ACCIDENT REPORT

Report on the investigation of

the fire on the main deck of the ro-ro cargo ferry

Corona Seaways

in the Kattegat, Scandinavia

on 4 December 2013

MAIB
MARINE ACCIDENT INVESTIGATION BRANCH

SERIOUS MARINE CASUALTY REPORT NO 17/2014 JULY 2014

This investigation has been conducted with the co-operation and assistance of the Danish, Swedish and Lithuanian accident investigation branches.

Extract from

The United Kingdom Merchant Shipping

(Accident Reporting and Investigation)

Regulations 2012 – Regulation 5:

"The sole objective of the investigation of an accident under the Merchant Shipping (Accident Reporting and Investigation) Regulations 2012 shall be the prevention of future accidents through the ascertainment of its causes and circumstances. It shall not be the purpose of an investigation to determine liability nor, except so far as is necessary to achieve its objective, to apportion blame."

NOTE

This report is not written with litigation in mind and, pursuant to Regulation 14(14) of the Merchant Shipping (Accident Reporting and Investigation) Regulations 2012, shall be inadmissible in any judicial proceedings whose purpose, or one of whose purposes is to attribute or apportion liability or blame.

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GLOSSARY OF ABBREVIATIONS AND ACRONYMS

AB	-	Able seaman
AB	-	Aktiebolag
A/S	-	Aktieselskab
BA	-	Breathing Apparatus
C	-	Celsius
CCTV	-	Closed-Circuit-Television
CO_2	-	Carbon Dioxide
COSWP	-	Code of Safe Working Practices for Merchant Seamen
CSMM	-	Company Safety Management Manual
DFDS	-	Det Forende Dampskibs-Selskab
FRS	-	Fire and Rescue Service
hp	-	horsepower
JRCC	-	Joint Rescue Co-ordination Centre
km	-	kilometre
m	-	metre
mm	-	millimetre
MCA	-	Maritime and Coastguard Agency
MGN	-	Marine Guidance Note
nm	-	nautical mile
OOW	-	Officer of the Watch
Ro-Ro	-	Roll on, Roll off
SOLAS	-	International Convention for the Safety of Life at Sea 1974, as amended
SSMM	-	Ship Safety Management Manual
t	-	tonne
UTC	-	Universal Co-ordinated Time
VHF	-	Very High Frequency

Volt	-	V

TIMES: All times in this report are UTC+1 unless otherwise stated

TERMS:

Aktiebolag	-	Swedish legal term associated with company liability and equivalent to the English “Limited”.
Aktieselskab	-	Danish legal term associated with company liability and equivalent to the English “Limited”.
Jalousie	-	A structure comprising a series of louvres which can be opened or closed for ventilation purposes.
MAFI	-	The German company name MAFI is widely used for describing low, heavy-duty trailers in the freight industry. The name originates from one of the company’s founder members, **Ma**rtin **Fi**la.
Nearside	-	The part of a vehicle which is nearest to the kerb (for a left-hand drive vehicle this is the right-hand side).
Offside	-	The part of a vehicle which is furthest from the kerb (for a left-hand drive vehicle this is the left-hand side).

SYNOPSIS

At 0215 on 4 December 2013, a fire was discovered on the main deck of the ro-ro cargo ferry *Corona Seaways* while the vessel was on passage from Fredericia to Copenhagen, Denmark. The crew mustered, closed the ventilation louvres, established boundary cooling and operated the fixed CO_2 fire-extinguishing system. Although smoke continued to escape from the louvres, steady temperatures in the vicinity of the fire indicated that the CO_2 had been effective in controlling it. At 0640, the vessel entered the Swedish port of Helsingborg, where assistance was provided by the local Fire and Rescue Service.

The vessel suffered light structural damage and the loss of some minor electrical supplies. Three vehicles and six trailers were severely fire-damaged and other vehicles suffered minor radiant heat damage. The fire was caused by an electrical defect on one of the vehicles' engine starting system.

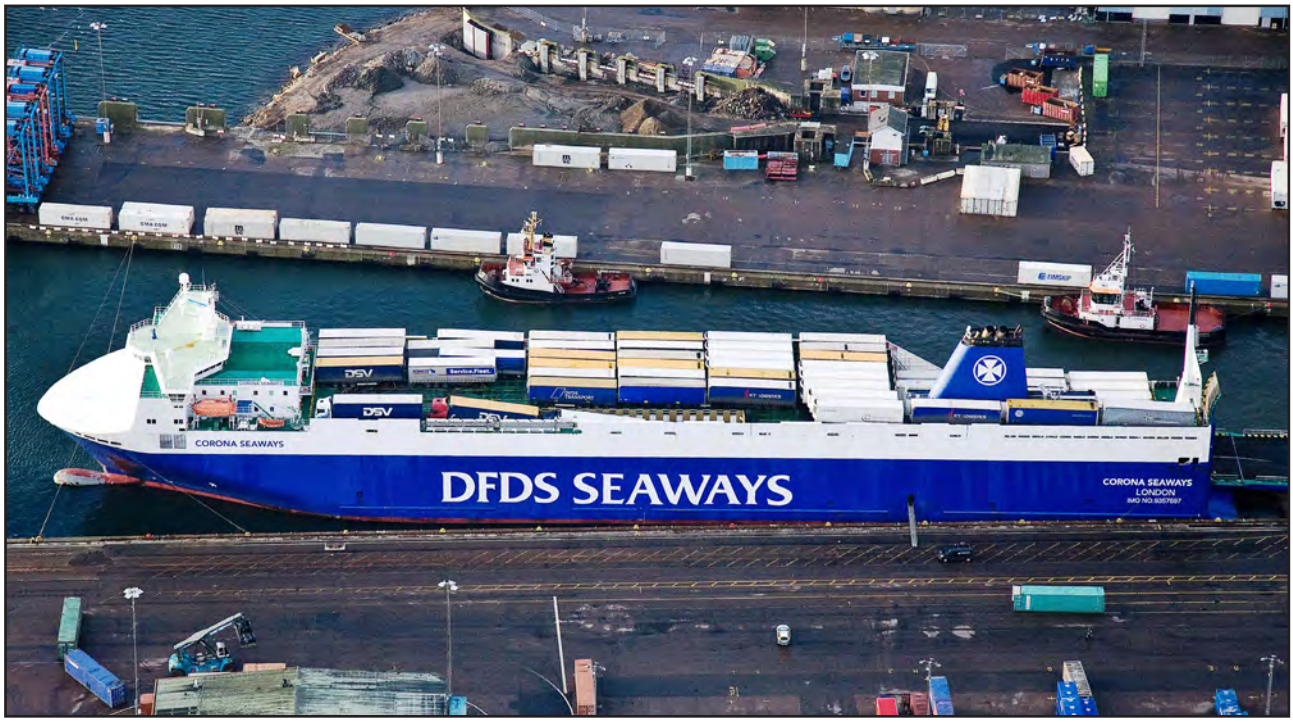
Recommendations to the management company include a review of its onboard instructions to take account of the revised procedures since introduced by the operator for the carriage of used and unregistered vehicles.

SECTION 1 – FACTUAL INFORMATION

1.1 PARTICULARS OF *CORONA SEAWAYS* AND ACCIDENT

SHIP PARTICULARS	
Vessel's name	*Corona Seaways*
Flag	United Kingdom
Classification society	American Bureau of Shipping
IMO number	9357597
Type	Ro-Ro cargo ship
Registered owner	Snowdon Leasing Company Limited
Manager	Ellingsen Ship Management AB
Construction	Steel
Year of build	Keel laid 20 October 2006
Length overall	187m
Registered length	169.85m
Gross tonnage	25,609.00
Minimum safe manning	12
Authorised cargo	Passengers and vehicles
VOYAGE PARTICULARS	
Port of departure	Fredericia, Denmark
Port of arrival	Copenhagen, Denmark (intended), Helsinborg, Sweden (actual)
Type of voyage	Short international
Cargo information	170 units, 10 accompanied
Manning	19
MARINE CASUALTY INFORMATION	
Date and time	4 December 2013 at 0215
Type of marine casualty or incident	Serious marine casualty
Location of incident	56º08'N 011º41'E, 59nm west of Helsingborg, Sweden
Place on board	Starboard side of the main deck
Injuries/fatalities	None
Damage/environmental impact	Severe damage to 3 vehicles and 6 trailers. Smoke damage to main deck, heat damage to 15m^2 of steel deck and 8 longitudinals between frames 131 and 134. Fire damage to the forward mooring winch supply cables and to minor electrical circuits
Ship operation	On passage

Voyage segment	Mid-water
External & internal environment	Cloudy, visibility good, wind south-westerly force 4, wave height 0.5-1.0m, air temperature 7ºC
Persons on board	19 crew and 10 vehicle drivers



Corona Seaways

1.2 BACKGROUND – OVERVIEW OF ROUTE AND CARGO SHIPPING PROCEDURES

Corona Seaways was chartered by Det Forende Dampskibs-Selskab (DFDS) A/S to operate an average 6-day circular, Baltic Sea freight ferry route between Fredericia and Copenhagen, Denmark and Klaipeda, Lithuania. Kiel, Germany was occasionally included in the schedule. The vessel's position when the fire was discovered is shown at **Figure 1**.

The cargo routinely included used driveable and non-driveable vehicles, loaded MAFIs, trailers, car transporters, and agricultural and heavy plant machinery predominantly for export to Eastern Europe. On average, about 15% of the vehicles were pushed or towed on board because of mechanical defects.

Used vehicles were subject to random checks to determine their suitability for shipment (i.e. checking for oil and fuel leaks). Stevedores loaded the vehicles and the vessel's crew were responsible for securing them. Once a vehicle was in position, the ignition key was left in the ignition barrel in the 'stop/park' position in accordance with the operator's required procedures.

1.3 NARRATIVE

1.3.1 Events leading up to the discovery of the fire

At 2100 on 3 December 2013, *Corona Seaways* finished cargo loading operations in Fredericia. A total of 170 units were tightly stowed in the lower hold, on the main, upper and weather decks, and on the access ramps. The cargo included 10 vehicles that were accompanied by their drivers, who were a mix of Latvian and Lithuanian nationals.

At 2110, with the cargo secured and all cargo space fans stopped, *Corona Seaways* sailed for Klaipeda via Copenhagen. At 0130 on 4 December, the on-watch able seaman (AB) informed the officer of the watch (OOW) that he had completed his fire and security rounds, including rudimentary checks of the cargo decks, and that all was satisfactory.

At 0215, the fire detection alarm system sounded on the bridge, indicating a fire in Zone 12 (starboard side) on the main deck. The OOW informed the master and sent the on-watch AB to the main deck to carry out checks. The OOW viewed the main deck on the Closed-Circuit-Television (CCTV) monitor and saw no evidence of a fire. The AB opened the main deck port aft door but did not enter the space because of the tightly packed vehicles. He reported to the OOW on his Very High Frequency (VHF) radio that he could not see any evidence of a fire, and he then closed the door. The OOW instructed the AB to return to the bridge as the fire alarm sounded again. On entering the bridge, the master looked at the CCTV monitor. He saw smoke and, shortly afterwards, flames, which appeared to come from vehicles in the vicinity of frame 131 on the starboard side of the main deck **(Figure 2)**. The general alarm was sounded as smoke and flames were seen to rapidly increase before the CCTV camera lens became obscured.

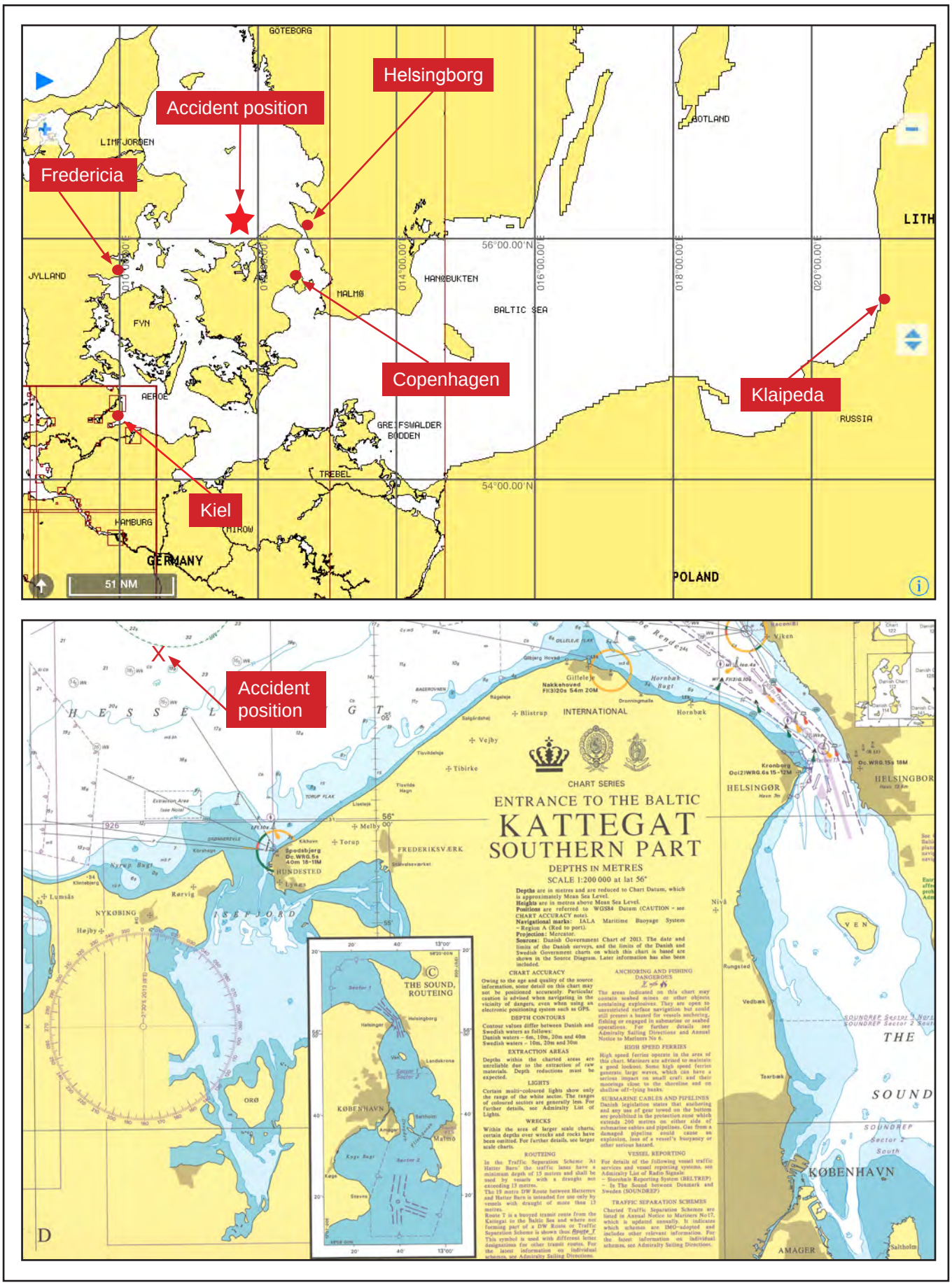


Figure 1: Accident position

Image courtesy of Ellingsen Ship Management AB

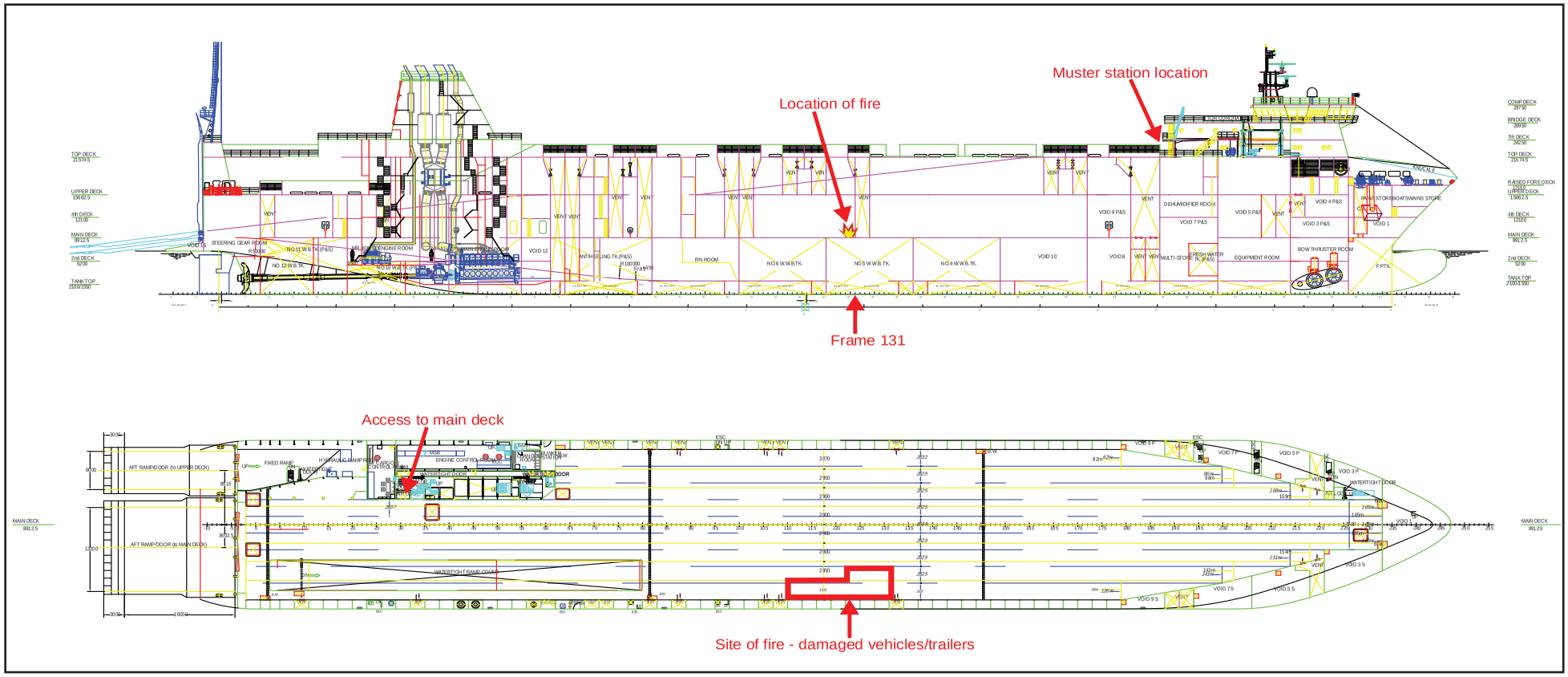


Figure 2: *Corona Seaways* - general arrangement

1.3.2 Fire-fighting at sea

After arriving at the muster station, two pre-designated teams started to close the manually operated louvres of the 36 ventilation jalousies located on the upper and weather decks. Because of the high levels of smoke coming from the ventilation openings, some crew members had to don Breathing Apparatus (BA) for protection. Although the louvres were reported closed to the chief officer, a considerable amount of smoke continued to emit from them. In the meantime, the master instructed the chief engineer to prepare the fixed CO_2 fire-extinguishing system for discharge into the main deck cargo space.

At 0225, the chief officer reported to the master that the ventilation louvres had been closed and that all personnel, with the exception of the fitter, had been accounted for. Not knowing the fitter's whereabouts, the master decided to delay use of the CO_2 in case he was on the main deck and, as he was not equipped with a VHF radio, he could not be readily accounted for. At 0230, the fitter arrived at the muster station having reportedly been closing upper deck ventilation louvres.

The master then approved the injection of CO_2 into the main deck using the forward CO_2 fire-extinguishing system control position located in the accommodation superstructure.

The 10 vehicle drivers, who had consumed alcohol and were now located at the muster station, started to become disruptive. As this was affecting the chief officer's ability to manage the incident, he decided, in consultation with the master, to relocate them to the passenger lounge from where they could be readily evacuated if necessary.

Meanwhile, the master reported his situation to Lyngby Radio, who transferred the information to the Danish Joint Rescue Co-ordination Centre (JRCC) at Brabrand. At 0248, the German Federal Navy corvette *Braunschweig* offered to assist in evacuating the crew if this became necessary.

By now, *Corona Seaways*' upper deck was being boundary-cooled using water from open fire hydrants. At 0300, the chief officer instructed the upper deck water drenching system to be operated as he considered that this would be a more effective method of cooling the deck.

At 0310, the chief engineer advised the master that the CO_2 storage tank contents gauge was registering about 12t. This suggested that only 9 tonnes (t) of the 21.3t of CO_2 stored in the tank had been released into the main deck instead of the required 19.8t. Unsure of the true situation, the master authorised the chief engineer to operate the system once more from the forward control position.

Following the second release of CO_2, the master, in consultation with the chief officer and chief engineer, determined that the fire appeared to be under control as no other fire detectors had operated and the temperature on the upper deck, above the fire, had not increased.

In the meantime, arrangements were made for *Corona Seaways* to berth at Helsingborg, Sweden. Accordingly, co-ordination of the emergency was transferred to the Swedish JRCC based in Gothenburg.

At 0400, the chief engineer advised the master that the contents gauge indicated that over 10t of CO_2 was still remaining in the storage tank. The master authorised the chief engineer to manually operate the system from the CO_2 storage tank compartment, which he did, leaving the discharge valve to the main deck fully open.

A short time later, the fire detection system alarm again sounded, indicating a fire in the upper deck forward staircase, which provided access to the main deck via a sliding watertight door. The chief officer sent a BA team to investigate. The BA team reported that smoke was wisping through the door seal but that the door was cold to the touch, indicating that the fire had not spread to the forward section of the main deck.

1.3.3 Fire-fighting in Helsingborg

At 0445, a Swedish coastguard launch, equipped with an infra-red thermal imaging camera, scanned *Corona Seaways* and confirmed that temperatures were steady, indicating that the use of CO_2 had been effective in controlling the fire.

At 0640, *Corona Seaways* was secured alongside 704 berth at Helsingborg. The 10 vehicle drivers and surplus crew were evacuated by the Fire and Rescue Service (FRS) while a harbour tug boundary-cooled the vessel's side with water using its fire-fighting monitor.

Following a briefing by the chief engineer, FRS personnel entered the main deck through the port aft door at 0704. However, their progress was hampered by poor visibility, restricted access between the stowed vehicles and the need to extend and re-lay the fire-fighting hoses.

At 0805, some of the main deck exhaust fans were started to help improve visibility. At 0914, it was agreed to lower the main deck access ramp and discharge some of the cargo to provide the FRS access to the seat of the fire. The vessel was re-positioned to allow the ramp to be safely located on the quayside and, at 1208, cargo unloading started. Following access to and dampening down of the main deck, the FRS declared the fire out at 1325. At 2110, after further dampening a number of 'hot spots', the FRS passed responsibility for monitoring the fire scene to the vessel's crew.

Following repairs at nearby Landskrona, *Corona Seaways* re-entered service on 29 December 2013.

1.4 VESSEL AND CARGO DAMAGE

1.4.1 Vessel's structure and systems damage

The majority of the structural damage was located above the fire on the underside of the upper deck between frames 131 and 134. Approximately 15m^2 of the steel deck required replacing, as did seven slightly distorted longitudinal deck head stiffeners.

Electrical cabling supplying the forward mooring winch, lighting, ballast tank ventilation pipe heating and fire detection equipment was fire-damaged. Other than soot contamination of the fixed CO_2 fire-extinguishing system nozzles, no mechanical or pipework systems were affected.

1.4.2 Cargo damage

The two vehicles at the locus of the fire were a Renault Premium 250.18 truck and a Renault Mascott-Master van that it was carrying; these are termed the primary vehicles and were totally destroyed **(Figure 3)**. They were positioned in Lane 8 and adjacent to frame 131 on the main deck.

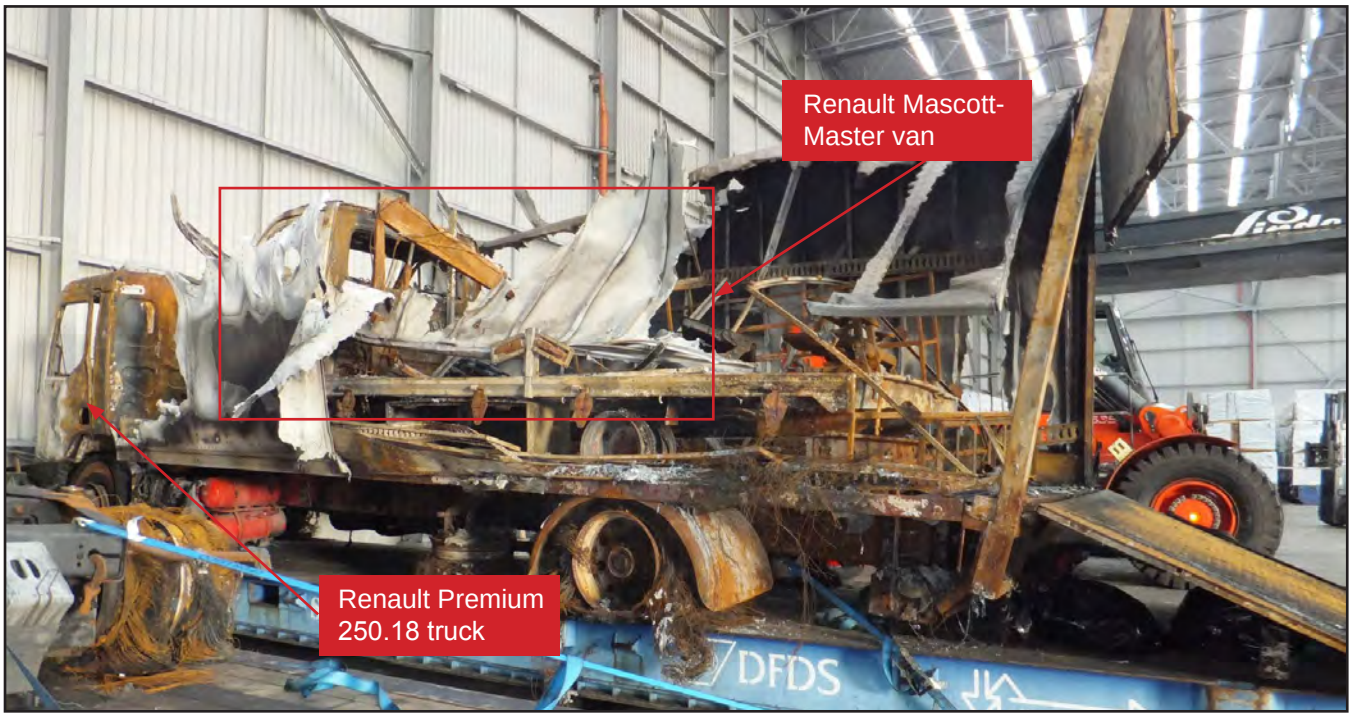


Figure 3: Fire-damaged Renault Premium 250.18 truck and Renault Mascott-Master van following their removal from the vessel

A Renault Premium 410 cab unit located alongside and inboard of the primary vehicles, in Lane 7, suffered severe fire damage to its nearside. Two 3-axle trailer units, each carrying two trailers, positioned in Lanes 7 and 8 and directly aft of the primary vehicles were also badly fire-damaged. Eighteen of the trailer tyres had been totally consumed by the fire. Other units forward of the primary vehicles suffered minor radiant heat damage **(Figure 4)**.

1.5 DESCRIPTION AND HISTORY OF PRIMARY VEHICLES

1.5.1 Renault Premium 250.18 truck

Manufactured in 1996, the left-hand side drive Renault Premium 250.18 truck was fitted with a 6-cylinder, 250 horsepower (hp) turbo-charged diesel engine. The cargo compartment sides and roof were made from light aluminium sheeting and the deck from aluminium checker plate laid over plywood sheeting. There was a rear-mounted electrically operated steel ramp.

From February 2013 until 28 November 2013, the truck was located at a used vehicle dealership based in Christiansfeld, Denmark. During this period, its engine was reported to have been occasionally started using a portable battery pack as the truck's batteries had been removed.

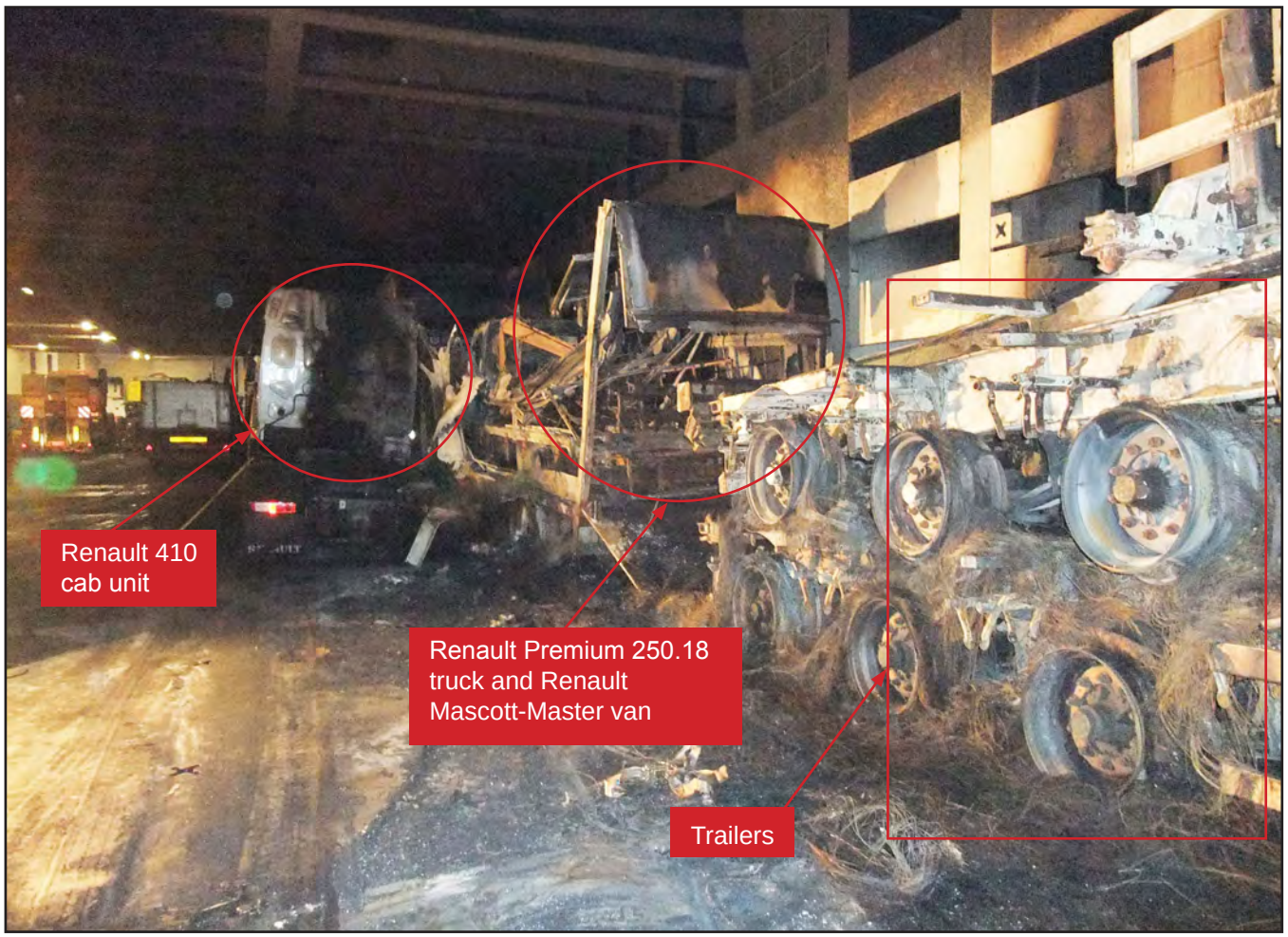


Figure 4: Damaged vehicles and trailers on the main deck

At the end of November 2013, the truck was purchased by Lithuanian-based UAB Amerija for import to Lithuania. On 1 December 2013, two 12 volt (V) batteries were fitted to the truck. It was then driven 240km to Fredericia, arriving the following day after picking up the Renault Mascott-Master van in Skjern, Denmark. The truck and its van cargo were left at the port overnight to await loading by the stevedores the following afternoon.

1.5.2 Renault Mascott-Master van

The rear-wheel drive Renault Mascott-Master van was manufactured in 2005. It was fitted with a 63hp naturally aspirated engine, drop-down wooden sides and a small hydraulically powered crane positioned immediately behind the cab. It suffered engine failure when it was last run in about December 2012, after which the cylinder head was removed.

1.6 RENAULT PREMIUM 250.18 TRUCK – OVERVIEW OF ELECTRICAL AND ENGINE STARTING ARRANGEMENTS

1.6.1 Electrical system

A schematic of the electrical and engine starting arrangements is at **Figure 5**. The 24V electrical system was provided by two 12V batteries, connected in series, which were located on a platform behind the front offside wheel arch. Power was

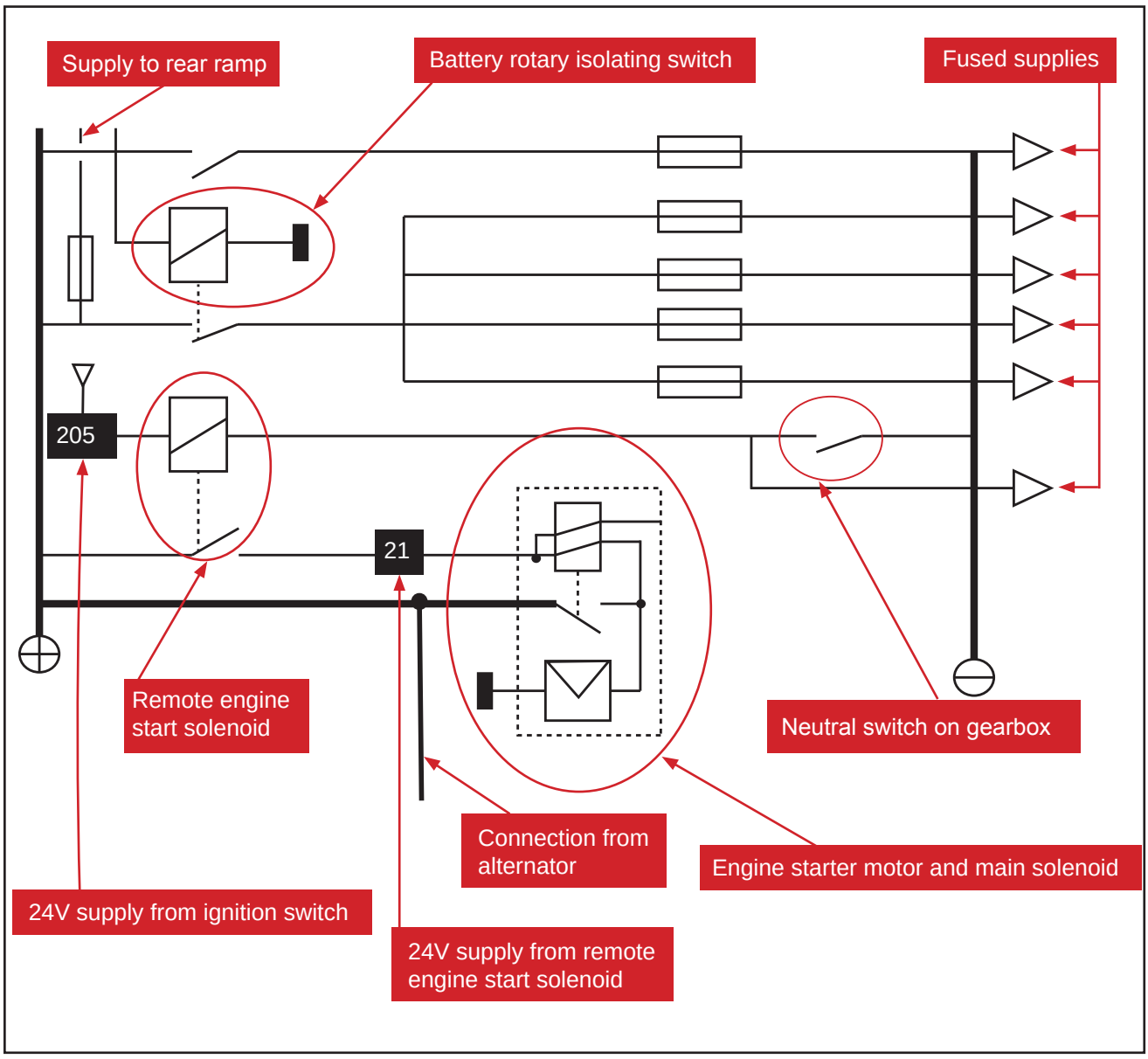


Figure 5: Schematic of Renault Premium 250.18 truck engine starting arrangements

distributed through a battery rotary isolating switch. A fused protected electrical supply for operating the rear ramp was arranged to by-pass the main isolating switch.

When the ignition key was removed or in the ‘stop/park’ position, a number of fused circuits remained live, including those for the tachograph, hazard warning lights and central locking system. Non-fused circuits that remained live included supplies to/ from the remote engine start solenoid, engine pre-heat solenoid and engine starter motor main solenoid, and its connection to the alternator output supply.

1.6.2 Engine starting arrangements

When the gearbox was in the neutral position, the neutral switch was closed, which completed the earth circuit for the remote engine start solenoid coil. When the ignition key was turned to the ‘start’ position, the remote engine start solenoid was energised through wire 205, which closed the circuit to provide power through wire

21 to energise the engine starter motor main solenoid. When energised, the engine starter motor solenoid connected the battery 24V supply to the starter motor which turned the engine over.

A second solenoid was fitted next to the remote starting solenoid to provide 24V power to two resistance-type engine pre-heaters. These were positioned in the engine air intake manifold to assist in engine starting in cold conditions. The pre-heater solenoid was activated by a driver-operated switch on the dashboard which was fed from the ignition circuit when the ignition was turned on.

The vehicle was also fitted with a three-element, resistance-type diesel fuel oil pre-heater. The heater, which was fitted to the offside top of the engine block, was automatically activated once the engine was running.

1.7 EXAMINATION OF RENAULT PREMIUM 250.18 TRUCK

1.7.1 Structure

The internal components of the truck's cab were totally consumed. Although the truck's ignition key barrel was partially melted, the key was found in the barrel in the 'stop/park' position.

Five of the six fitted tyres and the spare tyre were also consumed. Most of the truck's offside glass fibre cab front and wind deflector on the cab roof had burnt away, as had about 60% of the truck's offside and about 30% of the nearside aluminium cargo compartment shell. A large amount of the truck's cargo compartment aluminium checker floorplate had also melted. However, about a 2.5m section of the offside chassis rail and the air brake reservoirs were undamaged with the paint scheme being unaffected. A similar pattern was noted on the nearside except that the front of the fuel tank protective plastic facing had melted; however, a quantity of diesel oil fuel remained in the tank.

1.7.2 Electrical and mechanical systems

Most of the vehicle's electrical cable insulation was missing and the battery casings had partially melted. One of the battery's positive cables had become disconnected and there was evidence of partial melting of the lead terminal posts. The battery isolating switch was found to be in the 'on' position, indicating that the battery was not isolated.

The rear part of the engine's aluminium rocker cover had melted and the upper part of the aluminium engine intake manifold had been burnt away, exposing the pre-heaters **(Figure 6)**. The diesel oil fuel unit had melted. The three heating elements were still connected to their electrical cables, although the main supply electrical cable connection was loose, with about a 3mm gap between the nut and connection tab. The battery main supply cable insulation had been destroyed and the cable had welded to the chassis.

The main terminal post of the engine starter motor main solenoid was found to be extremely loose. The end Bakelite-type cap appeared brittle, and there were copper globules in the vicinity of the starter motor.

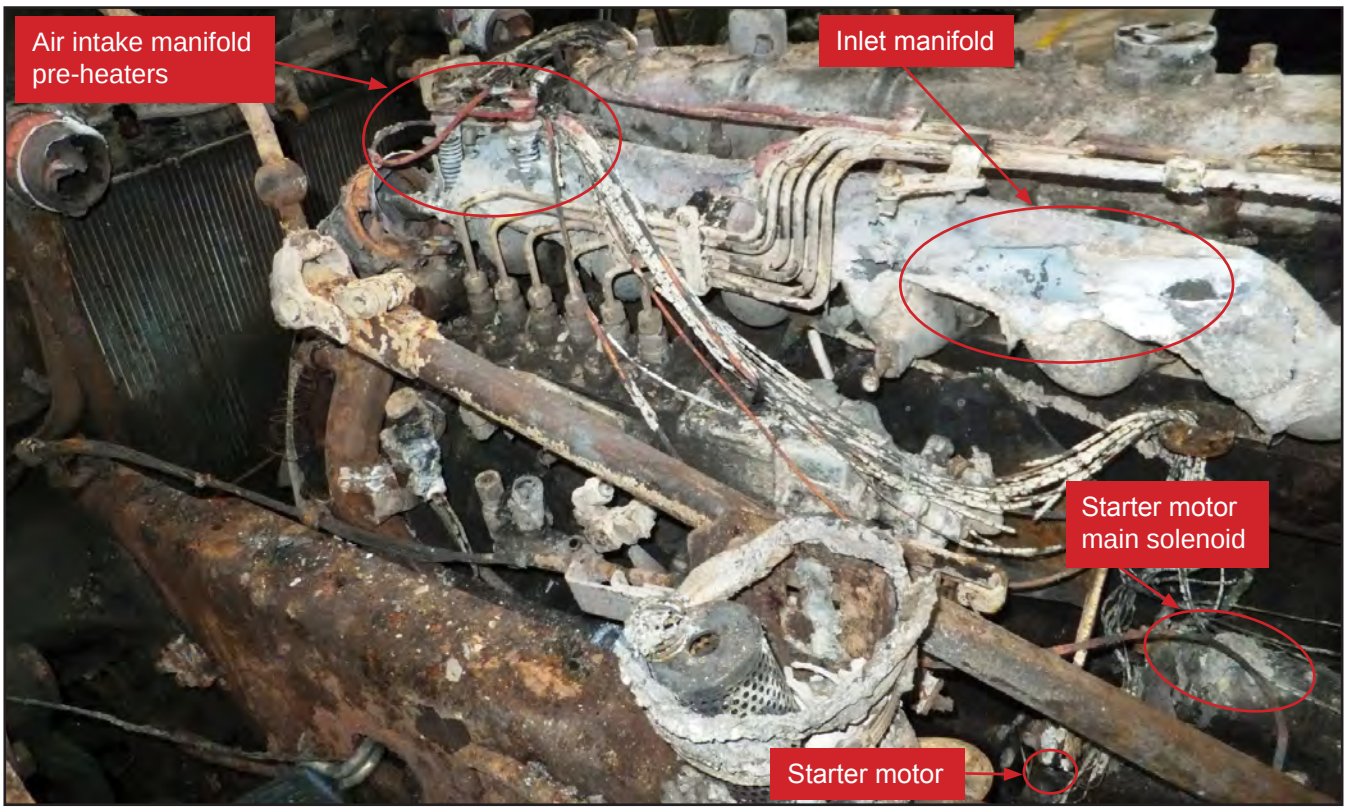


Figure 6: Fire damaged engine components

On dismantling the solenoid, the main contact post connecting the solenoid to the battery separated from the end cap, which exposed heavy arcing damage to the internal surfaces. The main contacts had suffered significant spark erosion and pitting. The moving contact had separated from its carrier, melted copper globules were found in the body of the solenoid, and the alternator connecting cable had melted through **(Figures 7** and **8)**.

The remote engine start solenoid was dismantled and found to be fully working. However, the engine pre-heat solenoid iron core was found seized within the electro-magnetic armature, and the contacts were in the 'open' position. Continuity testing confirmed there was no electrical path across the contacts.

1.8 EXAMINATION OF RENAULT MASCOTT-MASTER VAN

The van's cab was totally destroyed as were all of the tyres and the hinged drop-down sides. The van's fuel tank cradle was in place but there was no evidence of the fuel tank. It is unclear whether the tank was fitted at the time. The engine starting battery had partially melted and the cables had been disconnected, probably at the time that the engine cylinder head had been removed. There was also other loose steel framework in the van's cargo area.

1.9 LOW-PRESSURE FIXED CO_2 FIRE-EXTINGUISHING SYSTEM

Corona Seaways was fitted with a Danfoss-Semco low-pressure fixed CO_2 fire-extinguishing system. The CO_2 was held in a 21.3t capacity storage tank located in the CO_2 storage compartment in the vessel's port quarter. The compartment was equipped for local operation of the system. The system could also be operated

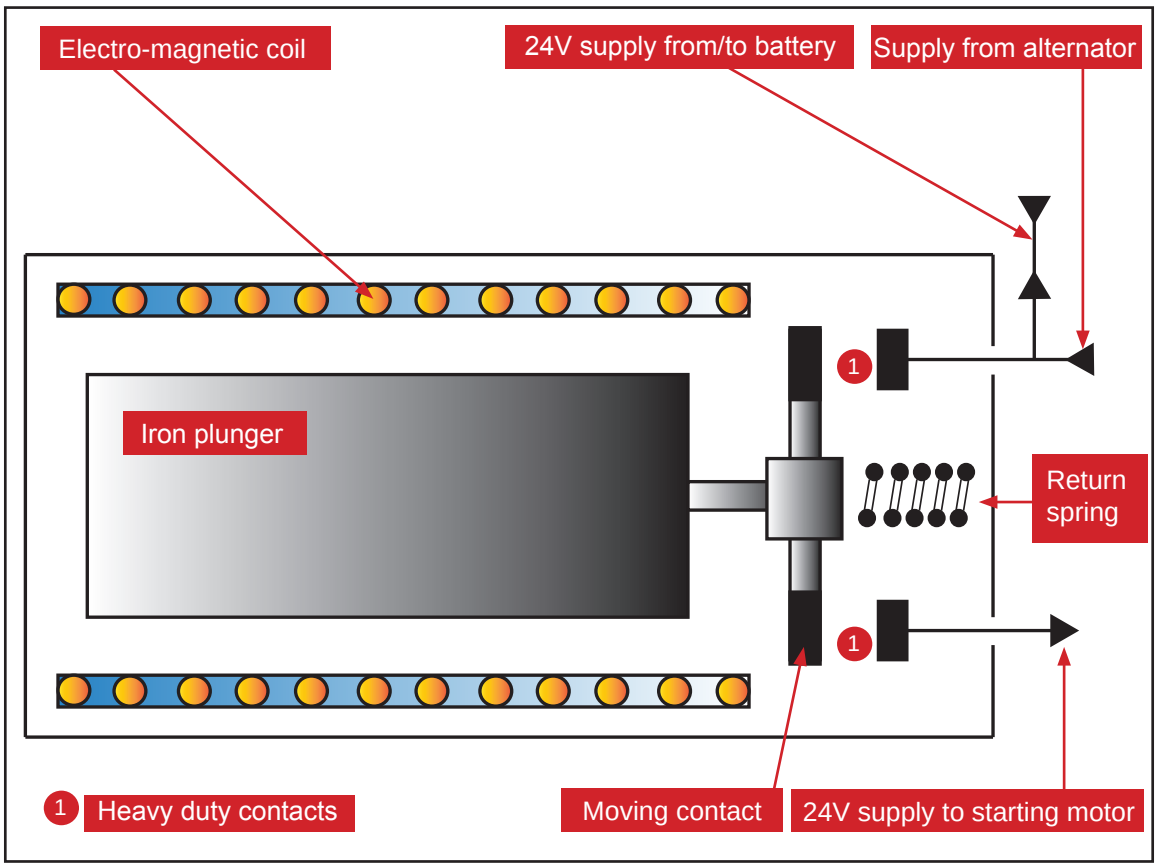


Figure 7: Schematic of engine starter motor main solenoid

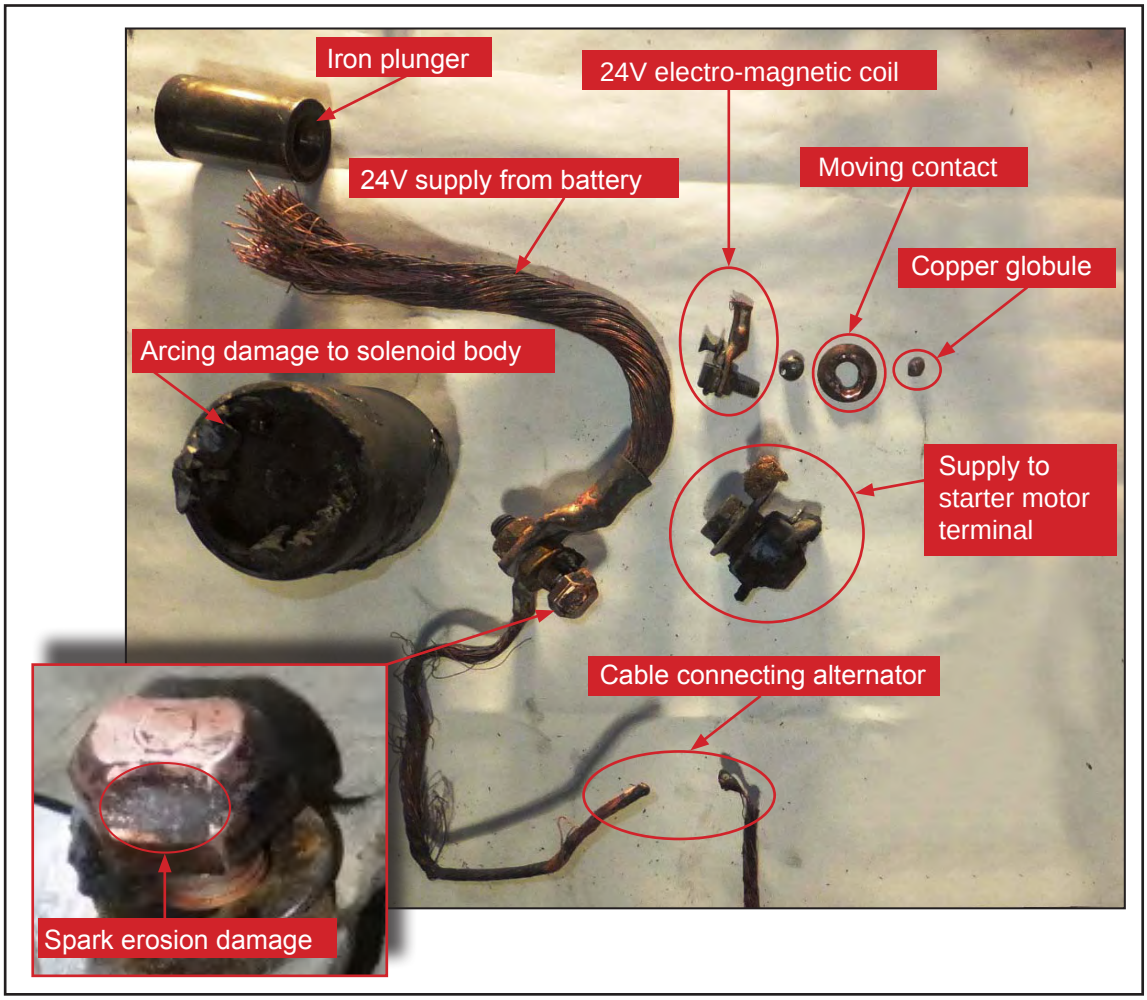


Figure 8: Damaged Renault Premium 250.18 truck engine starter motor main solenoid

from the remote operating station in the forward superstructure. Each of the compartments displayed a comprehensive system mimic diagram and operating instructions.

The timed discharge rate was designed to achieve the correct CO_2 concentration by compartment volume to extinguish a fire. The following compartments were protected: engine room; emergency generator room; separator room; paint store (between 0.3 and 4t of CO_2 were required over 2 minutes); lower hold and main deck (9 and 19.8t respectively over 15 minutes).

1.10 CARGO DECKS' VENTILATION ARRANGEMENTS

There was a total of 38 main deck ventilation jalousies. Six were located on the starboard side of the upper deck and 15 on each of the port and starboard sides of the weather deck. The jalousies serving the main deck were easily identifiable by a yellow-painted strip across their middle section[1]. Each jalousie comprised 11 manually operated louvres fitted with rubber sealing strips **(Figure 9)**.

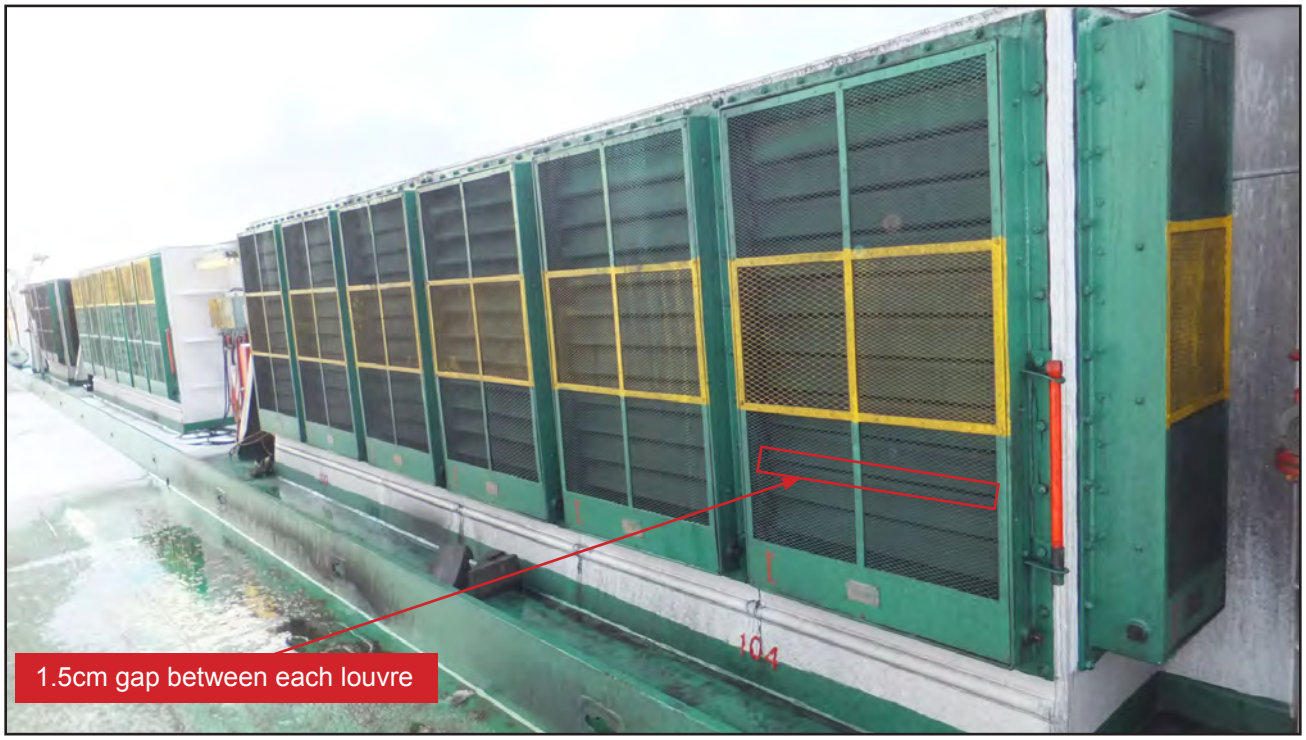


Figure 9: Main deck ventilation jalousie

There were also two automatically operated jalousies on the upper deck level at the port and starboard corners of the superstructure. These were linked to the fire alarm system and served both the main and upper decks.

The 14 fans servicing the main deck were controlled from the cargo control room. One was a dedicated exhaust fan, three were supply fans and the remainder were dual-purpose supply and exhaust fans.

It was normal practice to stop all cargo deck ventilation fans once loading was completed.

[1] Jalousies serving the lower hold and the upper deck were identified by a yellow-painted strip on their lower and upper sections respectively

1.11 REGULATION AND GUIDANCE

The International Convention for the Safety of Life at Sea 1974, as amended (SOLAS) Chapter II-2 – Fire protection, fire detection and fire extinction, Regulation 20, paragraph 3.1.2.2 states:

> *'In cargo ships, ventilation fans shall normally be run continuously whenever vehicles are on board. ….'.*

The instruction is reiterated in paragraph 8.7 of Marine Guidance Note (MGN) 341(M) Ro-Ro Ships Vehicle Decks – Accidents to Personnel, Passenger Access and the Carriage of Motor Vehicles, which states:

> *'…. ventilation systems serving the vehicle decks should be in operation during any loaded voyage……'*

The Code of Safe Working Practices for Merchant Seamen (COSWP) – Chapter 32 Ro-Ro Ferries paragraph 32.3.2 also covers the need to run ventilation fans while vehicles are on board. Section 32.7 – Inspection of Vehicles states:

> *'Before being accepted for shipment, every freight vehicle should be inspected externally by a competent and responsible person or persons to check that it is in a satisfactory condition for shipment.…'*

The Maritime and Coastguard Agency's (MCA) publication - The Code of Practice – Roll-On/Roll-Off Ships – Stowage and Securing of Vehicles, Section 1.1 identifies that a principal source of danger to ships and persons is the unsatisfactory condition or design of vehicles presented for shipment. Section 2.2 states:

> *'Before being accepted for shipment, every freight vehicle should be inspected externally by a responsible person or persons appointed by the ship owner, the ship manager and/or the master, to check that it is in a satisfactory condition for shipment.'*

1.12 SIMILAR ACCIDENT

At 0153 on 23 April 2013, a fire was discovered on No 3 cargo deck of the Lithuanian registered, and DFDS A/S operated, passenger ro-ro cargo ferry *Victoria Seaways* while on passage from Kiel to Klaipeda. At the time, there were 37 crew and 309 passengers on board. The fire was dealt with by the crew and was declared to be extinguished at 0400. The cargo included second-hand cars for export to Lithuania. Six cars and a car transporter were destroyed in the fire but there were no injuries or structural damage to the vessel.

The Lithuanian-led investigation identified that the fire was caused by an electrical fault on a second-hand car that was in poor condition.

The report included a recommendation to the effect that batteries of second-hand cars should be disconnected and that confirmatory checks should be made by the vessel's crew.

SECTION 2 – ANALYSIS

2.1 AIM

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

2.2 CAUSE OF THE FIRE

2.2.1 Renault Mascott-Master van

A number of potential causes of the fire were examined. The Renault Mascott-Master van was considered. However, its engine cylinder head had been removed and the battery was disconnected. As there was no viable ignition source on the van, it is not considered to be the origin of the fire.

2.2.2 Renault Premium 250.18 truck

The Renault Premium 250.18 truck had been driven about 240km before arriving at Fredericia and then onto the vessel. Neither the drivers nor stevedores reported any mechanical, electrical or instrumentation issues. However, the truck had not been driven for the previous 11 months and there was no evidence that any checks had been carried out to prove its roadworthiness or general safety, including the integrity of its electrical and mechanical systems.

The truck was lashed down about 8 hours before the fire was discovered. It had only been run for a short time during loading, and the chances of the fire starting from residual heat from the engine, exhaust or turbo-charger were negligible.

Although one of the truck's positive battery cables was disconnected and the batteries were heavily fire-damaged, there was no evidence of arcing in this area. Cables to the remote engine start and engine pre-heat solenoids, which were in the immediate vicinity, were virtually undamaged and can therefore be discounted as the cause of the fire. It is considered that the battery cable became disconnected as the terminal post melted and reduced in diameter, which released the cable securing clamp.

All the evidence, including the area of high heat energy and the burning and heavy radiant heat damage to the engine and to the front of the cab, indicated that the seat of the fire was located around the upper half of the engine. The engine starter motor main solenoid was severely damaged by internal arcing, which had destroyed the moving contact. As the engine pre-heat solenoid was defective, the air charge could not be pre-heated and the engine would have been difficult to start: there was anecdotal evidence that the engine had to be repeatedly cranked over to start it. It is probable that the internal arcing and damage to the engine starter motor main solenoid's fixed and moving contacts were initially due to repeated attempts to start the engine. This would have resulted in a continual current flow in the heavy duty cable from the battery which would have remained live despite the ignition switch being in the 'stop/park' position. Over time, continual arc tracking within the solenoid would have caused further damage and, together with the high current flow

experienced during engine starting, would have caused the cable to overheat, ignite the insulation and initiate the fire. As the insulation burnt, the now bare cable would have shorted, causing further sparks and for it to weld against the chassis.

2.3 FIRE DEVELOPMENT

Once the fire had started on the engine, it consumed insulation, plastic fittings and rubber hoses, and spread into the cab above and forward to destroy the glass fibre cab front. The 'V' shaped burn pattern at the rear of the cab indicated that the fire spread upwards. As the fire ignited the truck's tyres, the heat would have intensified, causing the fire to move aft and engulf the van and its tyres, and melt the truck's aluminium checker plate flooring. The location of the partially open ventilation louvres on *Corona Seaways'* upper deck was such that as the vessel made headway, a slight overpressure was created forward, resulting in a forward to aft air-flow on the main deck. This would explain why the vehicles forward of the truck suffered only minor damage and those behind were engulfed in the fire. While there was very little flammable material on the six trailers involved, their tyres would have added significantly to the generated heat energy.

2.4 RISKS OF THE CARRIAGE OF USED VEHICLES

The carriage of used vehicles and equipment that do not have appropriate road worthiness certification and whose history and condition are unknown, brings increased risks when compared with the carriage of well maintained vehicles that are in regular use.

2.4.1 Used vehicles – fire ignition risk

The vehicles routinely shipped on DFDS A/S's Baltic Sea route had often been laid up for long periods during which electrical insulation could become brittle, components could seize, and seals on fuel and oil systems could become ineffective, all contributing to an increased fire risk. Electrical systems that have been idle and are then connected to charged batteries are particularly vulnerable. The procedure to leave the ignition key in the 'stop/park' position did little to reduce the risk as many circuits still remained live. While there were other potential sources of ignition, including engine and turbo-charger residual heat transfer, and discarded lit cigarettes and heating equipment left in the cab, the prominent risk was electrically based. If the battery had been totally isolated, the risk would have been considerably reduced.

2.4.2 Vehicle checks

Following a car fire on board the Lithuanian registered ro-ro ferry *Victoria Seaways* on 23 April 2013, DFDS A/S introduced procedures to reduce the risk of fire. These included removing the battery, prohibiting the carriage of spare fuel or flammables, and requiring the vehicle's systems to be leak-free. However, the instruction applied only to used vehicles carried on designated car transporters.

The instruction was re-iterated by the master's undated 'Unsafe Cargo' notice displayed in several locations on board, including the cargo control room. In addition, the notice stated that for used, self-moving vehicles (not just those carried on

designated car transporters) loaded on board, the battery was to be disconnected or isolated by a switch, only a minimal amount of fuel was to be carried (approximately 5 litres), and the handbrake was to be engaged.

Drivers of designated car transporters signed a DFDS A/S check sheet to state that the requisite shipping conditions had been complied with. However, anecdotal evidence suggests that DFDS A/S contractors, who should have been verifying this, only occasionally carried out checks, but no documented evidence was identified or could be provided to corroborate this.

Furthermore, contrary to the MCA's Code of Practice there was no evidence that the vessel's crew made any vehicle electrical system isolations or other vehicle safety checks. Indeed, it would be very difficult for crew to safely isolate or remove battery connections in addition to their routine tasks of loading and securing the vehicles.

2.4.3 Vessel's safety instructions

The vessel's Ship Safety Management Manual (SSMM) Section SM11-11 – Cargo Operations, provided general instructions on stowing, lashing, ballasting and safety precautions. *Corona Seaways* also held risk assessments covering lashing and unlashing cargo, ro-ro cargo operations, and the loading/unloading of extraordinary cargo. However, neither the SSMM nor the risk assessments provided guidance on the specific risks associated with the carriage of used vehicles and equipment.

2.5 CREW'S FIRE-FIGHTING PRACTICE

The OOW's decision to send the on-watch AB to check the status of the main deck after the first fire alarm was reasonable and appropriate. He had no indication of a fire on the CCTV monitor, and he needed to clarify the situation. The AB also reasonably opted to check the main deck from the door. Had the AB ventured between the closely-packed cargo towards the seat of the fire he might have become trapped when the fire rapidly escalated, as observed by the master on the CCTV monitor.

The prompt use of the upper deck hydrants and, later, the drenching system to boundary cool the area above the fire was also well considered and helped to limit structural damage and the potential spread of the fire.

The speed at which the fire developed gave no opportunity to fight it with anything other than the fixed CO_2 fire-extinguishing system. It was therefore of the utmost importance that once the compartment was closed down the system was used, without delay, to maximise the chance of success.

Overall, the fire-fighting effort was well considered, effective and safely managed.

2.6 MUSTER STATIONS

While the crew were promptly ordered to their muster stations following the outbreak of the fire, it was 15 minutes before the chief officer was able to report to the bridge that the crew had been fully accounted for. The CO_2 system was ready to be used after 10 minutes, but there was a 5 minute delay in discharging the gas because the fitter's whereabouts were unknown. This allowed the fire to develop and demonstrates the importance of the crew reporting to their muster station promptly.

In other circumstances, the delay could have been critical. Many companies issue all crew members with portable radios to ease communication problems. Had the fitter been equipped with a radio, he could have been quickly accounted for.

2.7 FUNCTIONALITY OF THE LOW PRESSURE FIXED CO_2 FIRE-EXTINGUISHING SYSTEM

Although there was confusion about the actual amount of CO_2 discharged onto the main deck due to the information indicated on the storage tank contents gauge, the decisions to re-inject CO_2 were sensibly judged.

On 6 December, the CO_2 system was serviced by Wilhemsen Ships Service. The system was re-charged and underwent a comprehensive range of checks, including confirmation that the storage tank contents gauge was working correctly. However, there was no explanation for why the system apparently failed to discharge the allotted quantity of CO_2 as designed. It is vitally important that the crew have total confidence in the CO_2 system as there is no backup fixed fire-extinguishing system for the cargo decks.

2.8 CARGO DECK VENTILATION ISSUES

2.8.1 Isolation of ventilation supplies

It is important that a compartment is fully closed down before CO_2 is injected both to reduce any inflow of oxygen feeding the fire and to ensure the correct concentration of CO_2 is maintained to extinguish a fire. Although CO_2 is denser than air and will take time to dissipate through ventilators, the tighter a compartment is sealed the better the chance of success.

While the ventilation louvres were reported closed, smoke continued to emit from them for most of the incident. On investigation, it was found that there was a misunderstanding on board on how to lock the louvres in the ‘closed’ position. Not all crew were aware that two persons were required or of the need to rotate the operating spindle past the apparent ‘closed’ point to lock the louvres shut against the cam system. It was also noted that the vessel’s Training Manual did not cover the process.

During trials, it was found that there was an average gap of about 1.5cm between each of the eleven louvres in each of the 34, 1-metre wide jalousies when the louvres were in the ‘closed’ but not ‘locked’ position. This equated to a hole of approximately $5m^2$ through which CO_2 could escape, or air (oxygen) could be drawn in.

2.8.2 Operation of cargo deck ventilation fans

Flammable vapours that evolve from vehicles stowed on ro-ro cargo decks create an inherent fire risk. During the investigation, it was noted that it was usual practice on *Corona Seaways* for the cargo fans to be stopped once cargo operations were completed. SOLAS, COSWP and MGN 341(M) highlight the need for ventilation to be maintained while vehicles are on board to remove vapours and so minimise the risk of fire.

2.9 DRUG AND ALCOHOL POLICY AND PASSENGERS

The management company's drug and alcohol policy was set out in Document CSMM 02-06 of the Company Safety Management Manual. The policy covered the company's shore personnel and crew, but not passengers.

It is difficult to develop a policy preventing vehicle drivers/passengers from bringing alcohol on board for personal consumption. The control of vehicle drivers/passengers that have consumed alcohol requires careful management, especially during an emergency. The chief officer struck an appropriate balance in removing them from the muster station to the passenger lounge where they were safe, could be easily evacuated and were not disruptive to the management of the emergency.

SECTION 3 - CONCLUSIONS

3.1 SAFETY ISSUES DIRECTLY CONTRIBUTING TO THE ACCIDENT THAT HAVE BEEN ADDRESSED OR RESULTED IN RECOMMENDATIONS

1. There was no evidence that any checks had been carried out to prove the truck's roadworthiness or general safety, including the integrity of its electrical and mechanical systems. [2.2.2]

2. The carriage of used vehicles and equipment that do not have appropriate roadworthiness certification and whose history and condition are unknown brings increased risks when compared to the carriage of well maintained vehicles that are in regular use. [2.4]

3. DFDS A/S's fire risk control measures introduced after the fire on board *Victoria Seaways* applied only to used vehicles carried on designated car transporters. There was no documented evidence that these control measures were carried out. [2.4.2]

4. Contrary to the spirit of the MCA's Code of Practice and the master's 'Unsafe Cargo' notice, there was no evidence that the vessel's crew carried out vehicle safety checks. [2.4.2]

5. Neither the SSMM nor the onboard risk assessments covered the carriage of used vehicles and equipment. [2.4.3]

3.2 OTHER SAFETY ISSUES DIRECTLY CONTRIBUTING TO THE ACCIDENT[2]

1. The engine starter motor main solenoid was severely damaged by internal arcing, which had destroyed the moving contact. [2.2.2]

2. The heavy duty cable connecting the battery to the engine starter motor main solenoid was live and permitted unintended electrical arcing inside the solenoid which, together with high current flow experienced during engine starting, caused the cable to overheat and initiate the fire. [2.2.2]

3. The defective engine pre-heat solenoid prevented the air charge from being pre-heated, making the engine difficult to start. [2.2.2]

3.3 SAFETY ISSUES NOT DIRECTLY CONTRIBUTING TO THE ACCIDENT THAT HAVE BEEN ADDRESSED OR RESULTED IN RECOMMENDATIONS

1. Injection of CO_2 into the main deck was delayed, allowing the fire to develop, because it took time to establish the fitter's whereabouts during the crew muster. [2.6]

2. The reason why the CO_2 fire-extinguishing system apparently failed to discharge the allotted quantity of CO_2 as designed remains unexplained. [2.7]

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[2] These safety issues identify lessons to be learned. They do not merit a safety recommendation based on this investigation alone. However, they may be used for analysing trends in marine accidents or in support of a future safety recommendation.

3. The main deck ventilation louvres were not fully closed and some of the crew were unaware how to correctly operate them. This allowed air (oxygen) to feed the fire and potentially affected the CO_2 concentration levels needed to extinguish the fire. [2.8.1]

4. The cargo deck ventilation fans were not operated as required by the current regulations. This increased the fire risk due to the potential build-up of flammable vapours from vehicles. [2.8.2]

3.4 OTHER SAFETY ISSUES NOT DIRECTLY CONTRIBUTING TO THE ACCIDENT[3]

1. Vehicle drivers/passengers who had consumed alcohol were disruptive and started to affect the chief officer's management of the incident. [2.9]

[3] These safety issues identify lessons to be learned. They do not merit a safety recommendation based on this investigation alone. However, they may be used for analysing trends in marine accidents or in support of a future safety recommendation

SECTION 4 - ACTIONS TAKEN

Ellingsen Ship Management AB has:

- Developed risk assessment DE45 -14 - Ro-Ro Cargo Operation “Scrap Vehicle”.
- In respect to the ventilation system:
  - Developed risk assessment DE46-14 - Cargo and Engine Louvre Monthly Performance Test.
  - Introduced a 4-monthly maintenance item to check the full operation of the ventilation louvres and to conduct a watertightness check.
  - Provided instructions and illustrations on how to correctly operate the ventilation louvres for inclusion in the ship’s Training Manual Part 3.
- Instructed all vessels’ masters to highlight the importance of prompt mustering in an emergency during monthly Safety Committee Meetings.

DFDS A/S has:

- Promulgated the following revised procedures, which include full isolation of batteries and their terminals, and checks for oil and oil leaks, to improve the safe carriage of used and unregistered vehicles:
  - ‘Information to Car Carriers’ dated 28 January 2014 **(Annex A)**.
  - ‘Information to Unregistered Second Hand Segment’ dated 28 January 2014 **(Annex B)**.
- Introduced a system of signed checks by a technician as part of its ‘Instruction – Delivery Note, Single/Empty Units’ dated 6 January 2014, to ensure customer compliance with the conditions of carriage **(Annex C)**.

SECTION 5 - RECOMMENDATIONS

Ellingsen Ship Management AB is recommended to:

2014/127 Review its onboard documentation and the 'Unsafe Cargo' notice to take into account DFDS A/S's revised procedures for the carriage of used and unregistered vehicles:

- 'Information to Car Carriers' dated 28 January 2014.
- 'Information to Unregistered Second Hand Segment' dated 28 January 2014.

2014/128 Take appropriate action to:

- Ensure that cargo deck ventilation fans are run in accordance with current regulations.
- Investigate why the CO_2 fire-extinguishing system apparently failed to discharge the allotted quantity of CO_2 as designed.

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

Annex A

DFDS/AS Instruction - Information to Car Carriers dated 28 January 2014

Information to Car Carriers

Safety precautions to be taken prior loading Car Carrier onboard the vessel 28.01.2014

Safety precautions

Dear Customer,

DFDS A/S is committed to providing the best possible service to our customers and to ensuring the comfort and safety of all passengers and crewmembers on board our vessels. With that in mind, we are taking this opportunity to update all customers using the routes in the Baltic Sea of the following mandatory safety measures to be taken whenever second hand and/or damaged vehicles loaded on Car Carriers are to be shipped.

To minimise the risk of fire accidents, it is your responsibility to ensure that, apart from the previously introduced safety precautions (please refer yourself to DFDS' Newsletter dd. 29.04.2013), the following measures are also to be taken prior to shipment:

- **The batteries are completely disconnected - all cables**
- **The battery terminals are properly isolated**
- **The batteries have no visible damage**

All Car Carriers with second hand and/or damaged vehicles will be inspected in the port of loading and, based on the facilities available at the individual ports and on the routes, an inspection fee will be imposed.

Any Car Carriers that do not comply with these essential requirements will not be accepted for carriage on our vessels.

Your continuing co-operation in helping us to provide a safe travelling environment is very much appreciated. If you have any questions, please contact your local DFDS Seaways representative.

Sincerely yours,

DFDS A/S

Annex B

DFDS A/A Instruction - Information to Unregistered Second Hand Segment
dated 28 January 2014

Information to unregistered second hand segment

Safety precautions to be taken prior loading onboard the vessel 28.01.2014

Safety precautions

Dear customer,

DFDS A/S is committed in providing the best possible service to our customers and to ensure the comfort and safety of all passengers and crew members on board our vessels. With that in mind, we are taking the opportunity to update all customers using the routes in the Baltic Sea of the following mandatory safety measures to be taken whenever unregistered second hand and /or damages vehicles are to be shipped.

To minimize the risk of fire accidents, DFDS will arrange for an pre-shipment inspection of all vehicles within the segment mentioned above, where the following measures will be carried out:

- **The battery cables are disconnected completely**
- **The battery terminals are properly isolated**
- **The vehicle itself is determined in general condition not compromising any safety requirements**

All unregistered second hand vehicles, or other units carrying similar vehicles will be inspected in the port of loading and, based on the facilities available at the individual ports and on the routes, an inspection fee and/or a handling fee will be imposed.

Any unregistered second hand vehicle that do not comply with these essential requirements will not be accepted for carriage on our vessels.

Your continuing co-operation in helping us to provide a safe travelling environment is very much appreciated. If you have any questions, please contact your local DFDS Seaways representative.

Sincerely yours,

DFDS A/S

Annex C

DFDS A/S Instruction – Delivery Note, Single/Empty Unit dated 6 January 2014

Delivery Note, single/ empty unit

DFDS

Fredericia/Copenhagen – Klaipeda v.v

Updated: 06.01.2014

Date:	Shipper:
Phone no.:	Consignee:
Brand of unit:	Serial number:

Can the unit drive on to mafi?	YES	NO
Tara weight:		KG
Payable in:	FRC	KLJ

Conditions:
Orders undertaken as the Carrier of multimodal transports and Port-to-Port/Gate-to-Gate transports are carried out subject to our Bill of Lading/Waybill Conditions (NSFCC – North Sea Freight Conditions of Carriage, current edition). Special attention is drawn to the fact that lien is applicable in both present and previous orders (clause 4) and that freight shall be deemed earned on our receipt of the goods, and shall be paid regardless of the goods being lost (clause 3). In addition, in multimodal transports our liability for loss or damage to the goods is limited to SDR 2,00 per kilo (clause 16.5) and in respect of delay to a maximum of the freight for the transport (clause 14.2) For multimodal transports all liability of our shall become time barred within 9 months and for Port-to-Port/Gate-to-Gate transports within 12 months after delivery of the goods (clause 12).

I confirm above conditions:

Date: Signature:

Statement:

(Filled out by DFDS only)

The ignition is switched off	
The battery is disconnected and the battery terminals is properly isolated	
The interior of the car and the luggage compartment are free of any loose items, in particular oily rags, batteries, any kind of liquids and empty containers	
There are no dripping oil/fuel leakages, or signs or traces of such leakages	
Fuel tanks are not 100% full to prevent overflowing due to the movement of the ship	
Spare cans of fuel are not carried	

Date: Technician signature:

Delivery Note, loaded units

DFDS

Fredericia/Copenhagen – Klaipeda v.v

Updated: 06.01.2014

Date:	Shipper:
Phone no.:	Consignee:
Brand of unit:	Serial number:
Unit reload 1: Brand of unit:	Serial number:
Unit reload 2: Brand of unit:	Serial number:
Can the unit drive on to mafi?	YES NO
Tara weight:	KG
Payable in:	FRC KLJ

Conditions:

Orders undertaken as the Carrier of multimodal transports and Port-to-Port/Gate-to-Gate transports are carried out subject to our Bill of Lading/Waybill Conditions (NSFCC – North Sea Freight Conditions of Carriage, current edition). Special attention is drawn to the fact that lien is applicable in both present and previous orders (clause 4) and that freight shall be deemed earned on our receipt of the goods, and shall be paid regardless of the goods being lost (clause 3). In addition, in multimodal transports our liability for loss or damage to the goods is limited to SDR 2,00 per kilo (clause 16.5) and in respect of delay to a maximum of the freight for the transport (clause 14.2) For multimodal transports all liability of our shall become time barred within 9 months and for Port-to-Port/Gate-to-Gate transports within 12 months after delivery of the goods (clause 12).

I confirm above conditions:

Date: Signature:

Statement:

(Filled out by DFDS only)

Units:		1	2
The ignition is switched off			
The battery is disconnected and the battery terminals is properly isolated			
The interior of the car and the luggage compartment are free of any loose items, in particular oily rags, batteries, any kind of liquids and empty containers			
There are no dripping oil/fuel leakages, or signs or traces of such leakages			
Fuel tanks are not 100% full to prevent overflowing due to the movement of the ship			
Spare cans of fuel are not carried			
Cargo is properly loaded and lashed safely			

Date: Technician signature:

Marine Accident Report