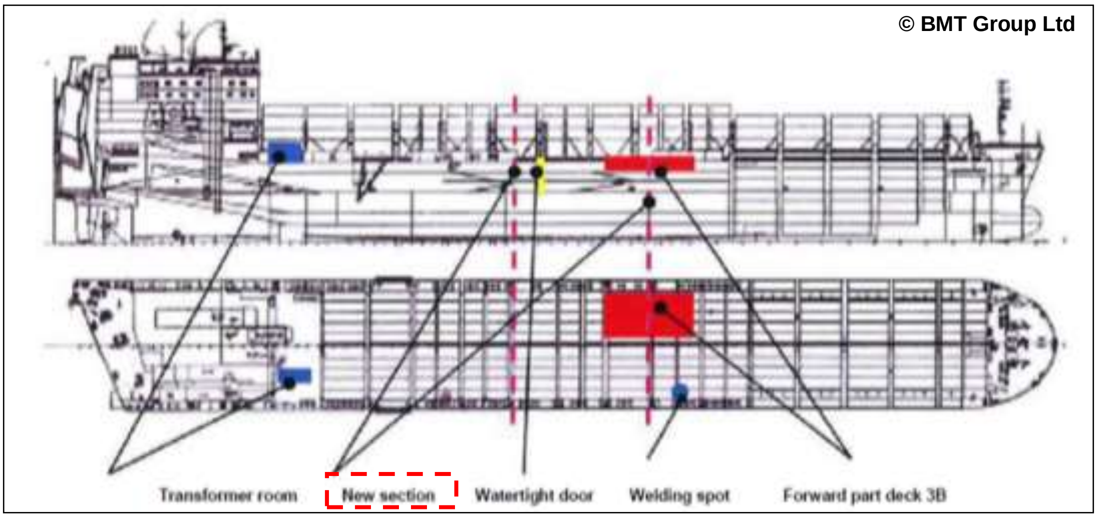

Figure 64: Seat of the fire on the threshold between the foreside of the inserted section and forward part of the ship[37]

The cable splices in the vicinity of the subsequently inserted section led from cables with a larger diameter or more conductors to cables with a smaller diameter or fewer conductors. At the time of the fire, there were various cables that consisted of three conductors, each with a diameter of 2.5 mm in the aft part of deck 3 B, while in the forward part they were continued with only two conductors, each with a diameter of 1.5 mm (see ***Figure 65****).*

Figure 65: Cable splice with inconsistencies in respect of diameter and number of conductors[38]

Such inconsistencies in diameter cause electrical resistances capable of generating heat until the metal conductors are red hot. Traces of such overheated cables and scorch marks can be found at various points on deck 3 B (see ***Figures 66 to 68*** *below).*

[37] Source: Expert opinion, BMT Surveys.
[38] Source: Expert opinion, BMT Surveys.

Figure 66: Example of charred cable insulation (1)[39]

Figure 67: Example of charred cable insulation (2)[40]

Figure 68: Example of charred cable insulation (3)[41]

*To demonstrate the existence of the defective wiring, the experts appointed by the cargo insurer also submitted photos that show sharply kinked or pressed in metal conductors protruding from and elsewhere within the protective sheath (see **Figures 69 f.**).*

[39] Source: Expert opinion, BMT Surveys.
[40] Source: Expert opinion, BMT Surveys.
[41] Source: Expert opinion, BMT Surveys.

Figure 69: Example of metal conductor protruding from the insulation[42]

Figure 70: Example of metal conductor within the insulation[43]

In addition to the safety risk arising from the defective cable connections, the experts appointed by the vehicle insurer also identified cable insulation damaged by earlier welding operations as the possible cause of an incendive smouldering fire during their assessment. Inter alia, ***Figures 71 f****. below taken on deck 3 B aim to demonstrate the existence of corresponding traces on cable insulation in the immediate vicinity of welding spots.*

[42] Source: Expert opinion, BMT Surveys.
[43] Source: Expert opinion, BMT Surveys.

Figure 71: Example of cable insulation damaged by welding operations (1)[44]

Figure 72: Example of cable insulation damaged by welding operations (2)[45]

A repair in the transformer room is cited as an example of the dangerous proximity between welding spots and cable routing, and the fact that the fire protection operated was reportedly only inadequate, (see ***Figure 73*** *below). Heat protection for the cables by laying a fire blanket was reportedly not carried out for these repairs made on the day of the accident.*

[44] Source: Expert opinion, BMT Surveys.
[45] Source: Expert opinion, BMT Surveys.

Figure 73: Example of close proximity between welding spot and wiring[46]

*Finally, to prove the existence of inadequate or damaged cable insulation, conspicuous signs of corrosion caused by the particularly aggressive saliferous air on seagoing vessels are referred to. This causes the formation of bright green copper chloride on metal conductors without proper insulation. The experts found chemical reactions of this nature on wiring above the positions 4 and 5 B (see **Figure 63** above and **Figure 74**).*

Figure 74: Example of conspicuous signs of corrosion in the wiring[47]

As regards the aspect of a cable fire spreading from the ceiling of the ro-ro deck to one or more vehicles stowed on the deck, the experts have referred to one ship-based idiosyncrasy that increases the risk. To prevent contamination of the stowed

[46] Source: Expert opinion, BMT Surveys.
[47] Source: Expert opinion, BMT Surveys.

*vehicles, plastic tarpaulins are hung in certain parts of the ceiling. Their purpose is to prevent droplets of hydraulic oil or lubricant stemming from mechanical components located beneath the ceiling that are needed for raising and lowering the mobile tween decks (see **Figure 75**). The tarpaulins have an exchangeable absorbent layer to soak up fluid discharge (see **Figure 76**).*


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Figure 75: Example of one of the tarpaulins beneath the cargo hold ceiling


© BMT Group Ltd

Figure 76: Close-up of a tarpaulin with layer for absorbing fluid

The experts appointed by the insurer of the cargo prepared the following schematic drawing to illustrate what they believe was the direct and causal link between the defects and sources of danger they identified, as described above, and the outbreak of fire on vehicle deck 3 B.

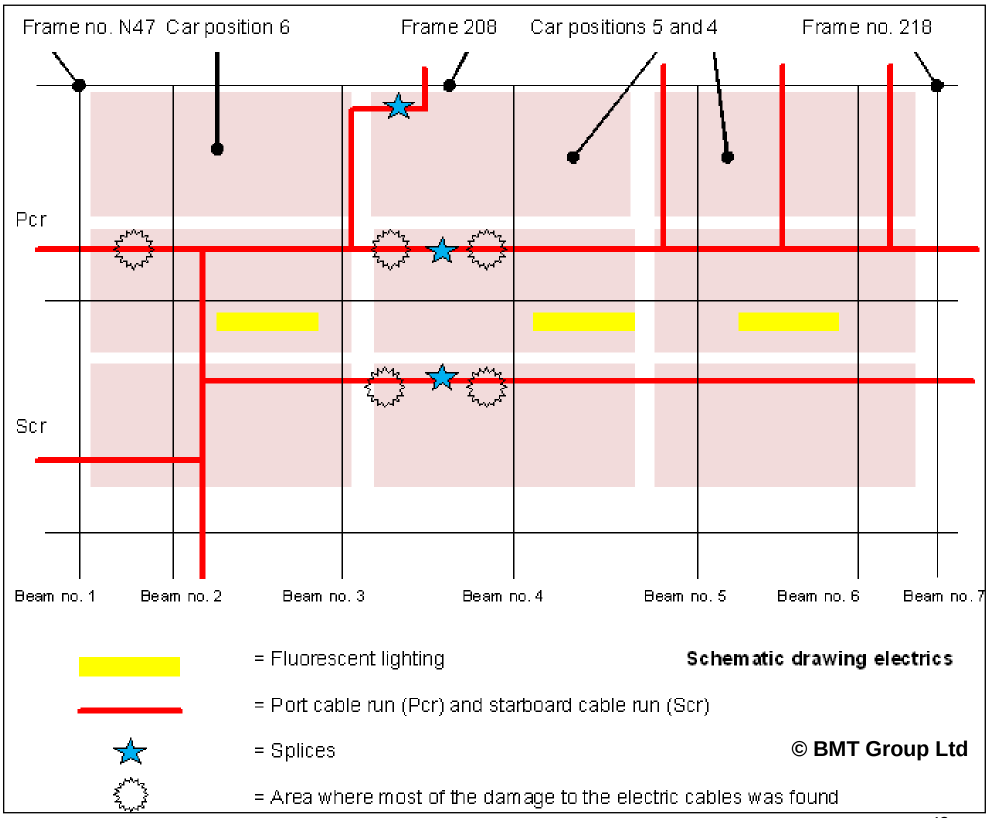

Figure 77: Schematic drawing of the defects in the wiring on deck 3 B [48]

3.2.3.3.3 Exclusion of the spontaneous combustion of a car as the primary cause of the fire

Referring first to the analysis of conflicting witness testimony (a) and second to the findings of an expert opinion (b) obtained to clarify this question specifically, the vehicle manufacturer and its insurer rule out categorically the possibility that the fire on board the ATLANTIC CARTIER could have been triggered by the spontaneous combustion of a motor vehicle.

(a) Observations of the person who discovered the fire as opposed to motor vehicle as the cause of the fire

According to consistent witness testimony, the external effects of the fire on the main deck emerged in the form of flaking paint and light smoke due to heat from the floor. However, the witness reportedly then observed dark smoke and – albeit confined to a vehicle's engine compartment – open fire in vehicle deck 3 B a short time later. The vehicle insurer and the manufacturer are of the opinion that this locally confined fire does not explain the some 10-mm thick steel floor of the main deck being heated at specific points, as described by the witnesses. Rather, having regard to the actual circumstances, only a separate ship-induced heat source immediately beneath the floor of the main deck is reportedly open to consideration. With that in mind, the observed vehicle fire was reportedly only an aftereffect and not the primary cause of fire breaking out on board the ATLANTIC CARTIER.

[48] Source: Expert opinion, BMT Surveys.

(b) Opinion on the possibility of a brand new Volvo S 60 car spontaneously combusting[49]

An American computer and electronics specialist tasked with clarifying this issue specifically examined a brand new motor vehicle that was identical to the one identified as being the first vehicle in flames on deck 3 B. In particular, he checked whether the current flow generated by the vehicle's battery within the various circuits and components of the vehicle's electrics and electronics could produce temperatures capable of triggering a vehicle fire.

The expert stressed that the fact the vehicles were brand new was the starting point for considerations. Consequently, any risk of fire originating from a traffic accident, improper modifications or wear was reportedly ruled out.

Furthermore, the expert points to the fact that prior to dispatch the vehicles are set to transport mode in the factory. As a result of that, various functions of the vehicle were disabled or reduced to a minimum for reasons of safety and to protect against the vehicle's battery discharging completely. It was claimed that a vehicle could only cover a few miles, for example. After that, the engine would switch off automatically. The engine also switches off automatically when the vehicle's electronics do not register any human activity for several minutes. Therefore, forgetting to switch off the engine, or other factor that play a role only when the vehicle is in operation, for example, are not open to consideration as the cause of the fire.

The expert looked closely at the electrical flows in transport mode and carried out various measurements in that regard. To this end, he installed a shunt in parallel with the vehicle's standard onboard power system, which he connected to measuring instruments so as to gauge the current flow produced by the vehicle's battery when the engine is switched off. Corresponding to the specifications of Volvo, average amperage of 3.5 milliamps was measured at a resistance of 1 ohm. The expert points to the fact that at a battery voltage of 12.6 volts and an amperage of 3.5 milliamps, electric power of only 44 milliwatts is produced. Reportedly, this would not even be enough to heat a wire of the same thickness as a human hair.

In extensive tests, the expert finally reviewed the possibility of dangerous heat development with ensuing fire in various printed circuit boards and other components of the test vehicle, as well as the sizing and operativeness of the installed electrical fuses. All the tests confirmed the theory that even based on the assumption of technical defects, the spontaneous combustion of a vehicle could be ruled out due to the low current, the fuses that interrupt the current flow if necessary, and the fire-retardant materials integrated with the relevant components of the vehicle. The corresponding tests revealed no risk of fire even if certain power consumers (headlights, windscreen wipers, central locking, for example) were running continuously due to a defect.

[49] Source: „OPINIONS AND COMMENTS CONCERNING THE FIRE ABOARD MV ATLANTIC CARTIER, PREPARED BY JAMES M. KNOX, PhD, 06 August 2015".

3.2.3.4 Expert assessment on behalf of the owner of the ship

3.2.3.4.1 Preliminary notes

The owner of the ship and its insurer commissioned an expert from the British inspection agency Dr J H Burgoyne & Partners LLP with determining the cause of the fire. The original version of the opinion of this expert, which was submitted on 9 September 2014 and, inter alia, considers in detail the possibility of fire caused by cables or other scenarios initiated on board the ship, was provided to the BSU on 17 September 2014 in English.

The key steps and findings of the assessment are reproduced below in a much abridged form. The expert and his contracting entity have kindly agreed to the BSU's use of figures and diagrams in the opinion.

As already noted in relation to the assessment on behalf of the vehicle insurer, it is also noted at this point that the inclusion of the findings of the assessment in the investigation report should not be seen as their confirmation by the BSU. With regard to the BSU's examination of the various theories on the fire, section 4.3 of this investigation report is once again referred to.

3.2.3.4.2 Focal points of the assessment

In addition to a local survey immediately after the accident, the assessment of the expert appointed by the owner focused on a detailed examination of the electric wiring on the port side of the forward part of the deck primarily affected by the fire (3 B). Inter alia, more surveys were carried out on the ship about three weeks after the fire for this purpose.
In August 2013, the expert – as with the experts of the cargo insurer – also took part in a detailed, approximately one-week investigation of the nine Volvo cars that had suffered the most destruction due to the fire and were transported back to the manufacturer's plant in Gothenburg, which the vehicle manufacturer had organised.
The expert attended witness interviews during his first inspection of the ship. Furthermore, he was present at follow-up interviews with two crew members in Hamburg in January 2014.
Also considered were the welding operations carried out on the day of the accident. The expert ruled out any connection between this and the fire.
To verify the various causes of the fire thought possible, the expert finally conducted a number of tests and experiments, some with the participation of an external laboratory. Inter alia, this involved an analysis of the chemical composition of the cable insulation and its flammability. Individual electrical and mechanical components of the fluorescent ceiling lights in the vehicle deck were also tested using intact comparison models. Inter alia, a test as to whether a Volvo car could be set on fire as a result of burning material (burning plastic, for example) coming into contact with body parts or plastic vehicle parts was also carried out under laboratory conditions.

3.2.3.4.3 Determination of the area to be examined[50]

*The expert agrees with the respective experts of the cargo insurer and the BSU that the fire spread from the area of the fourth row of vehicles in the forward part of vehicle deck 3 B on the port side. The expert prepared the schematic drawing below to illustrate the specific circumstances and location of the focal points of the investigation in the vicinity of the nine cars most severely affected by the fire (see **Figure 78**).*

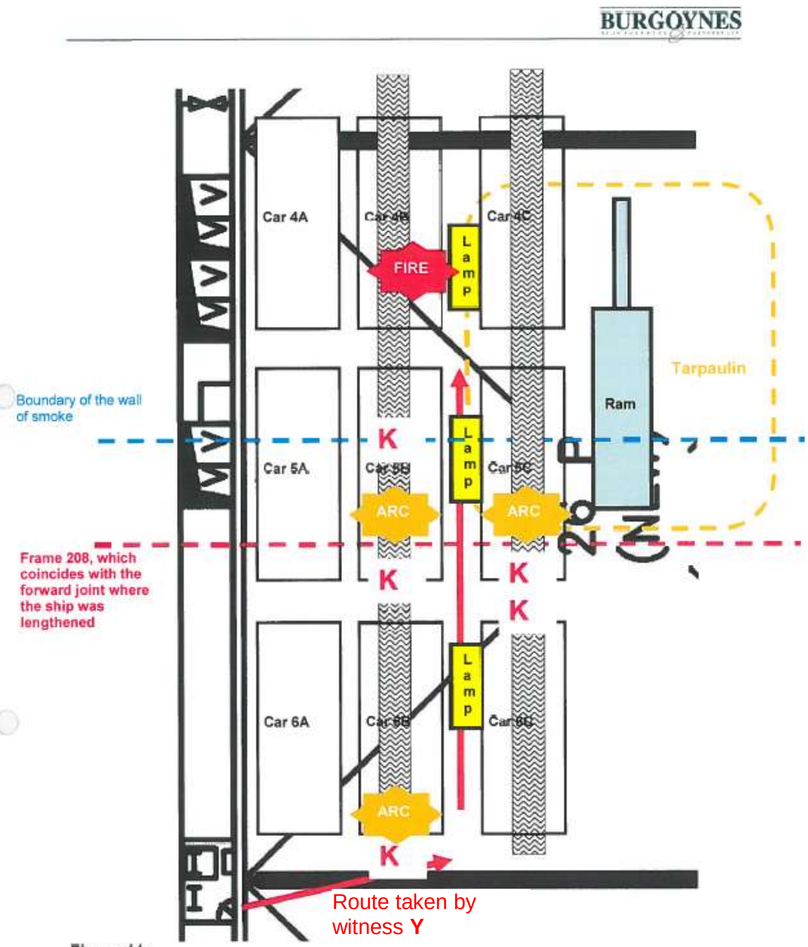

Figure 11:

Figure 10, with the cable routes superimposed on it. The three locations where the effects of arcing were found (ARC), and the five locations where cables had become kinked (K), have also been added.

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Figure 78: Schematic drawing of selected conditions in the vicinity the seat of the fire[51]

[50] Note: Verbatim or edited extracts/information from the expert opinion are shown in italics in this and the following items.

[51] Source: Expert opinion, Burgoynes (see Sources). Name of the person who discovered the fire rendered anonymous by the BSU.

3.2.3.4.4 *Investigation of the cable harnesses*

*In the course of the second local investigation after deck 3 B was fully cleared, the entire electric wiring in the forward section, i.e. the section of deck 3 B primarily affected by the fire, including the transition to the aft section of this deck was thoroughly inspected and the parts damaged by the fire then dismantled (see **Figure 79** below).*

Figure 79: Example of dismantled cable harnesses[52]

In particular, the new cable routing inserted due to the lengthening of the ship in 1987, as well as the transitions to the original wiring at the front and back of the new cable routing, were assessed.

*The forward cable splice (in the area of frame 208) was heavily damaged by the enormous effects of the fire and heat because of its position above car 5 B, one of the vehicles affected by the fire most severely (see **Figure 80**).*

Figure 80: Cable splice above vehicle 5 B[53]

[52] Source: Expert opinion, Burgoynes.
[53] Source: Expert opinion, Burgoynes.

In contrast, the rear cable splice (in the vicinity of frame 207) was located outside the forward section of the vehicle deck, which was affected primarily by the fire and isolated from the rest of deck 3 by the sliding door. Consequently, this cable splice was not destroyed and could be examined in greater detail (see ***Figures 81 f.*** *below).*


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Figure 81: Rear cable splice[54]


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Figure 82: Cable marked for repair purposes[55]

No deficiencies were found in the insulation, sheathing or the materials used in this respect (see ***Figure 83*** *below). The sheathing consists of a highly resistant armouring and could only be separated by means of a sharp blade.*

[54] Source: Expert opinion, Burgoynes.
[55] Source: Expert opinion, Burgoynes.

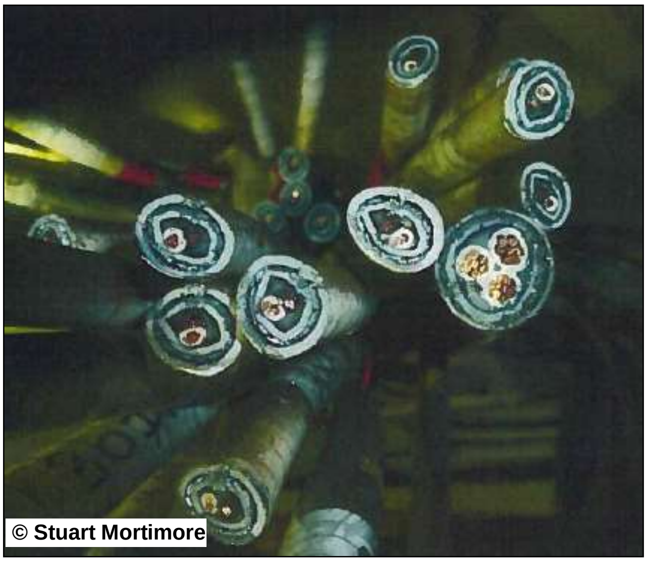

Figure 83: Close-up of the structure/cross-sectional area of single cable harnesses

*An investigation of the plastic material used for the insulation and sheathing, which was performed in a laboratory, revealed that they both contain fire-retardant additives. The ignition or fire performance of three single cables of different sizes or with different sheaths was tested in a laboratory using a lighter and a blowlamp, among other things (see **Figure 84**). It was not possible to set the various cables on fire with a lighter. While it was possible to ignite two of the three types of cable tested using a blowlamp, the fire extinguished within two or 25 seconds of the heat source being removed. It was also found here that the plastic insulation did not start to drip during the burning phase. Propagation of the fire on the insulation, similar to an ignition fuse, was not evident either.*

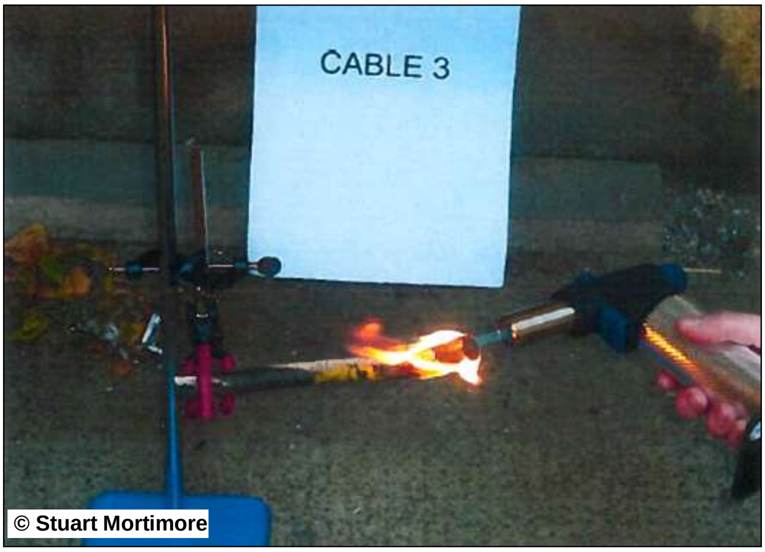

Figure 84: Test setup – ignition and fire performance of a cable sample[56]

[56] Source: Expert opinion, Burgoynes.

The expert appointed by the owner also made a detailed examination of the kinks and loops in individual cable harnesses (or metal conductors located within) found during the inspection. He found no evidence of a resulting sparkover, however. None of the cables above vehicle 5 B that had remained intact showed signs of a fault.

The owner's expert agrees with the experts appointed by the cargo insurer that past welding operations must have had an adverse thermal effect on the surface of the cable insulation due to insufficient thermal shielding. It was claimed that cable fires or progressive fires did not form, however. Due to the damage caused by the fire, it was not possible to determine whether such damage existed in the area damaged by the fire.

Finally, the expert confirmed that four cables in the area of the section subsequently inserted into the hull had a structure that differed from the original parameters. The differences are shown in the table below, which was taken from the expert opinion.

- Cable 6001 was 2 core 2.5mm^2 and the insert was 3 core 2.5mm^2.
- Cable 6002 was 2 core 1.5mm^2 and the insert was 3 core 1.5mm^2.
- Cable 6003 was 3 core 2.5mm^2 and the insert was 2 core 1.5mm^2.
- Cable 3072 was 3 core 7 strand and the insert was 3 core 33 strand.

Figure 85: Inconsistencies between the original and the newly installed wiring[57]

The expert opposed a causal link with the fire in that regard, however. There was no external evidence to suggest that linking the inconsistently sized cables would have resulted in heat and the subsequent development of a fire. What is more, the load on the ship's power system was said to be very low at the time of the accident, meaning that a build-up of heat in individual metal conductors can reportedly be ruled out for that reason, too.

3.2.3.4.5 *Investigation of the deck lighting*

Since ceiling lights were installed in the immediate vicinity of the vehicle that most probably caught fire first, the possibility that a defect originating from there could have caused the fire received special attention. In that respect, the expert conducted several laboratory tests and also contacted the German lamp manufacturer Sammode Lichttechnik GmbH in Saarbrücken. The manufacturer stated that the lamp model in question is still produced and designed so that a possible electrical fault within the lamp would on no account affect the external environment or lead to the ignition of materials outside of the lamp.

[57] Source: Expert opinion, Burgoynes.

The ceiling lights used were type certified in accordance with international technical standards and classified as 'explosion-proof' in 1969. Accordingly, the lamp should not radiate temperatures of more than 104°C.

***Figure 86** below shows the comparison model of the ceiling light tested by the expert. The lamp is 1.5 metres in length and contains two 40-watt fluorescent tubes.*

Figure 86: Model of the ceiling light installed in the vicinity of the fire[58]

As regards the possible consequences of an electrical fault, the expert also contacted the German manufacturers of the capacitors and ballasts installed inside the lamp. It was confirmed that each component is reportedly designed and certified so that fire is reportedly ruled out in the event of a technical fault.

Figure 87: Lamp socket and capacitor[59]

[58] Source: Expert opinion, Burgoynes.
[59] Source: Expert opinion, Burgoynes.

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Figure 88: Ballast[60]

Even though it is probably only theoretically conceivable that a flame could form in the body of the lamp due to a defect in the electrical components given the above considerations, the expert still tested the consequences arising from that in a test setup.

The plastic lamp cover holds only an extremely low amount of oxygen because of the airtight seal on the lamp cover. Accordingly, the candle positioned inside the lamp body during the test extinguished after the oxygen was consumed. Even if the candle was leaned against the plastic cover while it was burning, this resulted merely in scorch marks in the area of contact and a reduction in the plastic wall thickness of less than 25%.

[60] Source: Expert opinion, Burgoynes.

Figure 89: Test to establish the internal flammability of the ceiling lighting[61]

Regardless of the question as to whether and how it is possible to ignite the plastic cover of the ceiling lighting, the expert examined whether it would be possible to ignite a car if it were exposed to burning plastic. To this end, the door sill of a Volvo S60 car made out of plastic and metal parts was exposed to fire in various different ways. It transpired here that despite containing fire-retardant chloride, the plastic area of the door sill could be ignited using a lighter or blowlamp and continued to burn even after removal of the source of the fire.

In other tests a small amount of plastic that had been ignited with a blowlamp, which was supposed to simulate a drop falling from the burning ceiling light cover, was applied to the door sill. The burning drop, which slowly ran down the door sill, caused its plastic part to ignite. The fire died some time after the plastic drop had run off of the door sill (see ***Figure 90****).*

[61] Source: Expert opinion, Burgoynes.

Figure 90: Ignition of the door sill (1)[62]

Finally, the door sill was laid flat on the floor and the plastic drop applied to it permanently. The plastic under the drop had burnt through after about four minutes and it became apparent that the fire had now taken hold of the door sill so comprehensively that it would no longer extinguish alone (see ***Figure 91****).*

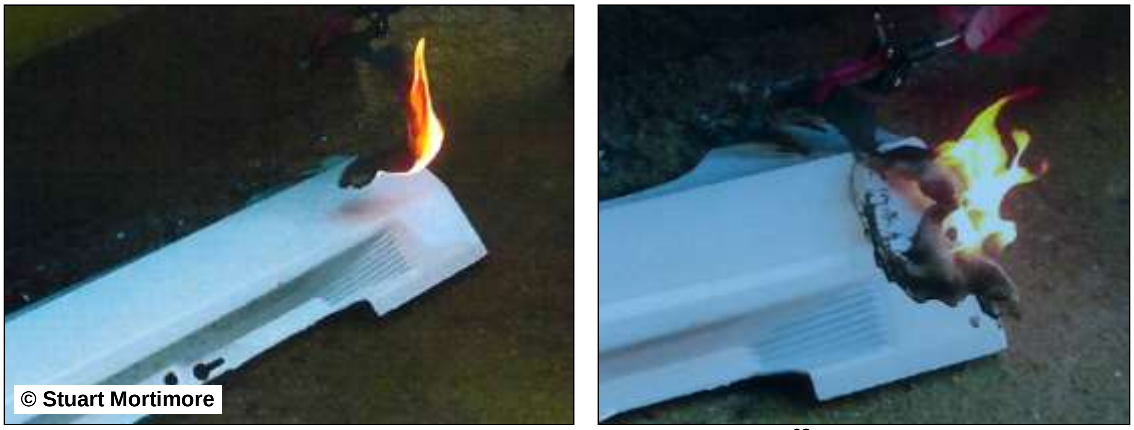

Figure 91: Ignition of the door sill (2)[63]

[62] Source: Expert opinion, Burgoynes.
[63] Source: Expert opinion, Burgoynes.

3.2.3.4.6 *Possibility that the fire started due to a tarpaulin igniting*[64]

*The area outlined in yellow at the top right of **Figure 78** above indicates a hydraulic ram in the vicinity of the fourth and fifth vehicle rows, which is needed for raising and lowering the segments of vehicle deck 3 B. To protect the vehicles stowed in the immediate vicinity of this hydraulic ram from oil spills escaping from the ram system, tarpaulins are hung above the vehicles stowed in the areas in question (see **Figures 92 f.** below). These tarpaulins are coated with an exchangeable absorbent textile layer.*

Figure 92: Example of the hydraulic ram beneath the ceiling of deck 3 B[65]

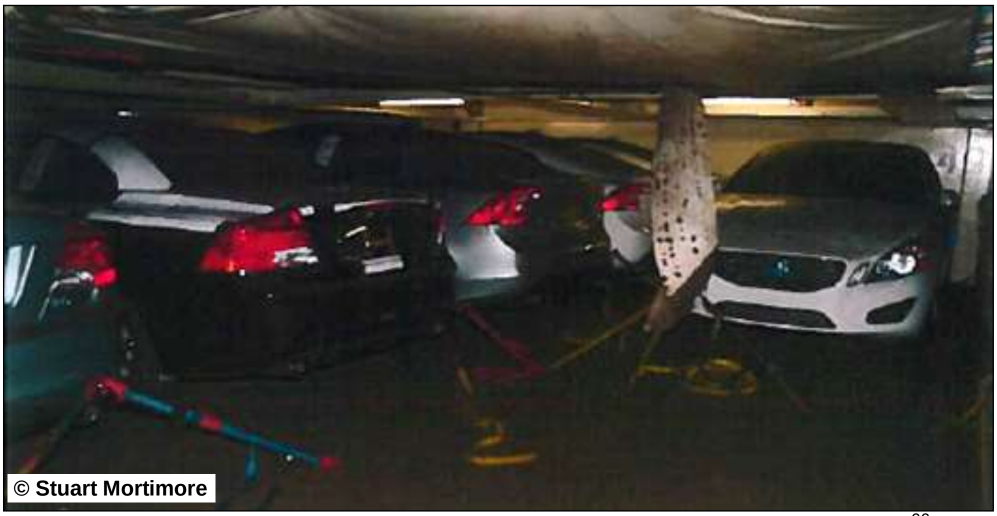

Figure 93: Example of the tarpaulin beneath the ceiling of deck 3 B[66]

The expert examined whether a possible sparkover from a defective cable running above the tarpaulin could have led to the tarpaulin igniting and then to a propagating fire on the vehicles stowed below.

[64] Note by the BSU: see also the related comments and figures in section 3.2.3.3.2 above.
[65] Source: Expert opinion, Burgoynes.
[66] Source: Expert opinion, Burgoynes.

In the course of the tests, sparklers were ignited a small distance above the tarpaulin to simulate a sparkover. It was not possible to ignite the tarpaulin in this manner.


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Figure 94: Test setup to establish the flammability of a tarpaulin[67]

The expert stressed that if a cable overheated to temperatures beyond those of a sparkover because of an electrical fault, then this could result in molten metal dripping onto the tarpaulin, theoretically causing it to ignite. Heating to such temperatures due to an electrical fault would require an extremely high flow of electricity through the cables. At the time of the accident, the flow of electricity on board the ship was reportedly very low, however. What is more, its effects would diminish because of the distance between the power generator and the area of the ship affected by the fire.

3.2.3.4.7 *Inspection of the vehicles*

During the period 26 August to 2 September 2013, the nine cars most severely affected by the fire underwent a detailed inspection at the manufacturer's plant in Sweden with the involvement of various experts.


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Figure 95: Inspection of the cars at the manufacturer[68]

[67] Source: Expert opinion, Burgoynes.
[68] Source: Expert opinion, Burgoynes.

The vehicles were positioned in the inspection shop in the same way as they were stowed on board. Proper allocation of the positions was made possible using the vehicle identification numbers, which were stamped on the chassis and still legible.

With the exception of one car, an ignition key was found in each vehicle (see ***Figure 96****).*

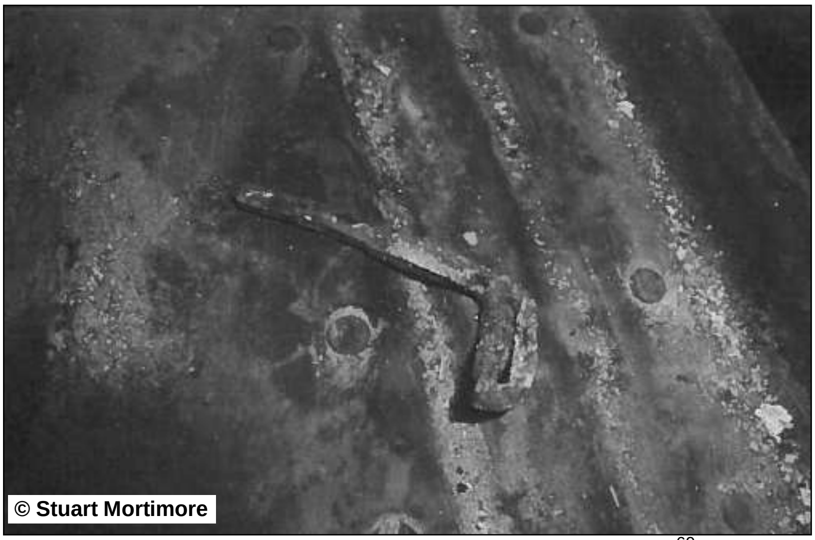

Figure 96: Remains of a vehicle ignition key[69]

Using the specific fire traces on each vehicle, the experts attempted to determine which vehicle could have burst into flames first. The expert appointed by the owner enclosed the image below with his opinion to illustrate the findings (see ***Figure 97****), but to that extent stressed that this only concerns his subjective assessment and a simplified graphic representation. Consequently, definitive conclusions on the actual course of the fire spread between individual vehicles could not be drawn from the image.*

[69] Source: Expert opinion, Burgoynes.

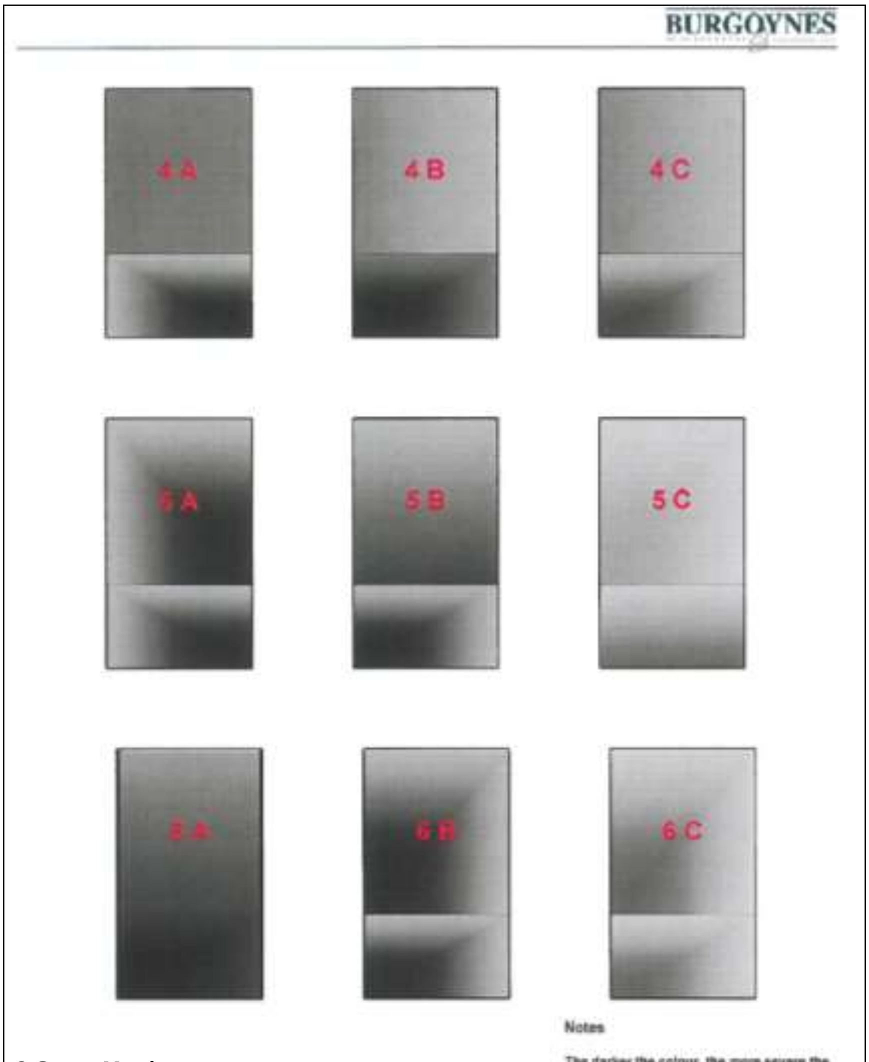

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Figure 97: Fire spread patterns relating to the nine cars that had suffered the most destruction[70]

The vehicle inspections focused on a search for indications of fire caused by a fault in the electrical system of a vehicle. To this end, the routing of the electric wiring in the vehicles, the fuse boxes, and the central electronic modules (or their remains) were examined thoroughly.

During this inspection, the expert appointed by the owner of the ship identified arcing activities in the electrical system of various vehicles and reproduced his observations in the chart below (see ***Figure 98****).*

(Expert's explanation of the term arcing activity: "If two electrical conductors at different voltages come into contact or very close proximity of one another, a very bright flash of light is created, which is known as an electrical arc.

[70] Source: Expert opinion, Burgoynes.

Such an arc produces extremely high temperatures, typically of about 2,000°C, which can cause metal conductors to melt and vaporise. The metal conductor melts at the point at which the arc forms and little balls of molten metal are catapulted from the arc. This causes the conductor from which the molten metal comes to lose some mass, resulting in a notch developing in the conductor. This notch and the resolidified balls of molten copper that are visible once the arcing ceases are typical signs of arcing activity."

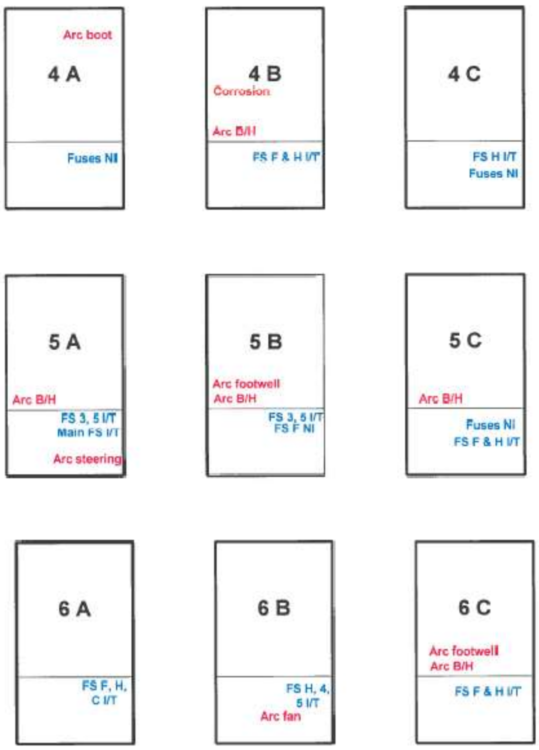

Figure 13:

A diagrammatic representation of the signs of the effects of electrical arcing activity that was found on the nine cars that were examined.

Notes for Figure 13

Arc boot	Arcing on a cable near a fuseboard in the boot
Arc steering	Arcing on cable to hydraulic power steering unit
Arc footwell	Arcing on cables in passenger footwell
Arc fan	Possible arcing at fan control relay
Arc B/H	Arcing at the bulkhead, where cables pass through the fire barrier between the engine compartment and the passenger compartment
Corrosion	Part of the cable loom has corroded totally to (probably) copper chloride
FS F & H I/T	Fuses for fan and steering hydraulic pump intact
FS F, H, C I/T	Fuses for fan, steering hydraulic pump and central control module intact
FS F NI	Fan fuse not intact
FS H I/T	Steering hydraulic pump fuse intact
FS H, 4, 5 I/T	Fuse H (steering hydraulic pump), 4 and 5 (central electronic module relay units) intact
Fuses NI	Fuses 1 to 5 and main battery fuse not intact
FS 3, 5 I/T	Fuses 3 and 5 intact: 3 serves the fuseboard in the boot and 5 serves part of the central electronic module relay units
Main FS I/T	Main battery fuse intact

Figure 98: Overview of the identified arcing activities[71]

[71] Source: Expert opinion, Burgoynes.

Figure 99: Burnt out engine compartment (example)[72]

Figure 100: Burnt out passenger compartment (example)[73]

[72] Source: Expert opinion, Burgoynes.
[73] Source: Expert opinion, Burgoynes.

Figure 101: Burnt out boot (example)[74]

The expert appointed by the owner cited ***Figures 102 f.*** *below in his opinion as evidence of arcing activities caused by electric current.* ***Figure 102*** *relates to the area of the cable run between the passenger and engine compartments of vehicle 4 B.*

Figure 102: Example of arcing activity caused by electric current (1)[75]

[74] Source: Expert opinion, Burgoynes.
[75] Source: Expert opinion, Burgoynes.

***Figure 103** below is intended to demonstrate arcing activity in the engine compartment of vehicle 5 A caused by electric current.*

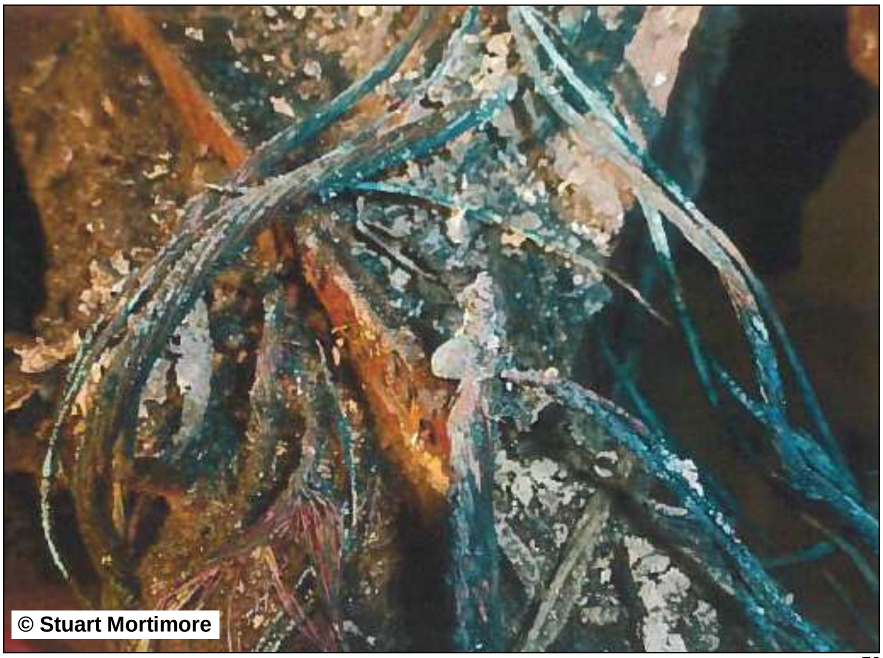

Figure 103: Example of arcing activity caused by electric current (2)[76]

In the course of the detailed inspection of the vehicle fuse boxes, during which partly intact but largely destroyed fuses were found, it was not possible to determine whether the fuse elements, which melt at temperatures upwards of about 200°C, were destroyed by the effects of electricity or as a result of the fire on the vehicle deck.

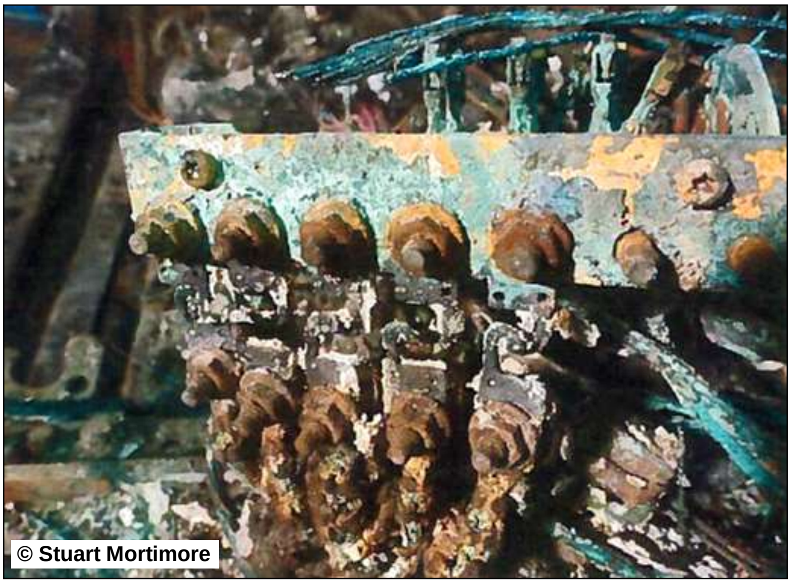

Figure 104: Close-up of the fuse box in the engine compartment of vehicle 5 A[77]

[76] Source: Expert opinion, Burgoynes.
[77] Source: Expert opinion, Burgoynes.

*The main boards on the central electronic modules from all the vehicles were also disassembled and examined. All the boards were severely damaged (see **Figure 103**). Nevertheless, the expert appointed by the owner believes that the destruction pattern of the boards belonging to vehicles 4 B, 4 C, and 5 C is consistent with the effects of arcing activities between the layers of the boards. (see **Figure 106**).*

Figure 105: Disassembled main boards from the automotive electronics[78]

Figure 106: Main board from vehicle 4 B[79]

The expert appointed by the owner summarised his findings as follows:

- *The information given by the witness, stating the fire on deck 3 B reportedly broke out in the forward area of vehicle 4 B, is consistent with the traces found on it and the other cars that were worst affected by the fire.*

[78] Source: Expert opinion, Burgoynes.
[79] Source: Expert opinion, Burgoynes.

- *All the potential sources of ignition in the vicinity of this and/or other vehicles stowed on the deck can – with the exception of a criminal act – be ruled out as the cause of the fire following the investigations carried out.*
- *Consequently, the only fire cause open to consideration is an electrical fault inside vehicle 4 B. The strong evidence found in support of such a fault does not permit conclusions as to its actual technical cause, however.*

3.2.3.5 Concluding opinion of the expert appointed by the BSU

3.2.3.5.1 Preliminary notes

The BSU instructed its appointed expert to evaluate the conflicting statements put forward by the owner and the cargo interest in respect of the cause of the fire originating from a car or the ship.[80] Edited extracts of his statement of 3 December 2014 made in this connection, which also contains concluding observations concerning the aspects of fire detection and firefighting, are reproduced below.

3.2.3.5.2 Development and cause of the fire[81]

All the relevant records refer to a relatively extensive propagation of temperature on the floor of the main deck. There is talk of "the deck feels hot", heat-related discolouration and peeling paint, for example. The expert appointed by the BSU believes this is indicative of an open fire on the underlying deck 3 B, and not of a cable fire. The cable routing runs directly beneath the main deck. Consequently, an extensive flame and thus broad thermal effects cannot develop. A sharply delineated zone along the cable racks would have been evident at most.

One other fact opposes the cable rack fire scenario. Fires in the cable routing form inside the bunch and always within the cable. As a result, a predominantly smouldering fire forms, which develops at very low temperatures. The extensive heating of the deck is more representative of a spontaneous event, such as a flashover from an initial fire with the development of a flame, as with a car fire. The acute build-up of smoke beneath the ceiling described is also an indication of a fire developing in the lower part of the cargo deck.

[80] Note by the BSU: the opinion prepared on behalf of Volvo Car Corporation by Dr James M. Knox (see section 3.2.3.3.3 (b) above) was not the subject of the final observations of the expert appointed by the BSU.
[81] The abridged, reproduced comments of the expert appointed by the BSU are shown in italics.

Figure 107: Cable harness above the seat of the fire; uniform fire exposure

All the cable harnesses exhibit typical patterns of an external ignition. There are hardly any open wire strands or droplets visible.

Figure 108: Cable routing above car 4 B

Similarly, the destruction patterns visible in ***Figures 109 ff.*** *below indicate that the fire developed from a car towards the ceiling and not the other way round from the ceiling towards the car.*

Figure 109: Car 4 C below the cable rack with fire pattern from the engine compartment

Figure 110: Incompletely burnt cable insulation above car (shielded by the roof of car 4 C)

The location of the seat of the fire was clearly classified as slots 4 A/B/C, 5 A/B/C, and 6A/B/C. In all likelihood, the location of the seat of fire was at the car on slot 4 B.

Figure 111: Car 4 B (the car destroyed by the fire most severely and thus the most likely location of the seat of fire)

The expert appointed by the BSU does not concur with the theory that defects or technical faults in the ship's wiring may have caused the fire. In his view, there is not sufficient evidence for such a presumption. For example, it was reportedly not proven that defects found in the wiring after the fire, which had raged for several hours without the use of extinguishing agents, were even partially existent before the fire.

In the view of the expert appointed by the BSU, the traces of green corrosion at certain areas of the wiring cannot be interpreted as evidence of earlier damage on the cable routing. The expert was unable to find extensive traces of green corrosion in or outside the vicinity of the fire during the surveys on 3 and 6 May 2013. Moreover, salt from the air does not react with copper in that form. The expert concurs with the expert appointed by the owner that the green covering originates from the fire event.

Burning PVC (primary constituent of the cable insulation) produces gaseous hydrogen chloride, which in combination with water or humidity forms hydrochloric acid. Inter alia, copper chloride forms on the copper cores exposed by fire, which turns into basic copper(II) chloride during subsequent oxidation. The compound is highly hygroscopic. The bound crystallisation water produces green salt crystals.

*The salt (NaCl) and copper compound shown in **Figure 112** below is merely the product of simple electrolysis in the laboratory.*

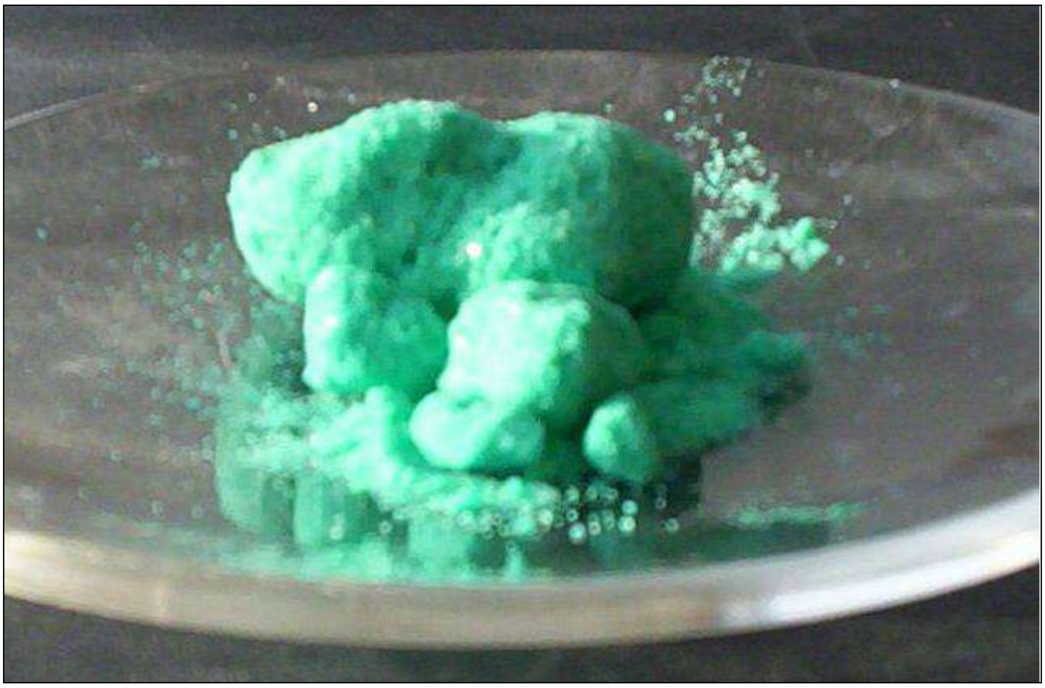

Figure 112: Copper(II) chloride dihydrate $CuCl_2 \cdot 2 H_2O$

The crystallisation water dissolves at temperatures upwards of 100°C and Cu Cl_2 forms again. Such traces are usual for cable routing after exposure to fire and consequential destruction of the insulation.

Similarly, the loops and kinks found at places in the vicinity of the fire are caused by the ignition of fixed cable harnesses, in particular. The reason for this is the inconsistent expansion of copper, steel, and, for example, PVC when exposed to temperature. This expansion is marked by the inconsistent longitudinal expansion coefficient. The formation of these loops is another possible indication of the ignition of the cable harnesses from outside, and not a fire event directly within the cable harnesses. A smouldering fire in a cable harness leads to the formation of hot spots. In the present case, the damage pattern on the cables is uniform across the entire length, however. This implies an expansive exposure to temperature that is relatively constant and persistent for a prolonged period due to convection, heat radiation or direct contact with flames from outside or below as a result of the propagating fire at the cars, for example. In terms of length, the expansion of the loops is consistent with the theoretical values in practice.

Longitudinal expansion on a 10 m cable length	1,000°C plastic and liquid fire	1,500°C metal fire on the cars beneath the cable routing
Copper	0.16 m	0.24 m
Steel	0.13 m	0.19 m

The expert appointed by the BSU also considered the impact of inconsistent conductor cross-sectional areas. It is clear that precise conductor cross-sectional areas are of huge importance in the medium-voltage range, in particular. These

heavily loaded cable connections are found on ships in the area between generator and main switchboard, as well as various large consumers, such as winches and transverse thrusters, etc. The cross-sectional areas are laid down in the rules for classification and construction.
The reduction of a cross-sectional area alone does not pose a hazard and is common practice in all secondary distributions. As long as the cross-sectional area corresponds with the maximum electrical load, the transition point is not vulnerable. Connections made using clamps or heat shrinkable tubing are also state of the art.
Moreover, the expert points to the fact that only the lighting circuit was under load (at 220 V) in the relevant area at the time the fire broke out. Under normal conditions, the currents flowing here are hardly capable of causing even 'only' two 1.5 mm³ conductors to become 'red hot'.

Another fact that opposes the presumption of a cable fire is the fire performance of overloaded cable harnesses. The overload and thus overheating first melts the inner layer of the insulation. After that, softening agents and flammable gases from the main insulation can diffuse and possibly ignite. This requires a relatively high activation energy. When the insulation of the internal cores starts to melt, the phases touch one another relatively quickly, resulting in a short circuit and an immediate drop in voltage. The affected cable loses its energy (no current flow) and thus its temperature immediately. In most cases, especially in voltage ranges up to 220 V and the relatively low core cross-sections (and thus low heat storage capacity), pyrolysis in the insulation is halted abruptly and even active (fledgling) cable fires extinguish.

3.2.3.5.3 Scenarios for the development of the fire from the perspective of the expert appointed by the BSU

Scenario 1
Ignition of a car due to a cable fire above the vehicle at a distance to the roof of about one metre:

The likelihood of a section of cable routing igniting is low. The energy produced when single cables ignite is not sufficient to ignite the low fire load (paint) on the body through heat radiation.
Possibly burning droplets of parts of the insulation are also unlikely, as the materials tend to char. Furthermore, the ambient temperature would not sustain combustion of the particles on the body or possibly the plastic parts (at the front and rear of the vehicles, in particular).

Broken cable ends, which may have caused arcing activity on the vehicle when energised, are not evident.
Defects and consequential burning droplets from any parts of a lamp are very unlikely to cause a fully developed fire on a car, especially since the lamp parts between vehicles 4 B and 4 C had fallen off in the rear area. The pattern of damage (complete destruction of the entire vehicle, in particular, of the engine area due to metal fire on both vehicles) would be difficult to derive from that.

Scenario 2

Disregarding the possibility of arson, which cannot be discounted, all that remains as the cause and source of the fire from the perspective of the expert appointed by the BSU is the car.

The following facts support this more probable scenario:

- *the modern, new vehicles had been switched to so-called transport mode[82]. Consequently, the vehicle electrical system was energised. Locking units, steering hydraulics, ventilation, central electronic module, and interior lighting remained energised;*
- *malfunction in the electrical system and/or related effects from the outside thus represent an increased risk of fire. For example, an improperly closed door or boot lid activates the interior lighting, which can lead to the central electronic module and/or the bulb in the ceiling lining overheating. Ensuing discharge processes in the battery can also lead to a hot spot in the engine compartment;*
- *movements of the ship, in particular due to a berthing/casting off manoeuvre or swell can lead to chafing of cable runs and thus arcing or short circuits in the vehicle, and*
- *the presence of fuels and lubricants in the tanks and systems of vehicles increases the risk potential*

3.2.3.5.4 Fire detection

The expert appointed by the BSU regards as questionable the only sparse inspections of deck 3, which had been disconnected from the smoke detection system due to the welding operations. In his opinion, permanent monitoring is required on a deck where the detector lines have been disabled in entire areas. Even though no hot work was carried out on deck 3 B, the vulnerability resulting from the detector lines being switched off should have been compensated. Safety inspections carried out at short intervals or better still a permanent monitoring of the area would have been a safe way of achieving this. Normally, only the detectors in the direct vicinity of the hot work are disabled, as the workers present can continuously monitor their work area.
The expert appointed by the BSU refutes the possible argument that there was no particular risk situation in the vicinity of the seat of fire as regards the emergence of a fire. Ro-ro cargo holds correspond with the IMO classification 'Special Category'. Here, the particular risk arises from the full vehicle tanks alone. The fire event on board the ship has vividly demonstrated the abstract risk situation posed by a ro-ro deck laden with vehicles.

Although the limited controls and thus limited monitoring of deck 3 B cannot be regarded as the cause of the fire, the expert appointed by the BSU believes it is highly likely that earlier detection of the fire in conjunction with resolute efforts to fight it quickly would have reduced the extent of the damage.

[82] The manufacturer-specific 'transport mode' is enabled in the manufacturer's plant and should ensure that the vehicle's battery is protected against self-discharge in transit and during any prolonged periods of storage as far as possible. To this end, the vehicle's power supply is reduced to minimum functionality, so that only short distances can be covered in the vehicle when in 'transport mode'. Before delivery to the end customer, transport mode is disabled by the dealer using a special programming unit and the vehicle is permanently set to 'normal mode' electronically.

3.2.3.5.5 Firefighting operation

The expert appointed by the BSU believes that not initiating use of the ship's CO_2 *low-pressure storage system shortly after the discovery of the fire is the most serious failing subsequent to the fire event. Late use of the* CO_2 *merits criticism of the ship's command only partially, however. Their control of the situation ended when the Hamburg fire services arrived on board the ship. The operational command initially focused its activities on a conventional extinguishing action on deck 3. Apart from the cooling efforts, effective firefighting or containment did not happen during the period of time wasted due to this prioritisation. Moreover, smoke and heat in the vicinity of the fire was able to spread unhindered. It can be assumed that the metal fires on the vehicles also developed during this period. It was only possible for the fire to spread fully to adjacent vehicles as a result of that.*[83]

3.2.3.6 Dangerous cargo on board the ship

3.2.3.6.1 Preliminary notes

The investigation of the possible causes of the fire on the ATLANTIC CARTIER yielded no evidence of a link between its outbreak and the dangerous goods containers stowed on board. Moreover, no material significance was attributed to the dangerous goods containers in respect of the spread of the fire. The risk of excessive heating of or even the spread of fire to the dangerous goods containers stowed in the vicinity of the ro-ro deck primarily affected by the fire (3) was accounted for by the precautionary decision of the fire services to remove the relevant containers from the ship, which was executed successfully.

Although the dangerous cargo carried by the ATLANTIC CARTIER had no effect on the formation or course of the ship fire, this aspect received the widest attention from the public and local policymakers after the accident.
In particular, this was triggered by the fact that ammunition, rocket fuel, and radioactive material were among the dangerous materials carried. The Senate, i.e. government of the Free and Hanseatic City of Hamburg, was confronted with various so-called 'short written questions' concerning this issue from individual members of City Parliament and answered them at length.[84]

It is the opinion of the BSU that its legal mandate does not extend to adopting a position on discussions held at political level and the questions of principle on such issues as nuclear waste and/or weapons transport, for example, raised in the process. In principle, aspects of emergency management or the equipment of the Hamburg fire services, for example, are not among the issues the BSU would consider in the course of a marine casualty investigation, either. The following comments in the investigation report are therefore limited solely to specialist or technical information obtained in connection with the dangerous goods containers carried by the ATLANTIC CARTIER.

[83] Note: as regards the action taken to fight the fire and its assessment by the BSU, in particular, see the comments in section 4.2.3 of the investigation report.
[84] See, inter alia, City Parliament of the Free and Hanseatic City of Hamburg, 20th legislative period – printed matter 20/7891; 20/8035; 20/8053; 20/8078; 20/8082; 20/8113; 20/8123; 20/8219; 20/8289; 20/8299; 20/8838

3.2.3.6.2 Schedule of the dangerous goods carried

The BSU had two different sources at its disposal for the investigation of the dangerous cargo on board the ATLANTIC CARTIER. One was a table of the ship management sent to the SHK, the other a list that the Hamburg Senate published in response, inter alia, to a related short written question from a member of the City Parliament of Hamburg.[85] The source of the latter list is – as far as is evident – the so-called Dangerous Goods Information System (GEGIS) for the Port of Hamburg.[86] Material information from the two sources has been set against each other in the following table.

[85] See printed matter 20/7891, response of the Senate dated 17 May 2013 to the short written question of Dr Anjes Tjarks MP (GREENS) dated 6 May 2013.

[86] The GEGIS is internet and database driven software for the registration, safety and monitoring of dangerous goods. The system gives the waterway police and fire services an accurate and up-to-the-minute overview of all movements of dangerous goods to, in and from the port area. (See http://www.dakosy.de/loesungen/gefahrgutabwicklung/gegis.)

Seq. No.	Position	Dangerous goods class | UN No.		Weight (kg)		Technical name (according to the Senate's list)
		Owner's data	Senate's data	Owner's data	Senate's data	
1	01 04 82	1.3 C | 0499	1.3 | 0499	5,500	2,589	PROPELLANT, SOLID
2	01 04 84	1.2 C | 0328	1.2 | 0328	1,900	1,620	CARTRIDGES FOR WEAPONS, INERT PROJECTILE
3	14 02 84	3 | 1263	3 | 1263	29,900	1,335	PAINT
4	14 02 86	4.1 | 1325	4.1 | 1325	23,800	19,823	FLAMMABLE SOLID, ORGANIC, N.O.S.
5	14 04 84	4.1 | 1325	4.1 | 1325	23,800	19,824	FLAMMABLE SOLID, ORGANIC, N.O.S.
6	21 07 82	7 | 3327	7 | 3327	12,800	10,800	RADIOACTIVE MATERIAL, TYPE A PACKAGE, FISSILE
7	21 07 84	7 | 3327	7 | 3327	3,800	1,800	RADIOACTIVE MATERIAL, TYPE A PACKAGE, FISSILE
8	22 01 R1		7 (8) | 2977		8,886	RADIOACTIVE MATERIAL, URANIUM HEXAFLUORIDE, FISSILE
9	22 03 84	9 | 3166	9 | 3166 2.1 | 1950	19,300	1,730 13	VEHICLE, FLAMMABLE LIQUID POWERED AEROSOLS
10	22 03 88	9 | 3166	9 | 3166	12,500	754	VEHICLE, FLAMMABLE LIQUID POWERED
11	22 04 84	3 | 1263	3 | 1263 3 | 1866	19,000	153 33	PAINT RESIN SOLUTION
12	33 05 82	6.1 | 2922	8 | 2922	21,200	19,000	CORROSIVE LIQUID, TOXIC, N.O.S.
13	33 06 82	8 | 2922	8 | 2922	22,500	19,000	CORROSIVE LIQUID, TOXIC, N.O.S.
14	33 06 88	9 | 3077	9 | 3077	10,900	8,520	ENVIRONMENTALLY HAZARDOUS SUBSTANCE, SOLID, N.O.
15	35 01 82	3 | 1170	3 | 1170	24,200	20,000	ETHANOL
16	35 01 84	3 | 1170	3 | 1170	24,200	20,000	ETHANOL
17	35 01 86	3 | 1170	3 | 1170	24,200	20,000	ETHANOL
18	35 01 88	9 | 2211	9 | 2211	11,600	9,400	POLYMERIC BEADS, EXPANDABLE
19	35 02 82	3 | 1170	3 | 1170	23,000	20,000	ETHANOL
20	35 02 84	3 | 1170	3 | 1170	23,200	20,000	ETHANOL
21	35 02 86	3 | 1170	3 | 1170	23,100	20,000	ETHANOL
22	35 02 88	6.1 (3) | 2334	6.1 | 2334	11,000	5,490	ALLYAMINE
23	35 03 82	3 | 1170	3 | 1170	24,200	20,000	ETHANOL
24	35 03 84	3 | 1170	3 | 1170	24,200	20,000	ETHANOL
25	35 03 86	3 | 1170	3 | 1170	24,200	20,000	ETHANOL
26	35 04 82	8 | 2735	8 | 2735	24,600	20,240	AMINES, LIQUID, CORROSIVE, N.O.S.
27	35 04 84	8 | 2735	8 | 2735	24,900	20,240	AMINES, LIQUID, CORROSIVE, N.O.S.
28	35 04 86	8 | 2795	8 | 2795 8 | 1814	18,600	10,422 1,902	BATTERIES, WET, FILLED WITH ALKALI POTASSIUM HYDROXIDE SOLUTION
29	35 06 84	8 | 2795	8 | 2795	18,900	16,575	BATTERIES, WET, FILLED WITH ALKALI
30	35 06 86	8 | 2795	8 | 2795	14,900	12,853	BATTERIES, WET, FILLED WITH ALKALI
Seq.	Position	Dangerous goods class |		Weight (kg)		Technical name

No.		UN No.				(according to the Senate's list)
		Owner's data	Senate's data	Owner's data	Senate's data	
31	38 08 88	3 | 1266	3 | 1266	8,900	5,557	PERFUMERY PRODUCTS
32	41 07 82	9 | 3082	9 | 3082	22,300	20,000	ENVIRONMENTALLY HAZARDOUS SUBSTANCE, LIQUID, N.O.
33	43 07 82	9 | 3082	9 | 3082	23,000	20,000	ENVIRONMENTALLY HAZARDOUS SUBSTANCE, LIQUID, N.O.
34	43 08 82	9 | 3082	9 | 3082	22,700	20,000	ENVIRONMENTALLY HAZARDOUS SUBSTANCE, LIQUID, N.O.
35	46 03 82	1.4 G | 0503	1.4G | 0503	25,700	860	AIR BAG MODULES
36	46 03 88	1.4 S | 0012	1.4S | 0012	14,200	2,167	CARTRIDGES FOR WEAPONS, INERT PROJECTILE
37	46 04 82	8 | 1823	8 | 1823	22,900	18,864	SODIUM HYDROXIDE, SOLID
38	50 11 84	5.2 | 3104	5.2 | 3104	17,700	33	ORGANIC PEROXIDE TYPE C, SOLID
39	54 10 82	2.2 | 3164	2.2 | 3164	24,000	4	ARTICLES, PRESSURIZED, PNEUMATIC
40	54 10 84	2.1 | 1950	2.2 | 3164 2.1 | 1950	17,400	240 240	ARTICLES, PRESSURIZED, PNEUMATIC AEROSOLS

A comparison of the data in the table makes it evident that there are considerable inconsistencies between some of the weights, in particular. In the preliminary notes to its response to a short written question, the Senate of the Free and Hanseatic City of Hamburg commented that the quantities it has published are all the gross tank weights including respective dangerous goods. Inasmuch, it is surprising that in each case the weights provided by the owner are higher (some considerably). As regards the stowed uranium hexafluoride at item 22 01 R1[87], which must be rated as particularly dangerous and is not included in the owner's list, the actual amount of dangerous goods is put into perspective according to information from the carrier responsible insofar as of the gross weight of 8.9 tonnes, only 10.3 kg is actually accounted for by the aforementioned radioactive substance, which, in turn, corresponds to a uranium volume of 6.964 kg. This concerns a residual amount in four empty uncleansed tanks (heels) on a 20-foot flat container.[88]

In respect of the dangerous goods quantities stated, regardless of the question as to whether the weights of the tanks were not included in the list, it remains to be noted that the quantities provided differ very considerably in places. It is impossible to attribute this solely to the inclusion or exclusion of the tank weights.

With regard to the items shown in purple in the table above, these are seven dangerous goods containers that remained on board the ATLANTIC CARTIER after

[87] Note: In contrast to counting by bay, row (row in the longitudinal direction of the ship) and tier (stacked), as is usual for traditional container slots, the (atypical) stowage of the container in question on ro-ro deck 1 is referred to as 'R1'.
[88] See printed matter 20/8053, response of the Senate dated 28 May 2013 to the short written question of Dr Anjes Tjarks MP (GREENS) dated 21 May 2013.

the removal of the dangerous cargo from the ship, initiated in the course of fighting the fire, was completed at 0335 on 2 May 2013.

In addition to differing quantities and the absence of uranium hexafluoride (or the tanks contaminated with residues thereof) in the list of the ship management, there are five further substantive discrepancies in the two lists (see the rows marked orange in the table above).

Against the backdrop of the dangerous goods containers being neither the cause of, nor otherwise playing a material role in the fire, determining the reasons for the inconsistencies in the reported data would have been beyond the scope of this report. Nevertheless, the competent bodies should investigate the issues raised.

3.2.3.6.3 Registration of dangerous goods/compliance with the stowage and segregation requirements

The dangerous goods on board the ATLANTIC CARTIER were registered in the Hamburg police's Dangerous Goods Information System on time before reaching the Port of Hamburg. During an inspection of the pre-registration on the morning of the day of the accident, the waterway police found that incomplete information had been provided for four containers. The slot position was missing for two tank containers (Dangerous Goods Class 8 – Corrosive Substances – UN 2922). Although maximum radioactivity was noted for two Class 7 (Radioactive Material – UN 3327) containers, the actual radioactivity was not specified.

Apart from the aforementioned inconsistencies and failings, the manner in which the dangerous goods were carried on board the ATLANTIC CARTIER does not merit any criticism. The stowage and segregation requirements of the IMDG Code[89], which has binding effect internationally, were complied with to the full.

[89] IMDG Code: **I**nternational **M**aritime Code for **D**angerous **G**oods.

4 Analysis

4.1 Discovery of the fire

It is very likely that the fire was only discovered with some time delay because certain zones of the smoke detection system, including that of deck 3 B, had been disabled on the day of the accident. The information gained by the BSU in relation to the first observations of smokiness and the implementation of safety inspections does not permit any definitive conclusions as to the time at which the fire in the forward part of the vehicle deck in question actually began to develop.
Uncertainty prevails even in respect of the time of the first observation of smokiness on the upper deck. While 1925 is recorded for the corresponding specification in the deck log book, the relevant witness first stated that he reportedly noticed the smoke at about 1930 when he made his way to the fore section to make a phone call. During another interview, he and other witnesses estimate the time of the discovery of smoke to be "just gone 1900." There is also no precise and verifiable information available with regard to the question as to when exactly the last safety inspection was made on vehicle deck 3 B. Even if it is assumed that the deck in question was actually last inspected at about 1830 with no particular observations made, this does not reliably clarify that the fire was not developing at this point.

4.2 Firefighting

4.2.1 Activities of the staff of the welding team

The exact chronological and thematic sequence of the first firefighting attempts by individual members of the welding team could not be clarified with absolute certainty in the course of the BSU's investigation, either. Indeed, the statements regarding this, according to which a staff member claimed that he initially tried to fight the fire with an extinguisher and after failing in his efforts reportedly carried out an extinguishing action by means of a firehose connected to an *unpressurised* hydrant together with a colleague appear credible, in principle. In particular, the chronological sequence and the duration of the described efforts are questionable, however.

Setting aside the now unresolvable questions of detail, from the perspective of the BSU it is highly problematic that people on board the ship – who evidently have no in-depth knowledge of extinguishing ship fires (and need not have, either) – attempt to fight a fire on their own initiative, especially one in a cargo hold. Although at first glance it may seem 'heroic' that these particular members of the welding team wanted to prevent the spread of the detected fire as soon as possible, by so doing, they exposed themselves to a more or less unpredictable risk situation unnecessarily.

4.2.2 Activities of the crew

It was not possible for the BSU to verify the information provided by the ship's command regarding the time the fire alarm sounded and ensuing decision-making processes in every detail for lack of usable VDR audio recordings. Nevertheless, there is no reason to doubt that the ship's command actually sounded the fire alarm at about 1930 and immediately and – as far as is evident – systematically began to make the necessary preparations for a conventional extinguishing action. The

withdrawal of the extinguishing team owing to the rapid build-up of smoke and heat and the almost simultaneous emergency call by phone to the fire services at 2001 are credible and the phone call objectively confirmed.
It was not possible to clarify the question of why the ship's command did not focus its efforts on closing the starboard sliding door so as to isolate the seat of fire as soon as possible and then put out the fire in the most efficient and safest way possible for the crew by means of the CO2 extinguishing system from the outset and before the arrival of the fire service, in particular, instead of on a conventional extinguishing action.

4.2.3 Activities of the fire services

After reaching the ship at 2012 and the failure of an immediately initiated first attempt at a conventional extinguishing action, the Hamburg fire services very quickly and on several occasions escalated the internal alert levels and started to mobilise gradually a large number of shore and water-based support units and operational equipment.

As far as the BSU could determine retrospectively, the fire service's main focus was initially to expand significantly the cooling activities that had already been set in motion on board and were still ongoing, and to establish and secure access points suitable for pushing forward to the seat of the fire. The fire service apparently did its utmost to fight the fire in the cargo hold by conventional means, i.e. by deploying extinguishing teams, to begin with.
Here, the operational command liaised with the ship's command and familiarised itself with the structural conditions of the ship and possible theoretical and practicable access routes. Moreover, it considered such aspects as the specific risk posed by the dangerous goods stowed on board. Consequently, the removal of 33 dangerous goods containers stowed in the vicinity of the seat of fire was ordered and the first steps taken to achieve this at about 2308.

The question as to why the decision to use the shipboard CO2 extinguishing system, with which it was ultimately possible to fight the fire successfully, was only made at about 2230 could not be clarified in every detail with absolute certainty.

The ship's command stated in this regard that the fire service was reportedly made aware of the option of using CO2 as an extinguishing agent shortly after it arrived and its use was requested. It was claimed that its operational command did not follow this advice to begin with, however. After watertight integrity was established, the use of CO2 eventually opted for was reportedly delayed solely due to the lengthy headcount of the multitude of operational units the fire service had deployed on board.

By contrast, the fire service stressed the point, which was proven to correspond with the facts, that when it arrived on board the (starboard) sliding door on deck 3 and the mobile vehicle decks there were reportedly set in open connection and different levels. This meant the situation as regards possibly using the ship's CO2 extinguishing system was reportedly unclear to begin with. Consequently, the possibility and concern reportedly prevailed that the necessary CO2 concentration for inerting the cargo hold would not be reached due to vertical and horizontal openings

and that it would not have been possible to correct this subsequently because of the limited volume stored on board.
The fire service also noted that the ship's crew reportedly gave contradictory descriptions in respect of the location of the fire and the accessibility options via the vertical emergency exits, meaning specification would have first been needed in that regard, too. The attempt at investigation and firefighting via the emergency exits reportedly had to be aborted due to the build-up of heat. Isolation of the damage location using the (partially disabled) fire alarm system was reportedly not possible, meaning the fire service was reportedly unclear as to the exact location of the damage.

The BSU is not in a position to assess the significance of the partly conflicting arguments put forward by the ship's command and the fire service on the issue of delays in using the shipboard CO2 extinguishing system.
However, there is much to suggest that a complex set of different factors was responsible for the late decision to use CO2, which with a probability bordering on certainty definitely included the following:

(1) a rapid build-up of fire and smoke on board before the arrival of the fire service and ensuing uncertainty as to the exact location of the fire;

(2) uncertainty as to the prevailing watertight integrity and the scope of action required for effective and safe use of the CO2 extinguishing system

It is possible that linguistic and/or technical communication difficulties between the ship's command and the fire service's operational command also contributed significantly to the late decision in favour of the CO2 extinguishing action. The BSU is unable to provide objective evidence of this, however.

It is clear that the extensive cooling efforts carried out over a large area on deck, in the area of the deck cargo, and on the port side of the ship during the entire extinguishing action were highly effective. The fire service believes – and the BSU explicitly concurs with this – that the resulting heat dissipation countered successfully a further spread of fire below deck and structural failure, despite the long period in which the fire was fully developed on a number of cars at extreme temperatures. Also worthy of recognition from the perspective of the BSU is the fact that nobody was injured during the dangerous extinguishing action, which lasted the entire night and involved an array of operational units.

4.2.4 CO_2 extinguishing system

Use of the CO_2 extinguishing system was crucial to success in fighting the cargo hold fire. However, two problems occurred in connection with activating the system, which in addition to the late decision to use it resulted in further delays in fighting the fire.

4.2.4.1 Cordoning off the extinguishing zone

At first glance, it appeared to be entirely incomprehensible to the BSU why on a properly classified ship whose condition basically merits no criticism that it was not possible to close the starboard sliding door remotely from the bridge.

The relevant legal framework currently in force requires that it be possible to control watertight bulkhead doors by remote means.[90] However, since the ATLANTIC CARTIER was built in 1985, then lengthened in 1987 and not converted again in the sense of a major conversion after 1992, the regulations of SOLAS 74 on watertight doors in cargo ships, which do not include provisions for the possibility to control them by remote means, apply to the ship as regards construction requirements to be adhered to.

That the sliding door had to be operated directly at the scene meant not only that valuable time was lost until the watertight integrity necessary for the effective use of CO_2 was established, but also that the fire service personnel and a crew member's very difficult advance to the control panel at the sliding door exposed them to unnecessary risk.

The technical and cost-related input for retrofitting a remote control system for sliding doors on a ship should be manageable. With that in mind, the BSU believes it is highly questionable that the international community in the form of the IMO and SOLAS did not find it necessary to adopt mandatory retrofitting requirements for a design feature so important to damage stability and effective firefighting as remotely operated sliding doors.

4.2.4.2 Leakage in the control room

The fact that a leaking flange resulted in CO_2 escaping unintentionally in the CO_2 tank and control room when the installation was activated is difficult to understand. This is all the more true if we consider that the ATLANTIC CARTIER is a ship with very recently renewed certificates that is overseen by a highly regarded classification society and that has to be inspected on a regular cycle, also in respect of the serviceability of her CO_2 installation, which sails under a flag regarded as extremely safe.

4.2.4.3 Errors in the technical documents and labelling of components

The inspection of the CO_2 installation's technical documents threw light on several errors and inconsistencies. The shortcomings found were equally as irrelevant to the course of the accident as the multilingual, partly handwritten labels on certain components of the system. Nevertheless, it is difficult to understand that documents containing errors that go unnoticed for years or decades are used in relation to a shipboard system that has such relevance to safety and has to be inspected on a regular cycle of all things.

4.3 Fire causes

Given the findings of the investigation, the BSU is not in a position to make statements about the cause of the fire on board the ATLANTIC CARTIER that are firm in every respect and unequivocal.

At first glance, and even more so based on the findings and conclusions of the expert appointed by the vehicle insurer, it hardly seems a coincidence that the fire started to develop precisely in the area of transition between the fore section and the section

[90] See SOLAS Chapter II-1, Part B, Regulation 13-1(2).

inserted into the hull subsequently. Witness testimonies also support the idea that the ship was primarily responsible for the outbreak of fire. The testimonies indicates that firstly, the fire was detected in the form of a build-up of heat and smoke on the floor of the main deck, and secondly, immediately after, the flames on the car observed burning in the underlying vehicle deck were reportedly only local in the area of the engine compartment. This actually implies that the observed car fire was not the cause but merely the result of a previous build-up of heat originating from the ceiling of vehicle deck 3 B. Also the fact that despite detailed investigations, the experts, designated by various contracting authorities, who were investigating the cause of the fire, were unable to find irrefutable technical or factual evidence that the fire originated in a car, supports the assumption of a fire stemming from the ship, i.e. one caused by defects in construction or maintenance.

However, this theory can be opposed by the fact that there is no compelling evidence for a ship-induced fire, either. None of the experts who dealt with the subject matter was able to record evidence of a causal link between the connection of electric cables with different diameters and/or improper welding operations capable of damaging cable insulation prior to the accident on one hand, and the development of a fire on the other. Added to this is the fact that based on his visual findings and theoretical considerations, the expert appointed by the BSU countered the presumption that a cable fire in the ceiling of the cargo hold must reportedly have been the primary cause of the fire with an array of plausible arguments.

The welding operations carried out on the day of the accident can be largely discounted as the cause of the fire. This is subject to the condition that the information on the repairs that were scheduled and carried out is complete and correct, however. A comparison of the documents submitted in this respect revealed that on the day of the accident welding beyond the scope of the CRMS also took place in parts of the ship. Understandably, it was thus not listed on the respective repair plan but no other planning documents were provided for it, either. Be that as it may, neither the investigations of the various experts nor the witness interviews yielded evidence of unscheduled welding operations in the immediate vicinity of the actual seat of fire.

Moreover, the investigations yielded absolutely no evidence of arson. However, the expert appointed by the BSU did stress that this could not be ruled out as a possible cause of the fire, which is something the BSU concurs with explicitly.

Since there is no evidence of a fire caused by welding operations or other negligent or malicious human conduct on board the ATLANTIC CARTIER, with regard to the question of the cause of the fire, the BSU is limiting itself to the conclusion that both in relation to the ship and the cars carried, technical factors that are objectively capable of heightening the risk of a cargo hold fire could certainly be found, regardless of the fact that the BSU is unable to establish the actual cause of the accident.

Whether or which of these factors were ultimately actually responsible for the fire on board the ship on 1 May 2013 may be of huge significance in terms of liability legislation. Having said that, the legally defined focus of the BSU's investigation is solely to detect vulnerabilities and safety deficits on board ships so as to prevent identical or similar accidents in the future. That being the case, the BSU concludes the following with regard to identified and objectively avoidable risks that at least increased the risk of a cargo hold fire and its capability to develop further[91]:

a) Ship-based risk factors

aa) Crack formation and welding operations
The specific structural situation, which is marked by the fact that operation of the ATLANTIC CARTIER has continuously involved crack formation and the ensuing need for flammable welding operations on an ongoing basis since her entry into service and, in particular, since she was lengthened two years later, undoubtedly represents an indirect objective risk factor with regard to the outbreak of fire on board. This risk is raised further by the fact that in the course of many years it is hardly feasible that every worker employed with welding operations actually displays the special care required always, in every respect and everywhere. The traces of exposure to external heat on cables in the vicinity of welded joints are a clear indication of corresponding failings.

bb) Disabling parts of the smoke detection system/monitoring of the area
One risk factor directly related to the problem of frequent welding operations arises from the fact that to carry out such works parts of the smoke detection system are probably disabled regularly to avoid false alarms. In theory, it is possible to compensate for this risk factor through frequent safety inspections or better still permanent monitoring of the area. However, experience gained from practical ship operation tells us that in times when minimum safe manning is reduced to an absolute minimum and having regard to the pressure on crews, which is reflected in the number of hours of overtime worked, guaranteeing absolutely effective monitoring of the area seems hardly realistic with the personnel available.

cc) Electric wiring
Even though it was not possible to provide evidence of a causal link between the outbreak of fire and the cable splices installed in the course of the ship being lengthened, it is still beyond doubt that connecting different cable diameters can lead to overheating with subsequent smouldering under certain circumstances (if there is an excessive current flow due to a fault, for example).

dd) Tarpaulins
Finally, the common use of tarpaulins on board to prevent the contamination of vehicles stowed beneath hydraulic components due to leaking hydraulic oil or lubricants actually pose a two-fold risk factor. It is impossible to rule out that the spread of fire is first enabled or at least facilitated by parts of a tarpaulin that has ignited for whatever reason. This is compounded by the fact that hanging tarpaulins gives rise to a risk of detecting overlying flammable and other dangerous faults or initial signs of overheating in the areas in question considerably later than may have been the case if such a barrier was not there.

[91] Note: The order of the risk factors shown is **by no means** a prioritisation by the BSU for or against specific potential risks.

b) Risk factor posed by the cargo

Only new cars with conventional drive systems were stowed in the cargo hold primarily affected by the fire. In spite of the batteries installed in the vehicles, the various electrical and electronic components, and the presence of flammable fuels and lubricants, it is reasonable to rate the risk of spontaneous combustion in such brand new, properly stowed and secured cars as extremely low for both technical reasons and based on practical experience.
The cargo insurer noted in this context that some four million new Volvo cars have reportedly been transported around the world by sea, road, and rail in the last ten years and there has reportedly not been one single case of a vehicle spontaneously combusting. Moreover, knowledge of cases of a vehicle spontaneously combusting due to an electrical fault can reportedly not be derived from the manufacturer's recall operations for the vehicle types of relevance here.
Practical tests and the theoretical considerations of the expert appointed by the manufacturer also support the assumption that it is reasonable to rate the likelihood of one of the new vehicles in question spontaneously combusting as extremely low.
Nevertheless, the BSU takes the view that the possibility of a fault-induced overload in a vehicle's electrical system in combination with a series of several, possibly extremely unfavourable circumstances causing a fire cannot be ruled out entirely.

4.4 Dangerous cargo

With a probability bordering on certainty, the dangerous goods stowed on board the ATLANTIC CARTIER contributed neither to the fire starting nor spreading. The removal of most of the cargo in question from the ship prevented the spread of fire to the dangerous goods containers – caused by the immense heat radiation that built up in the course of the fire, for example.

However, it must be rated as highly questionable that almost three and a half hours passed between the arrival of the fire service and the discharge of the dangerous goods starting, especially in a centrally located and modern major port in Western Europe. The Zentralverband der deutschen Seehafenbetriebe e.V. (ZDS), Federal Association of German Seaport Operators, put this into perspective in its statement to the draft of this investigation report, pointing to the fact that the operational command's decision on discharging the dangerous goods containers was reportedly not taken until more than two hours had passed, meaning the period between decision and operational readiness of the dockers was reportedly one and a half hours.[92] Nevertheless, in respect of fighting and containing a fire effectively, the BSU believes that under certain circumstances even this 'shortened' period is not short enough given the speed and drama with which a fire is known to spread on board a ship, in the presence of dangerous cargo, in particular. Even in the case of a comprehensive break in work at a terminal due to a public holiday, it should still be possible for the port to organise a contingency system to enable the mobilisation of necessary personnel and equipment promptly when there is an unavoidable demand for cargo-handling operations.

[92] As regards the remarks of the Federal Association of German Seaport Operators, see also the comments in section 6.4 of the report.

As found in the past during the analysis of manifests in the course of other investigations, inconsistencies were noticed in respect of the dangerous goods stowed on board the ATLANTIC CARTIER, especially with regard to quantities. The BSU has abstained from investigating this aspect in detail for lack of an apparent correlation between these errors and the course of the accident. Regardless of the foregoing, it must certainly be noted that mistakes were evidently made in the declaration of the dangerous goods containers.

Due to the high risk potential of certain goods, making sure it is possible to combat risk based on actual characteristics and the exact quantity is of paramount importance, especially in the event of an accident. To achieve this, it is necessary that the ship's command and the competent shore-based bodies have cargo information at their disposal that is reliable in every respect from the outset.

5 Conclusions

5.1 Fire detection and firefighting

The fire on the ATLANTIC CARTIER must have evolved very quickly into the fully-fledged fire on ro-ro deck 3 B after an initial fire in a car (or in its immediate vicinity) due to the formation of extreme temperatures with the emission of a relatively high amount of heat. The tremendous build-up of smoke meant that it was only possible to fight the fire directly using shipboard equipment within a very tight time window.

It is never possible to exclude fully fire events in the cargo areas of ro-ro ships. There will always be conditions that lead to the outbreak of fire. This is proven by numerous statistics. Consequently, it is always the action taken to limit the damage that is of importance. Beyond all else, absolute priority must be given to the objective of using the existing technology rapidly and safely.

The time it takes to put the fixed fire-extinguishing installation into action and to make the response teams ready must be reduced further through immediate alerting and intensive training. Emphasis must be given to the time factor for the spread of fire on vehicle decks in the emergency plan and the training of the crew. It is reasonable to assume that under certain circumstances a fully-fledged fire on a car would spread to adjacent vehicles within minutes. Alerting immediately by means of a manual fire alarm call point at the scene, for example, shows the ship's command the approximate position of the fire and enables it to take targeted preventive measures. If the fire alarm system is disabled due to repair work on the deck, as was evidently the case here, permanent monitoring of the area must be organised.

The CO_2 low-pressure system installed for enclosed ro-ro decks is approved under SOLAS. Use of the CO_2 installation must be made as soon as possible (within minutes) for the following reasons:

1. as the extinguishing agent, CO_2 has only an insignificant cooling effect in rapidly developing fires. This cooling effect is neither far reaching nor lasting and only evident directly at the nozzles;
2. the high degree of energy transformation causes steel parts to deform relatively quickly and the destruction of sealing materials on the interlocking mechanisms on deck. This means that it may not be possible to reliably create the necessary watertight integrity after only a short fire duration, and
3. due to a persisting, unimpeded fire, metal fires form relatively quickly on modern vehicles with a higher proportion of light alloys, in particular. After activation by normal initial fires, such fires burn at extremely high temperatures. The use of CO_2 after this development can facilitate combustion due to oxygen being released as a result of the breakdown/decomposition of the CO_2 to carbon and oxygen.

At the same time, the formation of CO, which reacts in a highly explosive form, is possible due to redox reactions.

It must also be considered that CO_2 is only effective with open fires. Fires in closed vehicles, as well as in containers are not affected. The spread of fire by heat conduction and heat radiation is also barely impeded. Only the spread of fire by convection can be impeded by using CO_2 at an early stage. With that in mind, it is strongly recommended that in addition to the basic equipment, vehicle decks be equipped with high or low-pressure drencher systems, similar to the same requirement for container holds and to the equipment requirements for permanently open (or partly closed) ro-ro cargo decks.

As can be seen in the present case, the operating conditions for personnel deployed directly on the deck concerned deteriorate rapidly and heavily. In this context, the use of rapid response systems on vehicle decks should also be considered. Due to easy handling, such systems enable both the person who discovers the fire and the response team to combat an initial fire on cars and similar cargo effectively using water or encapsulator technology.

Various technology and new extinguishing agents have been available on the market for this for some time now. Much of this innovative technology and these extinguishing agents are increasingly used on both conventional passenger ships and container ships voluntarily. Rapid response systems have been developed for fighting initial fires in vehicles selectively, which qualify for use on ro-ro decks, in particular.[93] Such systems use water or encapsulator technology with high-pressure equipment, are very easy to handle and make it possible for only one person to cool the area of a fire extensively and to fight trailer and car fires directly.

Special water lances have been developed[94] for fires in enclosed compartments, such as containers, cabins, cars, or even entire deck areas. They operate under high pressure with water alone or with additives (F-500 encapsulator technology, for example) and provide an effective means of fighting fire on ships.

One – as far as is evident – problem that remains completely unresolved in the area of ro-ro shipping arises from the fact that the main focus of shipbuilders and operators is usually directed very predominantly at the optimum utilisation of cargo holds. From the perspective of active firefighting, and especially in relation to access routes and areas, the slot gaps used between vehicles, which at times are only a few centimetres, represent a huge and to some degree insurmountable obstacle. Unless one wishes to rely on the use and effectiveness of fixed fire-extinguishing installations on board such ships from the outset, the establishment of a sufficient number of access lanes that remain unobstructed is an essential prerequisite for the effective and most importantly safe operation of extinguishing teams.

In addition to the factors discussed above, another lesson relating especially to the idiosyncrasies of ro-ro ships, but which also applies to other types of ship, can be drawn from the investigation into the firefighting operation on board the ATLANTIC

[93] See the description of the 'fireXtec' system at http://www.firextec.it below by way of example.
[94] See the description of the 'Fognail' system at http://www.fognail.de below by way of example.

CARTIER. With regard to the prospect of containing and fighting a fire effectively, the removal of horizontal and vertical fire protection barriers should be kept to the minimum absolutely necessary and not happen until immediately before cargo-handling operations. The ship's crew should document and check watertight integrity and the removal thereof diligently.

If fire breaks out on a ship at berth, it may under certain circumstances (and possibly at the same time as the primary firefighting operation) be necessary to discharge some of the cargo as quickly and as efficiently as possible to account for the particular risks and hazards of dangerous goods or to allow firefighters access to the seat of fire, for example. Implementation of the necessary cargo-handling operations is regularly possible quickly using the crane operators and other dockers available in the port. However, the accident on the ATLANTIC CARTIER has shown that on a non-working public holiday valuable time can pass until the necessary staff arrive at the scene. Consequently, port and terminal operators, together with the lead local administrative body responsible for disaster control, should reflect on the introduction of a contingency system to ensure the rapid availability of the personnel necessary for required cargo-handling operations in an emergency at any time.

5.2 Fire causes

The structural characteristics or flaws of the ATLANTIC CARTIER have resulted in welding operations in various places on the ship becoming part of everyday life on board for almost 30 years. In co-operation with the classification society, the ship management has developed and over the years enhanced a standardised procedure for registering and remedying cracks when they form. This procedure requires the careful selection of the repair team to be employed, inter alia. There is no evidence to suggest that welding operations caused the fire on the day of the accident. Although the heightened risk of a fire due to the frequent need for intrinsically inflammable welding operations can be mitigated by precautionary measures, it cannot be fully precluded in practice.

The works possibly had an indirect effect in this respect to the extent this required that part of the smoke detection system (on vehicle deck 3 B, in particular) be disabled as a precautionary measure. That this delayed the detection of the fire critically is something that cannot be ruled out.

Another factor that was at least conducive to the spread of fire arises from the fact that it was only possible to cordon off the seat of fire with some delay for lack of remote operation of the open starboard sliding door. There are no such construction requirements for older ships. Retrofitting requirements do not exist and were apparently not desired by international policymakers from the shipping community, at least not by the majority. Inasmuch, the BSU can only appeal to the operators of older ships to reflect seriously on retrofitting remote control units in co-operation with their respective classification societies voluntarily out of a sense of responsibility. It is possible that insurers would even be willing to make an indirect contribution to the cost incurred by way of a discounted premium.

The subsequent installation of a ship section in the cargo hold requires a high degree of care not only in terms of strength and stability, but especially with regard to expanding the various cable harnesses that run through her. Besides complying with the necessary technical requirements during the conceptual design and realisation of a lengthening or – as is also practised of late – widening project, it is also appropriate to pay close attention to any irregularities that may occur (at the 'joins' between sections, in particular) during the subsequent operation of the modified ship.

Neither the spontaneous combustion of a car due to an electrical fault in the vehicle nor malicious or negligent arson can be excluded as possible causes of the fire. Disconnecting and securing batteries during the relatively long transport routes and the small possibility of monitoring the cargo deck would effectively preclude the spontaneous combustion risk factor, as an internal source of ignition would be largely excluded. Such action would be extremely difficult to enforce for economic reasons in terms of transport and thus also for political reasons, however.

5.3 CO_2 installation

The ultimately successful use of the CO_2 extinguishing system on board the ATLANTIC CARTIER has demonstrated how valuable and quite essential an operational CO_2 extinguishing system can be when it comes to fighting a cargo hold fire. It is all the more important that its permanent operational readiness be checked regularly and carefully. In this context, it is necessary to keep the existing documentation up to date and to ensure that clear and simple labelling of the controls exist in English, as well as in the working language used on board.

5.4 Dangerous cargo

We are all aware that precise quantity data for any type of cargo are of extreme importance to such issues as stability and strength. In the case of cargo classified as dangerous, correct data on content, characteristics and quantity of the particular dangerous goods become even more important to the safety of the ship, with regard to the aspects of fire protection and any necessary emergency management, in particular. Consequently, any party involved in transportation – from manufacturer and/or consignor through to the operating carrier and any intermediaries within the transport chain – bears an extremely heavy responsibility with regard to declaring dangerous goods properly in every respect.

6 Actions taken

6.1 Owner of the ship

The statement of the owner of the ship dated 6 August 2015 to the draft of this investigation report (subheading 'Actions taken') is as follows:

"After the accident, the fire(fighting) drills on board both the ATLANTIC CARTIER and her sister ships, which were already comprehensive and carried out to a high standard, were intensified further in respect of potential vehicle fires.
Moreover, the owner is already working on putting into effect the recommendations arising from the BSU's draft investigation report."

6.2 Volvo Car Corporation

The manufacturer submitted, inter alia, a 13-page opinion of Dr James M. Knox, the American computer and electronics expert it appointed, as an annex to its statement dated 7 August 2015 to the draft of this investigation report. This opinion has been referenced in section 3.2.3.3.3 of the final version of the investigation report, in particular. Based on technical examinations on a brand new benchmark vehicle, the expert addressed the electrical and electronic conditions of the vehicle type the BSU cited as a risk factor extensively. The opinion was produced primarily in the context of clarifying questions of liability arising from the fire on the ATLANTIC CARTIER, and beyond that for the purpose of the statement to the BSU's draft investigation report. However, irrespective of the actual course of the accident, since it focuses on the question of the fire risk posed by brand new cars in maritime transport (and beyond) in general and in specific terms, the opinion in question and underlying investigations are, by their very nature, simultaneously an implemented and noteworthy preventive measure in the sense of section 6 of this investigation report.

The expert appointed by Volvo Car Corporation summarised his conclusions at the foot of his report as follows:

"… As explained above, at the time of the fire, the newly manufactured Volvo vehicles were placed in transport mode. When in transport mode, the vehicles have no designed circuitry which consumes energy sufficient to cause ignition. Moreover, the vehicles, even when not in transport mode, provide no "hot spots" or other electrical nodes which, as designed, would consume sufficient electrical energy so as to source ignition. Similarly, there is no evidence that a Volvo car suffered from any manufacturing defect. To the contrary, each vehicle was thoroughly tested at the factory. And, given that the cars were brand new, they were not subjected to the effects of routine wear and tear, or the possibility of owner abuse or neglect. There is absolutely no support for the conclusion that the fire may have been initiated in one of the Volvo cars."[95]

[95] Note by the BSU: the inclusion of the quotation in the report does not mean the BSU has embraced the conclusions of the expert in every detail.

6.3 Lloyd's Register

The classification society of the ATLANTIC CARTIER declared the following in its statement dated 24 July 2015 to the draft of this investigation report in respect of the safety recommendations addressed to it (see sections 7.2.1 and 7.2.2 below):

"Para 7.2.1 Inspection of the electric wiring
LR will, with the agreement of, and in conjunction with representatives of the owner, specially inspect the ship's and her sisters ship's electrical wiring for deterioration and damage since installation."

"Para 7.2.2 Serviceability, documentation and labeling of the CO2 installation
LR will with the agreement of, and in conjunction with representatives of the owner and an approved Service Supplier for the servicing of CO2 installations, specially inspect components of the ship and her sisters ships CO2 extinguishing system, especially in respect of any leakage. Technical documentation will be reviewed, corrected as necessary and brought up to date. Existing labels and instructions on the system will be reviewed for accuracy and intelligibility, and amended or renewed as required."

6.4 Zentralverband der deutschen Seehafenbetriebe e.V. (ZDS) (Federal Association of German Seaport Operators)

The Federal Association of German Seaport Operators declared the following in its statement dated 5 August 2015 to the draft of this investigation report in respect of the safety recommendations addressed to it, inter alia (see section 7.4 below):

"We are pleased to note the Federal Bureau's proposal to liaise and search for solutions that would ensure the short-term availability of port personnel in all German sea ports in the event of an urgent need to discharge part of a ship's cargo for reasons of safety on general rest days. […]
The dates in question here relate solely to the five days per year when the port is shut down completely. This port shutdown is centrally regulated at federal level by collective agreement and does not provide for mandatory opening options.[96] Accordingly, collective bargaining would be necessary for comparable emergencies. Corresponding talks with ver.di, the relevant trade union, are scheduled for September this year. In the event of a positive collective agreement, additional operational regulations relating to specific obligations and corresponding remuneration, as well as questions of liability in an individual case, are necessary. For example, the question as to who assumes responsibility for the allocation of deployed staff needs to be answered.

Due to the complexity of the issues that need to be answered, we believe that discussions as to whether the fire services deployed in the event of a similar accident should be given the requisite skills needed to partially discharge a ship if necessary should be held as an alternative. Deliberations should also cover the question as to

[96] Note by the BSU: see also Article 2(10) of the "Rahmentarifvertrag für die Hafenarbeiter der deutschen Seehafenbetriebe" (collective agreement for dockers of Germany's seaport operators). This states that New Year's Day, the first day of Easter, the first of May, the first day of Whitsun, and the first day of Christmas are generally regarded as days of rest in all German seaports.

whether additional qualified staff could be made available at short notice in an emergency through the port authority.

The parties involved should also discuss whether voluntary standby units can be reliably drawn on from an organisational perspective."

7 Safety recommendations

The following safety recommendations do not constitute a presumption of blame or liability in respect of type, number or sequence.

7.1 Owner of the MV ATLANTIC CARTIER

7.1.1 Disabling certain parts of the smoke detection system/monitoring of the area

The Federal Bureau of Maritime Casualty Investigation recommends that the owner of the ATLANTIC CARTIER supplement its safety management system in relation to welding operations carried out on board the ship and her sister ships so that shutting down certain areas of the smoke detection system is reduced to an absolute minimum. Permanent monitoring of the area should be organised for areas where it is absolutely necessary that they be disconnected from a remote monitoring system.

7.1.2 Safety instructions for welding teams

The Federal Bureau of Maritime Casualty Investigation recommends that the owner of the ATLANTIC CARTIER regularly instruct the repair teams deployed on board on its behalf on the specific fire protection requirements during welding operations on board ships. In addition to the need to pay particular attention to the absolute necessity of ensuring that the vicinity of the required welded joint is protected against an excessive heat build-up, such instruction should include the correct behaviour in the event of the discovery of an outbreak of fire, in particular.

7.2 Owner of the ship and the classification society

7.2.1 Inspection of the electric wiring

The Federal Bureau of Maritime Casualty Investigation recommends that the owner of the ATLANTIC CARTIER and the ship's classification society– as far as is still outstanding – conduct a careful inspection of the ship's and her sister ships' electric wiring, especially in respect of defects in the splices between the original and the new section subsequently inserted.

7.2.2 Serviceability, documentation, and labelling of the CO_2 installation

The Federal Bureau of Maritime Casualty Investigation recommends that the owner of the ATLANTIC CARTIER and the ship's classification society – as far as is still outstanding – inspect all the components of the ship's and her sister ships' CO_2 extinguishing system, especially in respect of any leakage. Technical documentation should be corrected and/or brought up to date. In addition, existing labels should be reviewed for accuracy and intelligibility, and renewed if necessary.

7.3 The vehicle manufacturer VOLVO Car Corporation

The Federal Bureau of Maritime Casualty Investigation recommends that the vehicle manufacturer Volvo Car Corporation review whether it is structurally possible to minimise the risk of spontaneous combustion in the vehicles it produces due to possible faults in the on-board electronics even further than has already been the case.

7.4 Ministry of the Interior and Sport of the Free and Hanseatic City of Hamburg and Zentralverband der deutschen Seehafenbetriebe e.V. (ZDS) (Federal Association of German Seaport Operators)

The Federal Bureau of Maritime Casualty Investigation recommends that the Ministry of the Interior and Sport of the Free and Hanseatic City of Hamburg (in relation to the Port of Hamburg) and the member cargo-handling companies of the Federal Association of German Seaport Operators (in relation to all German seaports) liaise to search for solutions, which ensure the short-term availability of port personnel in the Port of Hamburg and all other German sea ports in the event of an urgent need to discharge part of a ship's cargo for reasons of safety on general rest days.

8 SOURCES

- Written statements, documents, logs, and photos
  Ship's command and management of the MV ATLANTIC CARTIER
- Exchange of information with the Swedish maritime casualty investigation body, SHK
- Various witness statements
- BURGOYNES CONSULTING SCIENTISTS AND ENGINEERS GLASGOW: 'REPORT CONCERNING THE CAUSE OF THE FIRE INVOLVING MV ATLANTIC CARTIER AT O'SWALD KAI TERMINAL, HAMBURG ON 1 MAY 2013 FOR ATLANTIC CONTAINER LINIE SWEDEN AB, NORWEGIAN HULL CLUB AND NORTH OF ENGLAND P&I CLUB BY STUART MORTIMORE, 9 SEPTEMBER 2014'
- Information about the investigation into the cause of the fire (provided by the insurer's German law firm) conducted by the experts Yrjo Migchelsen and Erik Overtoom (both working for the British/Dutch inspection agency, BMT Surveys) on behalf of the insurer of the vehicle manufacturer, Volvo Car Corporation
- Opinion of 14 February 2014 on the fire on the con/ro-ro multipurpose ship ATLANTIC CARTIER on 1 May 2013 on behalf of the BSU by Dipl.-Ing. Lars Tober, Rostock
- Supplementary statement of 3 December 2014 to the opinion on the fire in the ATLANTIC CARTIER case, regarding the specific aspect of the cause of the fire on behalf of the BSU by Dipl.-Ing. Lars Tober, Rostock
- Nautical charts and ship particulars, Federal Maritime and Hydrographic Agency (BSH)
- Photo of the MV ATLANTIC CARTIER; Dietmar Hasenpusch Photo-Productions, Hamburg
- Findings and photos of the Hamburg police
- Full report on the firefighting by authors Ingo Schwarz, Jan Peters and Bernd Herrenkind with the title 'Hamburger Hafen: Feuer auf der ATLANTIC CARTIER' [Port of Hamburg: fire on the ATLANTIC CARTIER] in the journal 'Brandschutz' [fire protection] (W. Kohlhammer publishing house in Stuttgart), p. 974 ff. of the 12/2013 issue
- Author's internet research on the history of the ATLANTIC CARTIER, her conversion, and new firefighting technologies, inter alia
- Contact with Prof. Dr.-Ing. Stefan Krueger, Naval Architect, Head of Institute TU Hamburg-Harburg Institute of Ship Design and Ship Safety
- Opinion prepared by Dr James M. Knox, computer scientist, TriSoft/CyberSearch, Austin, Texas, on behalf of Volvo Car Corporation dated 6 August 2015 on the question of the possibility of a brand new Volvo car spontaneously combusting, in particular
- Statements on the draft investigation report by
  - Owner of the ship
  - Cargo interest/insurer of Volvo Car Corporation
  - Hamburg Fire Service
  - Classification society of the ship
  - Federal Association of German Seaport Operators
  - Hamburg Port Authority