Report of investigation

into a fire in the aft engine room of ro-ro ferry

Norsea

on 2 September 2002

Marine Accident Investigation Branch
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Report No 16/2003
June 2003

Extract from

The Merchant Shipping

(Accident Reporting and Investigation)

Regulations 1999

The fundamental purpose of investigating an accident under the Merchant Shipping (Accident Reporting and Investigation) Regulations 1999 is to determine its circumstances and the causes with the aim of improving the safety of life at sea and the avoidance of accidents in the future. It is not the purpose to apportion liability, nor, except so far as is necessary to achieve the fundamental purpose, to apportion blame.

Note

This report is not written with liability in mind and is not intended to be used in court for the purpose of litigation. It endeavours to identify and analyse the relevant safety issues pertaining to the specific accident, and to make recommendations aimed at preventing similar accidents in the future.

CONTENTS

GLOSSARY

ARPA	:	Automatic radar plotting aid
BA	:	Breathing apparatus
CCTV	:	Closed circuit television
cm	:	centimetre
C/E	:	Chief engineer
2/E	:	Second engineer
3/E	:	Third engineer
2/O	:	Second officer
CO_2	:	Carbon dioxide
cSt	:	Centistokes
°C	:	Degrees celsius
DGPS	:	Differential global positioning system
EO	:	Engineer officer
ETO	:	Electrical technical officer
GPS	:	Global positioning system
IMO	:	International Maritime Organization
kg	:	kilogram
LSA	:	Life saving appliances
m	:	metre
“Mayday”	:	Distress signal
MCA	:	Maritime and Coastguard Agency
MCR	:	Machinery control room
MF	:	Medium frequency
MRCC	:	Maritime Rescue Co-ordination Centre

MRSC	:	Maritime Rescue Sub-Centre
PA	:	Public address
“Pan Pan”	:	Urgency signal
POM	:	Petty officer motorman
ro-ro	:	roll on, roll off
RMS	:	Royal Mail ship
SOLAS	:	Safety of Life at Sea (convention)
UK	:	United Kingdom
UMS	:	Unmanned machinery spaces
UTC	:	Universal co-ordinated time
VDR	:	Voyage data recorder
VHF	:	Very high frequency

SYNOPSIS

While on passage from Hull to Zeebrugge, with 487 passengers and 124 crew on board, the passenger ro-ro ferry *Norsea* suffered a fire in her aft engine room during the early hours of 2 September 2002. She was about 7 miles off the East Anglian coast.

Shortly after 0048, the watchkeeping third engineer made commendable efforts to extinguish the fire before raising the alarm at 0051. After the arrival of all off-duty engineers in the machinery spaces, the chief engineer decided the aft engine room would have to be closed down and carbon dioxide injected to smother the fire. The necessary steps were taken, and carbon dioxide was injected at 0116.

Although one main engine in the forward engine room was still operational, because the vessel's main gearboxes are in the aft engine room, all propulsion power was lost. As the weather conditions were good, the vessel was able to drift without serious risk.

Assistance was requested from Yarmouth Maritime Rescue Co-ordinating Centre. Various units responded and shore-based firefighters boarded the vessel.

At 0508, firefighters and ship's crew entered the aft engine room and found the fire had been extinguished. Following checks throughout the space, two main engines were restarted and the vessel continued her passage, arriving at her berth in Zeebrugge at 1602 that day. There had been no loss of life, but the third engineer was affected by smoke inhalation.

The fire was caused by the failure of a low-pressure fuel pipe on the main diesel generator in the aft engine room.

Norsea also had a fire in the forward engine room on 14 August 2002. This was caused by ignition of thermal heating oil, which had soaked into the lagging on an engine exhaust pipe during repairs. There is no connection between the causes of the two fires.

Following their investigation of the accidents, the owners addressed a number of issues.

Recommendations have been addressed to the MCA and to the manufacturers of the generator's engine, which, if implemented, should help in preventing a recurrence of the accident.

Photograph courtesy of P&O Ferries

Norsea

Figure 1

SECTION 1 - FACTUAL INFORMATION

1.1 PARTICULARS OF *NORSEA* AND ACCIDENT

Name	:	*Norsea* **(Figure 1)**
Type	:	Passenger ro-ro ferry
Flag	:	UK
Port of registry	:	Hull
IMO Number	:	8501957
Gross tonnage	:	31 785
Length	:	179.2m
Year built	:	1987
Builder	:	Govan Shipbuilders Ltd Glasgow
Main machinery	:	Four Sulzer diesels, geared to two controllable pitch propellers. Two independent, Wartsila, diesel driven generators.
Crew	:	124
Passengers	:	487
Classification Society	:	Lloyd’s Register of Shipping
Owner	:	P&O North Sea Ferries King George Dock Hedon Road Hull HU9 5QA
Type of accident	:	Engine room fire
Casualties	:	No fatalities. One person affected by smoke
Time, date and position	:	0044 on 2 September 2002, 52° 47.7’ N 001° 47.5’E

1.2 NARRATIVE

Note: All times are quoted as UTC on 2 September 2002 and most are taken from the vessel's voyage data recorder (VDR). Where other sources of information indicate times that slightly disagree with the VDR, such as from eyewitnesses, for consistency those from the VDR are taken as correct.

Norsea left Hull, UK, at 1800 on 1 September 2002, with 487 passengers and 124 crew on board, for a passage across the North Sea to Zeebrugge, Belgium.

At 0040 the next day, the vessel was making a speed of about 16.5 knots off the Norfolk coast, east of England, on a course of 138°, in position 52° 47.7'N 001° 47.5'E **(Figure 2)**.

At 0044 the watchkeeping third engineer (3/E) was in the forward engine room, walking aft, when the local alarm panel indicated a fire alarm. He went through the watertight doors into the aft engine room, closing the door after him, and then through the watertight door at the aft end of the aft engine room. He partially closed this door behind him, and entered the machinery control room (MCR).

The fire alarm panel readout in the MCR indicated 'forward engine room fan room'. After speaking to the bridge watchkeeping second officer (2/O), the 3/E left the MCR to walk forward to investigate the cause of this alarm. In his first few steps into the aft engine room, his eyes became irritated and he smelled what he thought might be insulation burning.

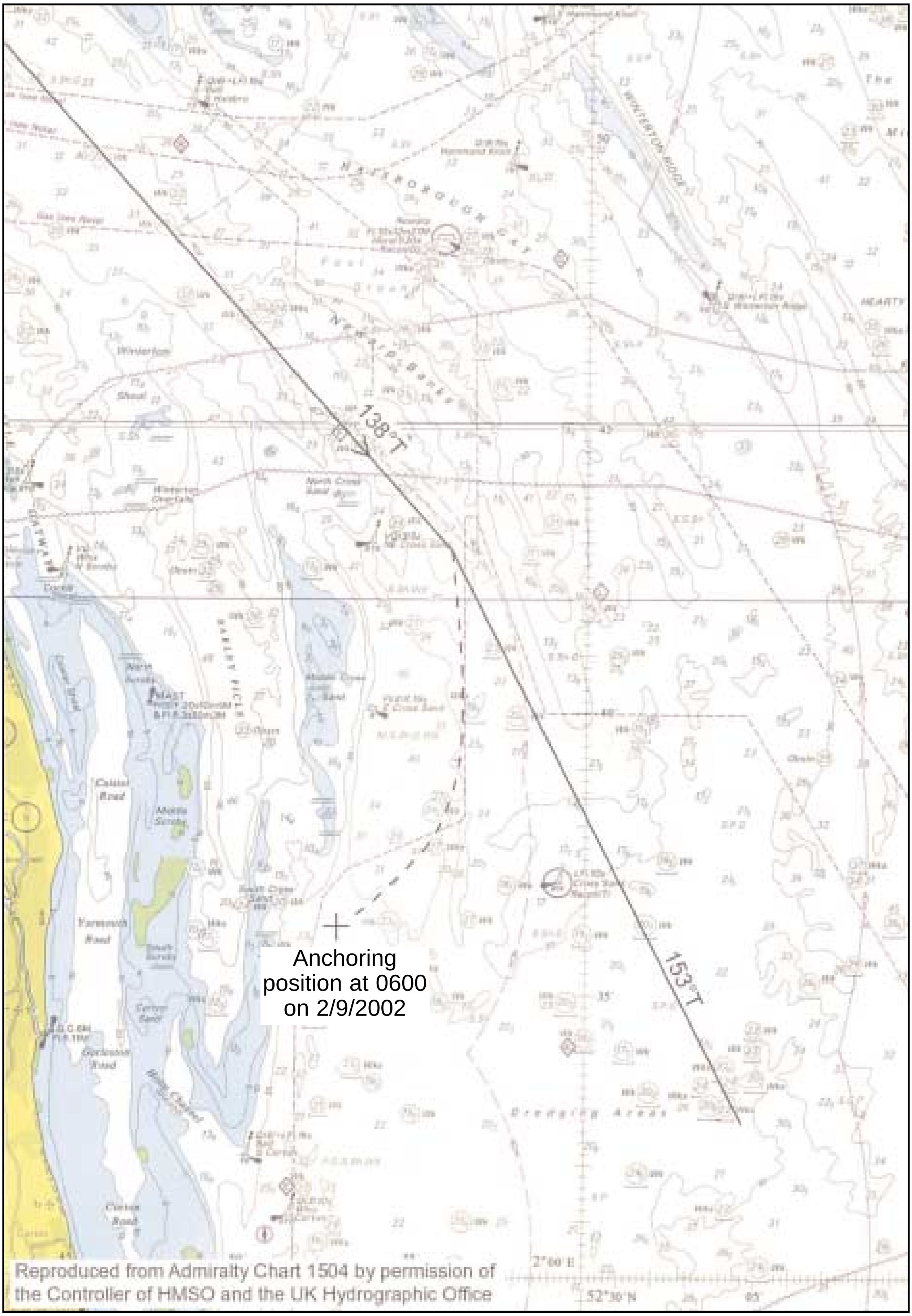
The 3/E did not see smoke, but he moved to the aft end of the starboard engine where the smell was stronger. The smell was so strong, he returned immediately to the MCR and telephoned the bridge and spoke to the 2/O. He asked for the call-out engineer to be alerted and to be told to go to the engine room. The time was 0048. He also stated that there was a tremendous smell of fire. While in the MCR, the 3/E noticed another fire alarm readout, this time for the aft engine room.

The 3/E returned to the aft engine room through the watertight door, and immediately saw flames at the forward end of the generator's engine. The flames were about 30cm high, but with little smoke.

Meanwhile, the 2/O contacted the call-out engineer at 0049, asked him to go to the engine room and told him of the reported tremendous smell of fire.

Taking one of the portable fire extinguishers stowed by the watertight door, the 3/E went to the port side of the alternator and aimed the extinguisher at the top of the generator's hot box cover, beneath the cover and on the lower part of the engine, beneath his feet. This extinguished all flames he could see in these areas.

Figure 2


138°T
153°T
Anchoring position at 0600 on 2/9/2002
Reproduced from Admiralty Chart 1504 by permission of the Controller of HMSO and the UK Hydrographic Office

He returned to the watertight door and activated the engineers' dedicated fire alarm. This was at 0051. Because the flames had burst out again, the 3/E returned to the generator. Again, he extinguished flames on and beneath the hot box, on the lower part of the engine and on its starboard side. He could see no other flames at this stage.

He returned to the MCR, started the diesel generator in the forward engine room, put it on load and shut down the fire-affected aft generator.

He returned to the aft engine room and again saw flames on and around the hot box of the generator; this time to a much greater degree.

Collecting a second extinguisher stowed by the watertight door, the 3/E returned to the generator, where the flames were very much larger, some 2 metres high. Again, he put out all those he could see. He then went to the lower level of the aft engine room, by the generator, with the objective of closing the quick closing valve on the fuel line serving this engine.

However, in spite of knowing this valve and its position very well, he was unable to locate it. At this stage, he decided it was prudent for him to leave the engine room and return to the MCR. A later medical examination showed that he was affected by carbon monoxide poisoning.

By this stage, the call-out engineer had reached the MCR complex and was standing by the open watertight door to the aft engine room. He did not enter the aft engine room because of high smoke levels. Instead, he called to the 3/E who soon appeared at the door, after climbing from the lower level. The watertight door was closed behind the 3/E as he left the aft engine room.

All the other engineers had responded to the engineers' dedicated fire alarm and were, by then, in the MCR complex. At 0055, a telephone call to the bridge from the MCR reported a fuel spill in the aft engine room, some smoke, and that the generators had been changed over.

Off duty deck officers had also responded to the dedicated engineers' fire alarm and were on the bridge.

At 0057, it was recognised that the master was not on the bridge and it was decided to alert him by telephone.

Two engineers donned breathing apparatus (BAs) to prepare for entering the aft engine room. Once ready, the watertight door was opened but, because so much black smoke came out, the door was shut without making an entry.

The closed circuit television (CCTV) screen in the MCR showed a white spot on its screen. This image was interpreted as a flame on the generator. The chief engineer (C/E) began to plan for flooding the aft engine room with carbon dioxide (CO_2) smothering gas. Two engineers were sent to the funnel deck to close the ventilation flaps of the aft engine room and, from the MCR, the second engineer (2/E) stopped the ventilation fans to the aft engine room.

In response to the telephone call, the master was on the bridge at 0102. The main engine shutdown began at 0102.

The master contacted the C/E in the MCR to discuss the emergency. The C/E stated his wish to use CO_2. Therefore, a 'working party red' message was broadcast on the Public Address (PA) system at 0106. At the same time, Group 4 remote stops, serving the low and high-pressure fuel oil booster pumps for the aft main engine room, were operated from the bridge at the C/E's request.

From the safety control room, the C/E and 2/E operated the hydraulically operated quick-closing valves serving fuel and oil systems for the aft engine room. One of these valves was on the fuel supply line to the aft generator. Two other engineers were sent to check the aft bulkhead of the forward engine room for hot spots.

Yarmouth Maritime Rescue Co-ordinating Centre (MRCC) received a satellite telephone message from the ship requesting assistance at 0110.

For boundary cooling purposes, several sections of the drencher system over the aft engine room were activated at 0111. At about this time the ventilation flaps to the aft engine were confirmed shut.

At 0113, in a PA announcement, the master requested passengers to make their way to assembly stations.

By that stage, all was considered ready for release of CO_2 into the aft engine room. Once a satisfactory headcount of engineering staff had been made, the C/E and a 3/E went to the aft engine room's CO_2 release cabinet on the main vehicle deck, F deck. The cabinet's door was unlocked, opened and the main valve and pilot-gas bottle valve were opened. Release of the main gas bottles was confirmed by the chilling effect of the gas on the manifold. This was at 0116.

At 0118 the master broadcast a "Mayday" on VHF Channel 16, indicating his vessel had a fire in the engine room and that 600 persons were on board.

He then broadcast a second PA announcement, instructing passengers to proceed to assembly stations and for crew to perform general emergency duties.

The vessel's lifeboats were reported lowered to embarkation level at 0132.

Crew members, allocated the task of locating hot spots on the engine room casing and bulkheads, reported at various times that no signs of heating were being found.

Checks on the accumulation of drencher water on F deck showed that water was draining correctly from the main vehicle space.

At 0142, the master and C/E discussed progress of the accident, the absence of casing hot spots and the availability of remaining CO_2 bottles for a second injection of gas, should it be required.

The master then made another PA announcement to passengers, asking them to remain at their assembly stations, and reporting that the accident was under control.

The master made a further PA announcement, asking passengers to remain within the accommodation spaces, as a helicopter would soon be approaching the vessel. He explained that any passengers on an open deck ran the risk of being blown overboard by downdraught.

Rescue helicopter R125 arrived on scene at 0212. Its winchman was on board *Norsea* at 0217.

At 0231, the master made another PA announcement to the passengers. He told them the situation was under control and that the C/E was waiting for the engine room to cool.

The vessel was told at 0236 that another helicopter, R128, was heading for the vessel with three firefighters. Expected time of arrival was a further 10 minutes.

Further discussions between the master and C/E resulted in a decision to wait until the arrival of shore-based firefighters before making an entry into the aft engine room.

The three firefighters from rescue helicopter R128 were on board *Norsea* at 0304. The drencher pump was stopped at this stage.

The passengers were told of the firefighters' arrival in another PA announcement.

Rescue helicopter R125 returned to *Norsea* at 0321 and lowered two firefighters on board. A further seven remained on the helicopter, which then stood by. The CCTV in the aft engine room showed that visibility in the space was improving. The C/E and the senior fire officer discussed plans for entering the aft engine room.

Some of the surface vessels which responded to the "Mayday" were released from the scene at 0329.

The seven firefighters remaining on R125 were lowered on to *Norsea* at 0338. Several more vessels in attendance were released at 0408.

Following discussions between the master, C/E and the senior fire officer, it was decided to start ventilation of the aft engine room with a view to making an entry.

One ventilation fan for the aft engine room was started at 0452. Fire teams stood by at the forward and aft watertight doors of the aft engine room.

At 0508 the aft watertight door was opened and firefighters, with BA sets, entered the aft engine room. The atmosphere was clear of smoke and visibility was good. Use of the breathing apparatus was not necessary.

The C/E confirmed that the fire was out at 0511 but reported some residual heat. Examination of the full height of the aft engine room casing showed it was clear of fire and smoke through to the funnel.

At 0528 the master requested Yarmouth MRCC to downgrade the “Mayday” to a “Pan-Pan”, until main propulsion became available. The passengers were told, in a PA announcement, that the fire was out, the vessel was safe and that they could stand down from their assembly stations.

The vessel was slowly drifting south during the earlier parts of the accident. However, from about 0500 this drift became south-west, towards Middle Cross Sands. Preparations were made to anchor the vessel to arrest this drift.

At 0600, the vessel was anchored in position 52° 36.4’N 001° 53.8’E, with one anchor down.

Preparations were made to start *Norsea*’s main engines at 0700. At 0723, two of the vessel’s four main engines were running and she was ready to proceed on passage. At 0758, the “Pan-Pan” was cancelled.

The anchor was weighed at 0813 while the shore firefighters were recovered by helicopter. All remaining surface vessels were released by Yarmouth MRCC, except Lowestoft lifeboat. This remained with *Norsea* until she passed Southwold. There, co-ordination of the accident passed to Thames Maritime Rescue Sub-Centre (MRSC) who monitored the vessel until her arrival in Zeebrugge.

The last of the shore personnel were off the vessel at 0836 and she resumed her passage to Zeebrugge.

Norsea arrived alongside her berth in Zeebrugge at 1602 on 2 September 2002.

There were no fatalities, but the third engineer was affected by smoke inhalation.

1.3 GENERAL DESCRIPTION OF VESSEL

Norsea is a Class II stern loaded/unloaded roll-on, roll-off (ro-ro) passenger/cargo ferry, operating a regular service between Hull, UK, and Zeebrugge, Belgium.

The decks are given an alphabetical designation, starting at the uppermost deck, A deck **(Figure 3)**.

Her passenger accommodation covers three decks. To ease passengers' identification of these decks they are known from upper to lower deck, as blue deck (B deck), red deck (C deck) and green deck (D deck). The uppermost of these decks, blue deck (B deck), is the lifeboat embarkation deck.

Most of the vessel's officers and crew have their accommodation on A deck. On the next deck above, situated at the forward end, is the wheelhouse.

Approximately the forward half of each passenger deck contains passenger cabins. The aft areas of these decks contain passenger services, such as restaurants, bars, shops etc.

Beneath the three passenger decks are the main vehicle spaces, which run virtually the full length of the vessel. Running longitudinally through approximately three-quarters of the length of these spaces, slightly offset to port from centre, is the central citadel. This contains stairways, lift shafts, engine casing, and various safety-related control spaces.

Beneath the main vehicle deck (F deck), taking up slightly less length than the aftermost half of the hull, are the main machinery spaces. Forward of the main machinery spaces, but below the main vehicle deck level, is the lower freight hold.

1.4 BRIDGE LAYOUT

On the bridge of *Norsea*, the helm is on the centre line, forward, in a steering console which also incorporates a rudder indicator, auto-pilot and associated controls.

The main engine controls are in another operating console, which is also forward, but to starboard of the steering console. An ARPA radar is on either side.

On both the extreme port and starboard sides of the bridge there is a docking radar, again housed in an operating console.

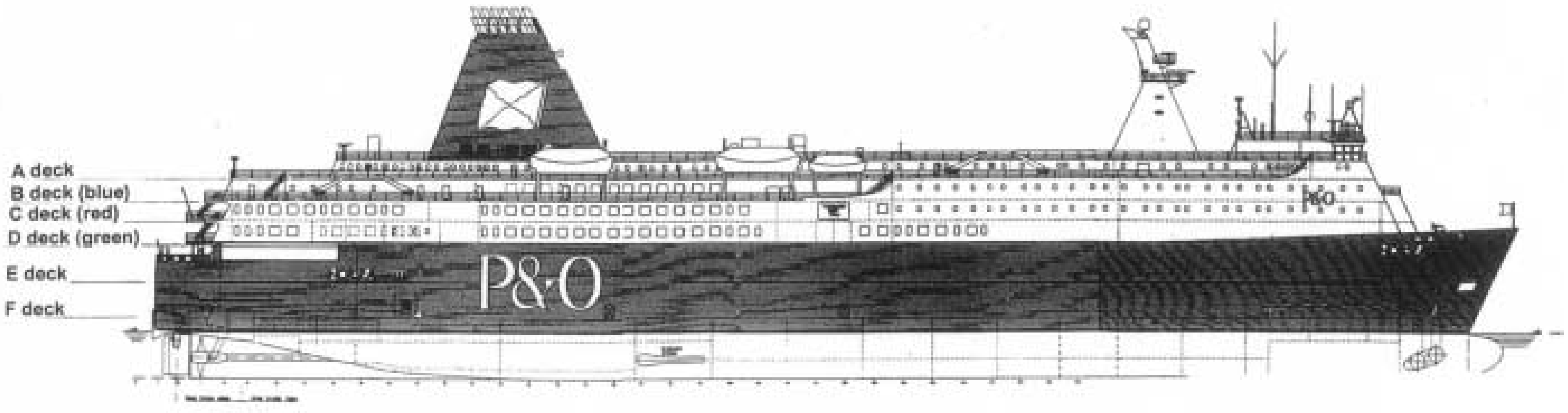


Figure 3

Norsea's alphabetical designation of decks

To the rear of the bridge on the starboard side is a semi-enclosed area that contains a chart table and various navigational equipment. On the port side, further consoles contain the stability controls, and again further to port, the radio instrumentation. Seating on the bridge is available for two watchkeeping officers.

The fire alarm indication panels are at the rear of the bridge on its aft bulkhead. There are two panels. One houses the indication, alarm and warning lights for a system covering the accommodation and passenger spaces. The other covers the vehicle decks, engine room and spaces below the accommodation including the uptakes.

Norsea is fitted with navigational equipment which includes one GPS and one DGPS navigator, gyro and magnetic compasses, auto-pilot, echo sounder, MF and VHF radios, and two ARPA radars.

1.5 THE MACHINERY SPACES

The main propulsion and electrical generating machinery is in two engine rooms, separated by a watertight transverse bulkhead **(Figure 4)**.

The forward engine room contains two, nine cylinder in-line diesel main engines. Each may be coupled to a controllable pitch propeller through a gearbox in the aft engine room. Between each of these main engines is an eight cylinder in-line diesel generator.

The aft engine room contains two six cylinder main engines. Each may drive one of the propellers, through a gearbox shared with one of the forward main engines. Each aft main engine may also drive an electrical generator.

An independent diesel-driven generator is between the two aft main engines. This is a similar generator to the one in the forward engine room. Each is driven by an eight cylinder Wartsila Vasa 32 diesel engine.

At the aft end of the aft engine room, but separated from it by a transverse watertight bulkhead, is the machinery control room (MCR) complex. In here are machinery monitoring and control systems. In the adjacent space is the main electrical switchboard.

Each independent diesel-driven generator, and each forward main engine, is fitted with an exhaust gas heat exchanger/economiser in its uptake. These are filled with thermal heating oil as the working fluid, as opposed to water and steam as used in steam boilers. However, the heated thermal oil from these units is used for purposes similar to that of steam and hot water; namely the heating of accommodation spaces, fuel oil, domestic units etc.

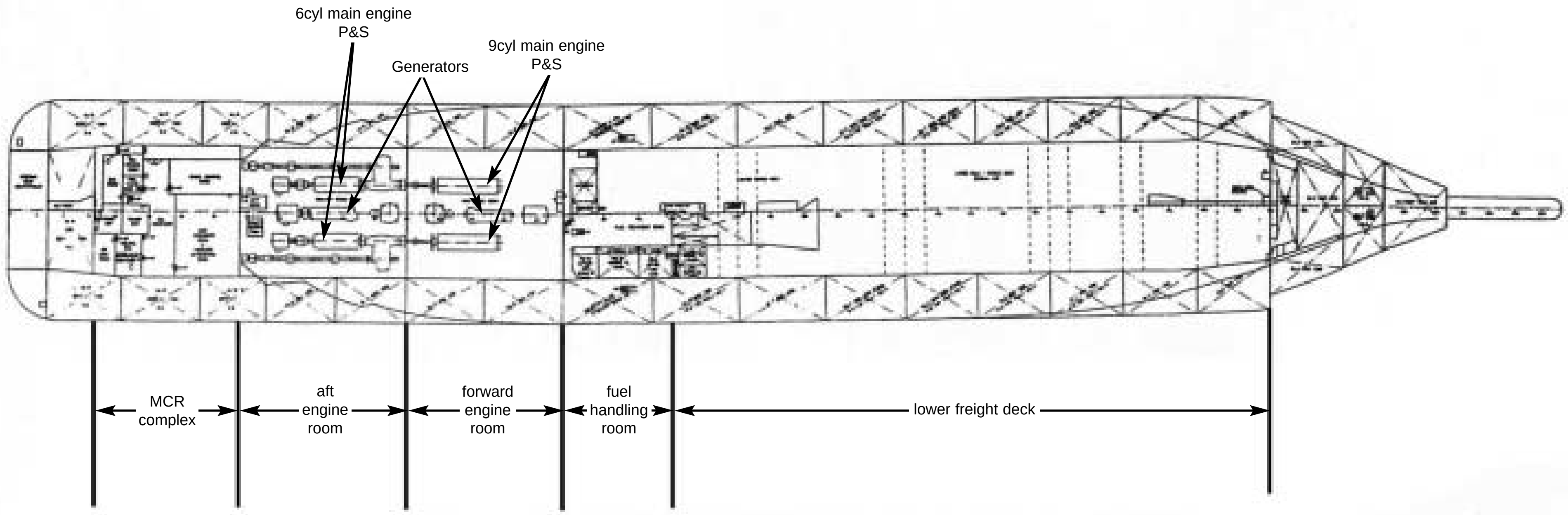


Figure 4

Engine rooms' layout showing main propulsion and electrical generating machinery

1.6 THE FUEL SYSTEM

Forward of the two main engine rooms is the fuel handling room, containing fuel booster pumps, separators, etc.

Heavy fuel of 380cSt viscosity, and minimum flash point of 60°C, is used in the main engines and generators. This type of fuel requires some processing before it is sufficiently clean and suitable for use in an engine. The cleaning is mainly performed by centrifugal separation.

Once cleaned, the fuel is stored in a service tank to await use. From the service tank, fuel passes to low-pressure booster pumps and then to filters. Its pressure is again increased by high-pressure booster pumps before being heated to a temperature to make it suitable for combustion.

This temperature is not predetermined, as it is controlled by the need to obtain a suitable viscosity. Thus, a viscosity measuring device is used to determine and control the level of heating automatically. Typically, the temperature needed to achieve the necessary viscosity is between 120°C and 130°C. This processing is performed in the fuel handling room.

Once sufficiently heated, the fuel passes to the main engines and generators at a pressure of about 8bar. Not all fuel supplied to the engines is used immediately, and a significant proportion is returned to the fuel handling room to be reheated. This continuous circulation ensures that fuel temperature and viscosity in the pipelines is maintained.

Each engine, therefore, has a fuel supply line and a fuel return line **(Figure 5)**.

The fuel supply line of each engine and generator is fitted with a quick closing valve. These may be closed locally, or remotely and independently from the safety control room in an emergency. The return lines are each fitted with a non-return valve. Thus, with the quick closing valve on an engine's supply line closed, that engine is effectively isolated from the fuel system.

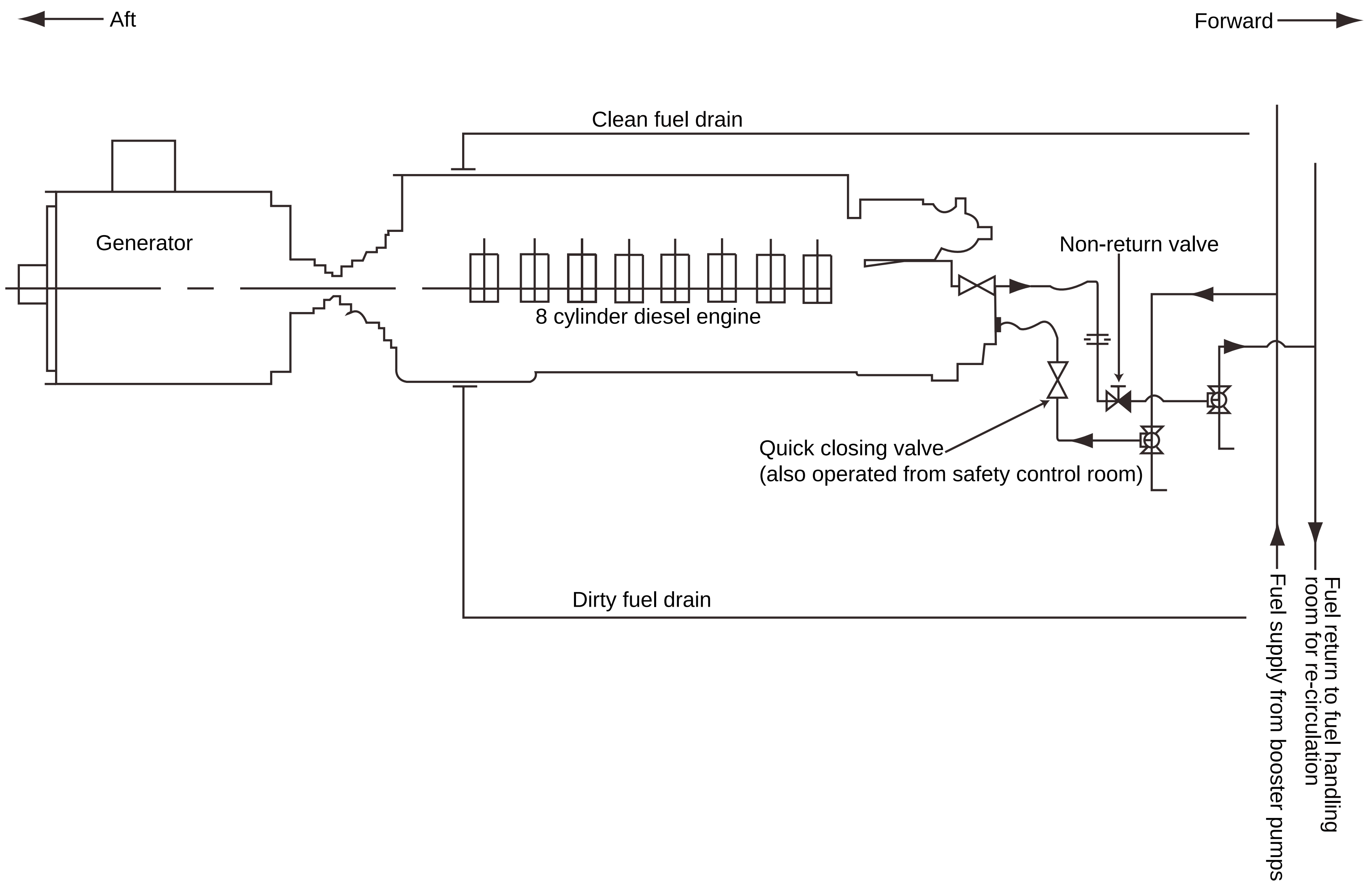


Figure 5

Fuel system for aft generator

1.7 ENGINE HOT BOX

On the port side of the aft diesel generator's engine, near the top, is an area of the engine referred to as the 'hot box'. This is formed by the engine's main structure and thin sheet metal, removable, covers **(Figure 6)**.

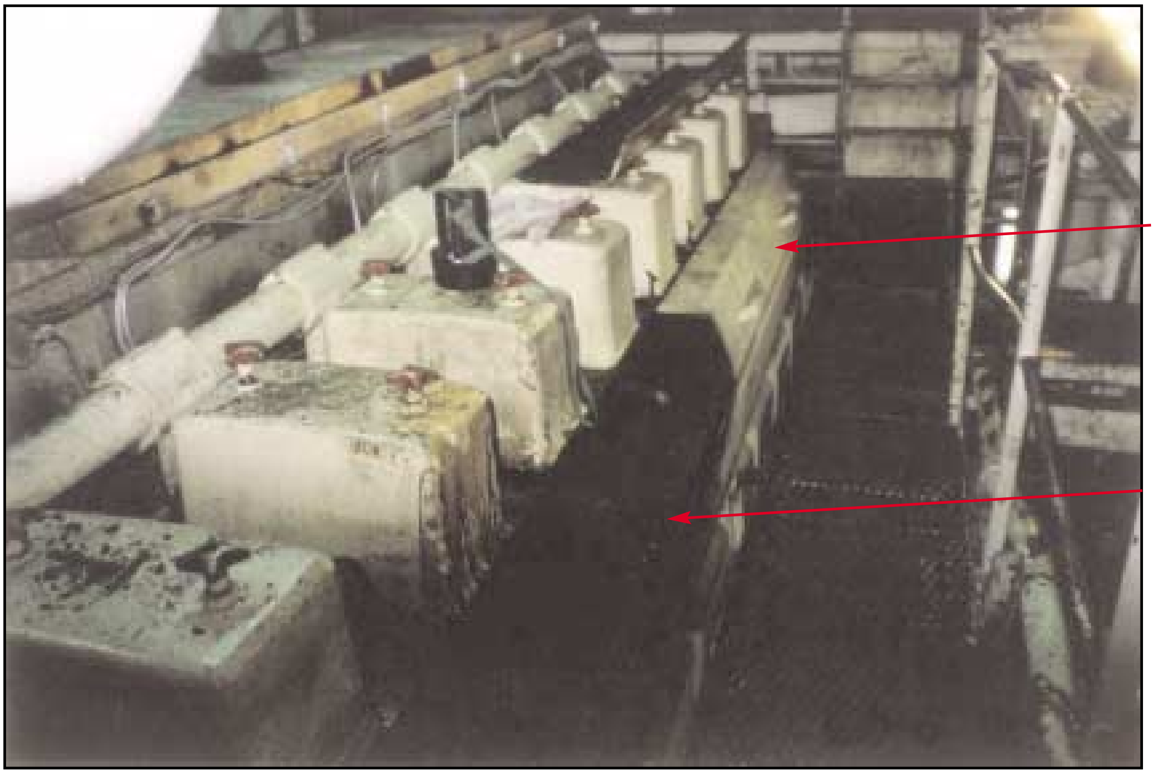
In the hot box are the engine's high-pressure fuel pumps, high-pressure fuel pipes and low-pressure fuel pipes.

One function of the hot box covers is to contain any fuel which might spray from a leakage site. Another is to retain heat within the fuel circulating through the supply and return low-pressure fuel lines. These covers are not designed to be gas tight.

Until the fire of 2 September 2002, routine examinations of the hot boxes were made according to the following schedule:

Monthly: *Check free motion in fuel pump control linkage and lubricate. Wash out hot box with chemical/hot water, prove gutters and drains clear, check for leaking pipework and rectify as required. Any leaking pipes must not be repaired, only renewed.*

Figure 6



Aft diesel generator engine (port side)

1.8 AFT ENGINE ROOM VENTILATION ARRANGEMENTS

Reversible motor-driven ventilation fans are fitted in the funnel casing. These may be stopped locally, remotely or automatically when the door of the CO_2 cabinet for the aft engine room is opened.

These fans are normally kept on the 'blow' setting, and discharge air through sheet metal trunks into the aft engine room. Flow of air into the trunks may be shut off by closing flaps, the control levers of which are set in the port side of the funnel casing, accessible from the deck.

Air entering the aft engine room which is not used by the engines, or escapes by other means, can flow upwards within the engine room casing, until it again reaches the funnel casing where it can escape to atmosphere through flaps and a grill in the aft end of the funnel. These flaps can be closed by operating levers at the starboard side of the funnel casing, accessible from the deck **(Figure 7)**.

The flaps on the supply and exhaust side of this ventilation system must, in the event an engine room fire, be closed to prepare the engine room for the release of smothering CO_2.

1.9 THE CO_2 SMOTHERING SYSTEM

For fire extinguishing purposes, five spaces of the vessel are served by a CO_2 gas fire extinguishing system. These spaces are: machinery control room complex, aft engine room, forward engine room, fuel handling room, lower freight hold. Gas for this system is stored in banks of 45kg high-pressure cylinders in the CO_2 room **(Figure 8)**, accessed from the main vehicle deck (F deck). There is a total of 96 cylinders.

The discharge of CO_2 to each space is controlled at a dedicated release cabinet; one adjacent to the exit from each of the five protected spaces. All cabinets are set in the central citadel at F deck level.

The door to each cabinet is normally kept locked, but each of the vessel's engineers has a key.

As required by regulation, opening of any cabinet door activates a warning siren within the space served by that release cabinet. This action also stops the ventilation fans for the space.

Inside each cabinet are two valves which require opening to release gas into the selected space. The first is a cock fitted in the gas distribution manifold. Moving the lever of this cock through 90° connects the gas bottles in the CO_2 room to the selected space and gives the operator access to the isolating valve on a small pilot-gas cylinder in the cabinet. Opening this valve releases pilot-gas to selected master cylinders of CO_2 housed in the CO_2 room. Gas from these cylinders goes into the selected space and, simultaneously, activates a predetermined number of other CO_2 cylinders, also releasing their contents into the selected space through the manifold.

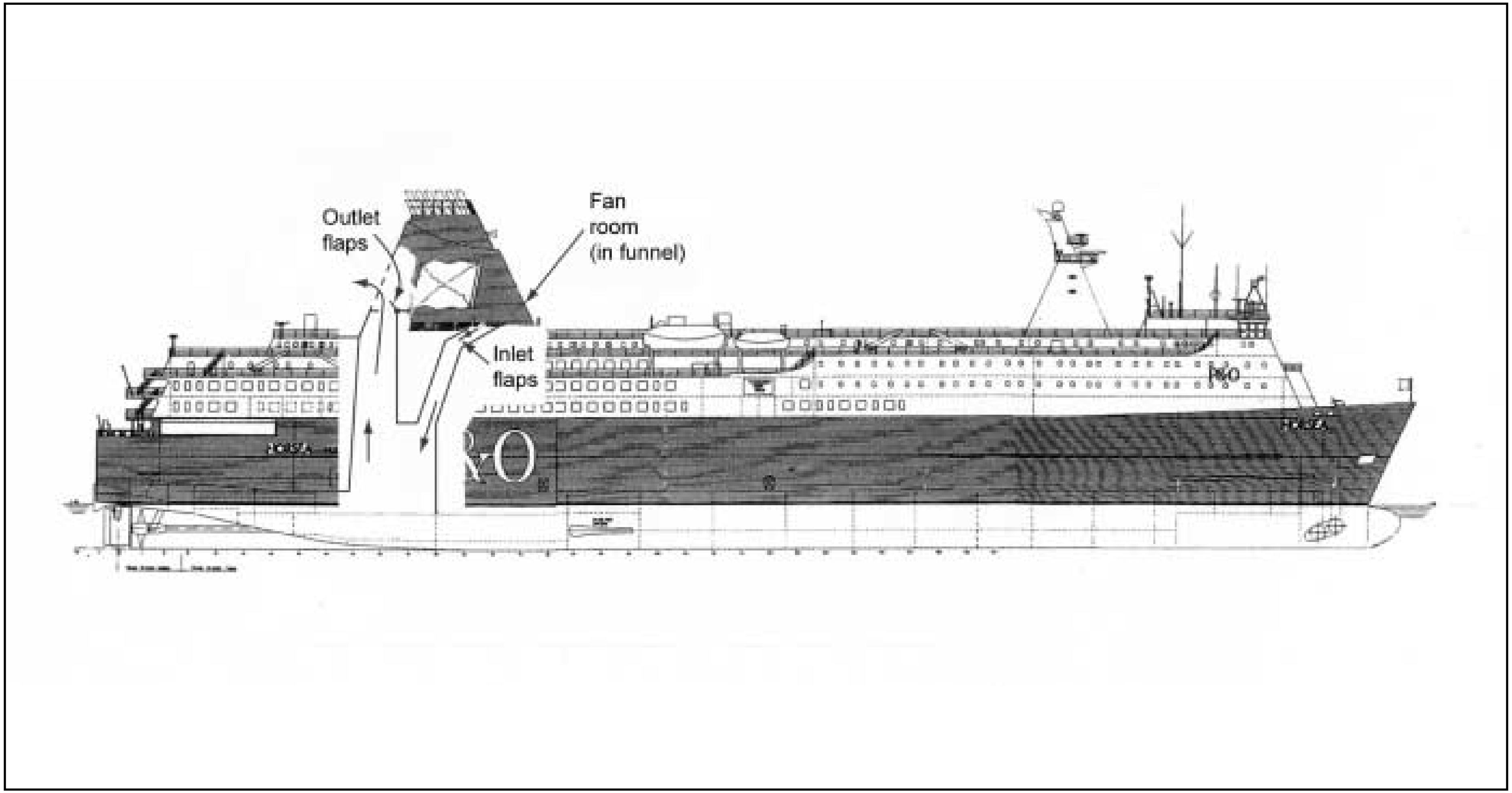
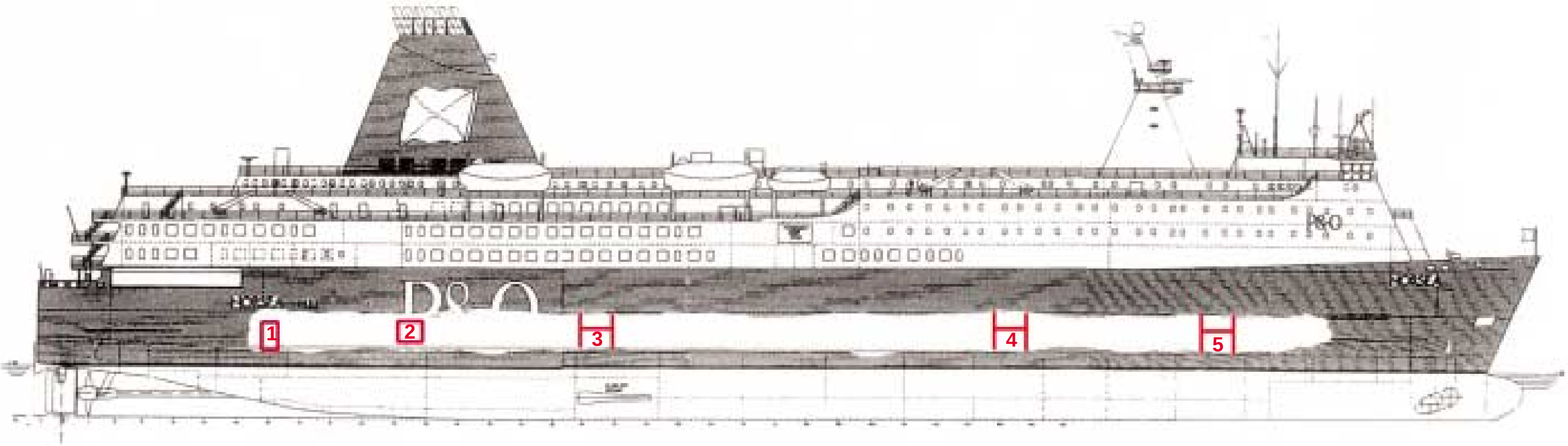


Figure 7

Ventilation arrangements for aft engine room (diagrammatic only)



Significant items and spaces in central citadel on 'F' Deck

1. MCR escape door
2. CO_2 release cabinet for aft engine room
3. Safety control room
4. CO_2 room
5. Drencher control station
   (access from internal stairway only

Figure 8

The discharge valve in the actuating head on each 45kg cylinder is operated by a piston, activated by the gas pressure from the pilot system **(Figures 9 & 10)**. When the valve is in the full open position, a spring-loaded plunger latches on to the piston, locking both it and the discharge valve in the open position. This ensures the cylinder's discharge valve remains open even when the pilot system pressure drops.

The complete system is arranged so that the following numbers of 45kg CO_2 cylinders can be released into the respective spaces:

Lower vehicle hold:	76
Fuel handling room:	6
Forward engine room:	46
Aft engine room:	34
Machinery control room complex:	10

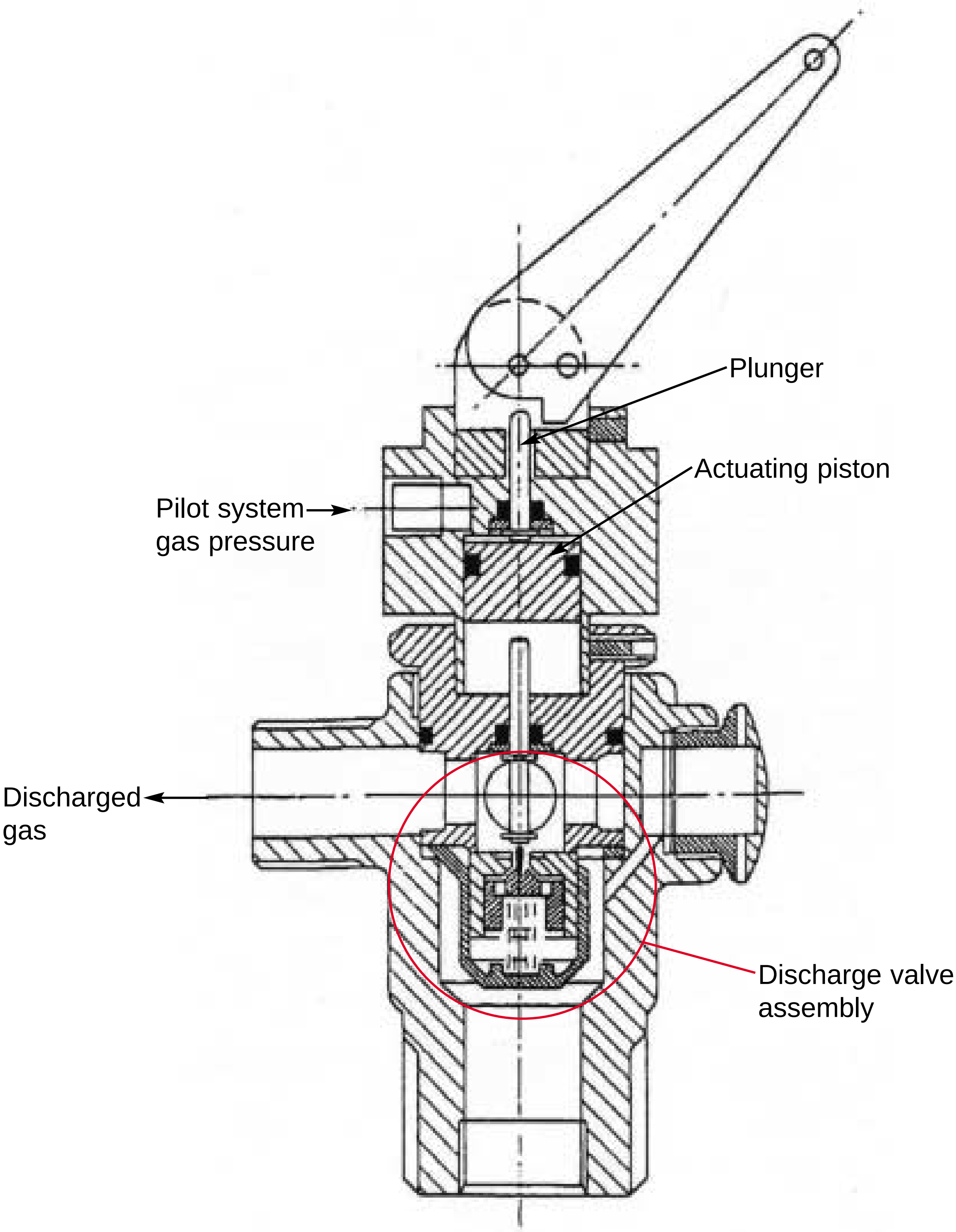
In addition to the remote release facility from the cabinets, each 45kg gas cylinder can be individually released locally, from within the CO_2 room. Local operation of a cylinder requires a safety clip to be pulled out and a lever to be operated. This lever pushes the piston in the cylinder's actuating head, so opening the discharge valve and latching it in the open position.

In this mode of local operation, the necessary manifold cock within a release cabinet must previously have been opened to ensure the gas passes into the selected space.

Figure 9

High pressure cylinders in the CO_2 room

Figure 10



CO_2 bottle actuating head assembly (shown in the closed position)

1.10 THE SAFETY CONTROL ROOM

Also within the central citadel, accessible from F deck at the forward end of the engine room casing, is the safety control room **(Figure 8)**. This houses remote closing arrangements for oil system valves and remote stop switches for pumps and ventilation fans in the machinery spaces.

To close the oil systems' valves from this room, selected colour-coded cocks are opened and a hand-operated hydraulic pump activated. The hydraulic pressure generated then trips the valves closed. The cocks serving the aft engine room are designated by blue colour coding and cover the fuel oil, diesel oil, lubricating oil and thermal heating oil valves.

The remote stop switches are in numbered groups and are colour coded. In particular, those serving systems in the aft engine room are again colour coded blue. These are: Nos 2, 4, 5 and 6, which serve fuel oil booster pumps, lubricating and hydraulic oil pumps, fuel oil pumps and separators. These pumps may also be stopped from the bridge.

In addition, the safety control room contains a repeater panel for the fire detection and alarm system for the machinery spaces and vehicle decks.

1.11 THE DRENCHER SYSTEM

Towards the forward end of the central citadel, but accessible only from a stairwell within the citadel, is a room housing the drencher pump and system controls **(Figure 8)**.

This system allows sea water to be sprayed over selected areas of the vehicle spaces through nozzles set in the deckheads. The primary function of the system is to control and extinguish a fire in the vehicle spaces. However, it may also be used to cool the decks and machinery casings in case of a fire within.

To prevent a dangerous accumulation of water on the vehicle decks, because of the drencher system operation, scuppers are fitted to drain the water overboard.

1.12 FIRE DAMAGE

After the vessel's arrival at Zeebrugge, the aft engine room was available for examination.

Generally, the space had suffered only very limited smoke damage. No fire damage was visible, except in the immediate vicinity of the engine of the diesel generator.

The starboard side of the engine had suffered the most from heat damage, particularly to wiring running fore and aft beneath the exhaust manifold. Adjacent light fittings in this area had also been affected by heat.

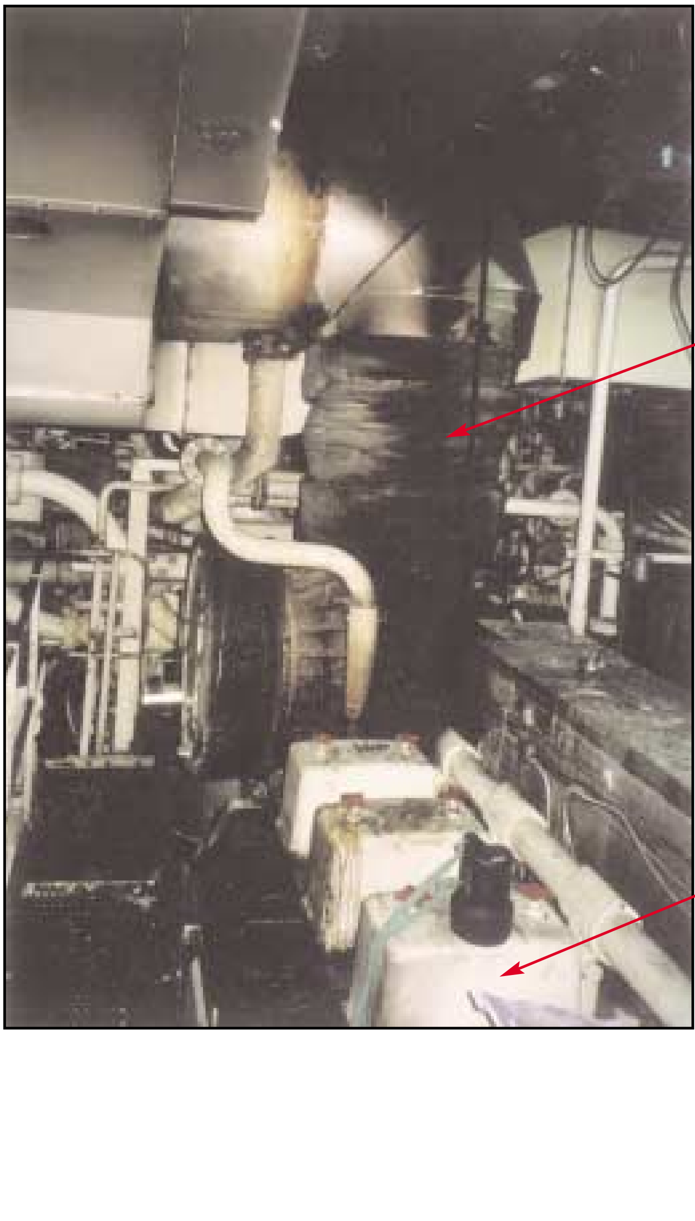
There was no obvious heat damage at the rocker box level of the engine. However, at the engine's forward end the turbocharger's lagging had been affected by smoke **(Figure 11)** and plastic fittings on an adjacent manometer had been affected by heat. Immediately above the engine, a detector head for the fire detection and alarm system had been heat damaged.

Internally, the engine's hot box was covered with carbon, particularly at the forward end. The underface of the forward cover of the hot box was also covered with carbon at about mid length. This corresponded to carbon deposits in the lower part of the hot box adjacent to cylinder No 7.

There was no obvious sign of fuel leakage in the hot box until fuel oil pressure was restored to the engine. Once pressurised, the low-pressure fuel pipe running fore and aft by No 7 cylinder leaked. This was in way of a securing clamp for the pipe. Removal of the clamp and pipe showed that the clamping screws were loose, some clamps were incomplete, and the pipe was worn in this area. It was concluded that the pipe had been allowed to fret, wear, and this resulted in its failure.

There was no fire damage to any structural elements of the vessel.

Figure 11



1.13 REPLENISHMENT OF CO_2 SYSTEM

Following the vessel's arrival in Zeebrugge, one essential step in returning the vessel to service was the restoration of the CO_2 system, requiring the replenishment of the relevant storage bottles.

The contractor employed to do this work expected that 34 of the 45kg gas bottles needed refilling. These were the bottles designated for discharge using the aft engine room's release cabinet controls.

However, on examination of the system, the contractors found that 86 of the 45kg bottles needed refilling. Presuming that all had inadvertently discharged into the aft engine room, the system was examined to establish the causes.

An initial assessment of the system concluded that 86 bottles could be released, if three of the manifold in-line check valves had leaked. These are valves 1, 2 and 6 on the manifold **(Figure 12)**. This could have caused the corresponding three banks of bottles to be released.

This conclusion was supported by later tests on these valves and the finding of dirt and water in the manifold, which was judged to have affected the functioning of these check valves.

All check valves in the system's manifold were renewed, and the system cleaned out and returned to service.

Further consideration of the system showed that 86 bottles might also be released if only one of the check valves leaked, No 6, together with one non-return valve in the pilot-gas line leading from the lower hold release cabinet, No 11. These pilot line valves were renewed.

1.14 STANDING ORDERS

The vessel's Safety Management System includes procedures and associated checklists to be followed in the event of a fire in the machinery spaces.

Specific instructions covering this event are:

In the event of a fire in the Engine Room complex ***the main fire alarm,*** *situated near the watertight doors and in the MCR must be activated. (Siren in alley way of engineers' accommodation).*

Off duty alerted Engineer Officers must ***always*** *take this alarm as an Engine Room fire and muster at the emergency muster station, in this case – the MCR complex emergency escape on 'F' deck (the main vehicle deck).*

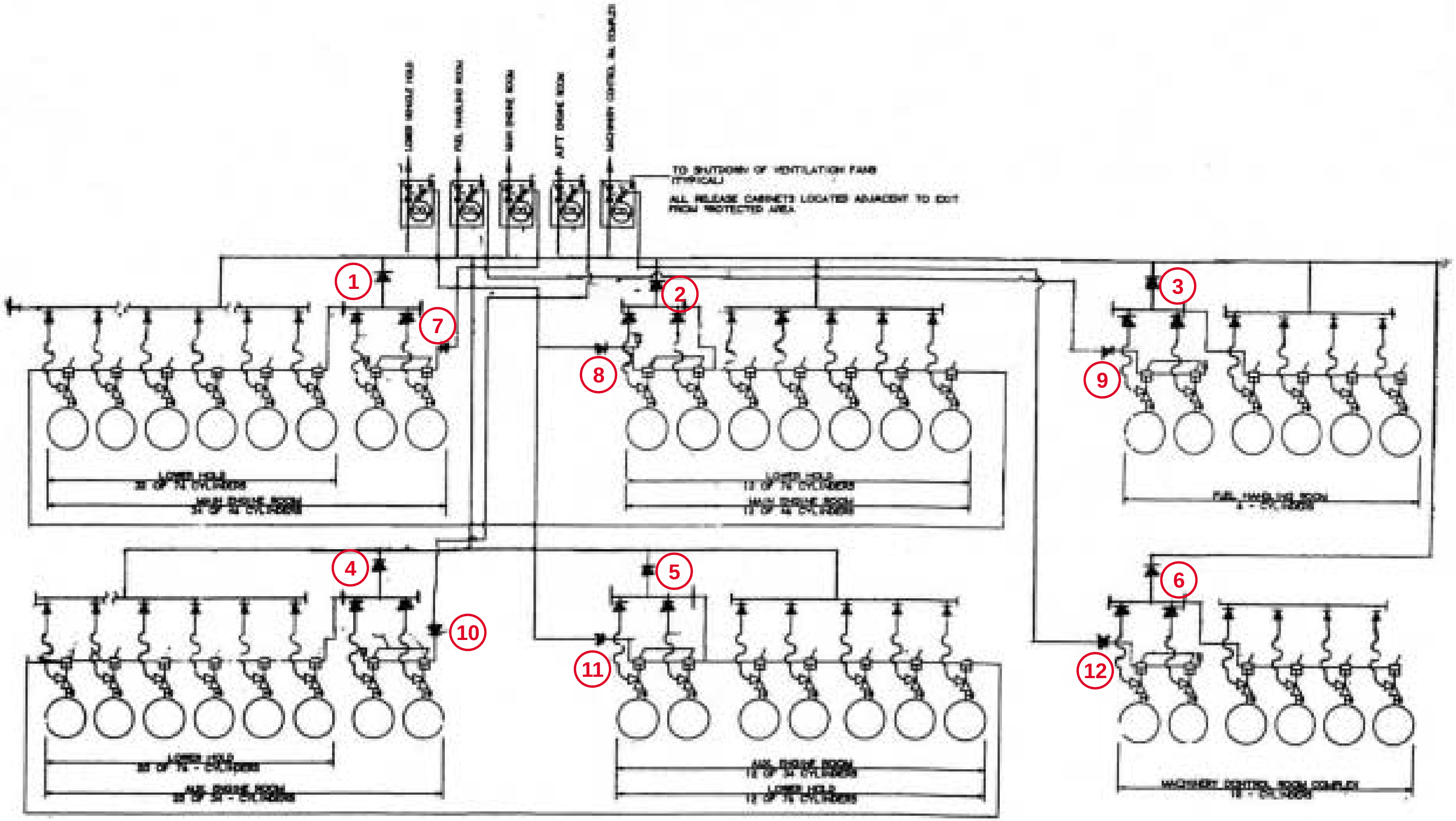


Figure 12

The CO_2 system

In the event of a fire in any other part of the vessel, ***"WORKING PARTY RED"*** *the off duty Engineer Officers must go to their emergency muster stations, in this case outside lift/deck office on 'A' deck and from this position they will be instructed in their normal emergency duties.*

Electrical Technical Officer (ETO) – Will proceed to the Bridge for communication purposes.

Some of the General Instructions for fire in machinery spaces are:

All fire panel/smoke detectors and heat detector alarms are to be investigated immediately, if you are in the MCR quickly check the camera monitor screen for possible inferno before proceeding. If in any other machinery spaces, open watertight door a bare minimum for first sighting of smoke etc.

If fire is present, activate as described above, phone Bridge giving all possible details, ie machinery space designation, Engine Room for'd, Engine Room aft, Fuel Handling Room etc ***"ON FIRE".*** *Switch on walkie-talkie to Channel 8. Then the Chief Engineer Officer (C/E) will be able to contact you from the muster station or on the way to your position.* ***Note:*** *It is up to the Engineer Officer (EO) in charge of the Watch as to whether he should attempt to fight the fire (dependent on the type of fire, size and position/location), but whatever the EO must stay in the control room or at his command post until the C/E arrives, to enable a positive report to be made of the current situation. This will be assessed and appropriate action taken.*

During this period of waiting for back up team the EO on watch will shut down/start up and change over relevant machinery and stop ventilation fans serving the space on fire.

Note: *If the fire is in the MCR, the EO on watch or the Petty Officer Motorman (POM) must be at the 'F' deck MCR escape door in order to stop entry by any back up team.*

Tests made show that it could take up to 4 to 5 minutes before back up engineers arrive to help. These first few minutes are vital to containment/extinguishing of fire. It is therefore imperative that on duty personnel do all that is possible to remove at least some of the fire components, air/heat/combustibles without endangering themselves.

Important: *duty EO watchkeepers have a responsibility of conveying information as to whether the fire is small enough or of a type which is capable of being brought under control by local fire fighting methods. Volume of smoke, fire area, intensity of heat and personnel safety must all be deciding factors. If you decide to close the fire related space down and* CO_2 *is required, initiation of same can be started. Remember that remote stops for pumps and fans are situated on the bridge as well as F Deck defence station, therefore utilise Bridge Deck Officer for shutting down fans, pumps etc. if necessary.*

A fire procedure checklist, covering fire in any of the main machinery spaces, is available. The checklist for a fire in the aft engine room, designated the Blue Section, with actions to be considered, and the person responsible, is reproduced in **Annex A**.

A similar checklist for CO_2 flooding of a machinery space is reproduced in **Annex B**.

1.15 BRIDGE EMERGENCY PROCEDURES

In the event of an accident on board, at sea, the crew incident alarm is sounded from the bridge, and working parties are called. In case of fire, the announcement will be "working party red". The master is then to be called.

The following announcement will then be made to all crew members:

> *Working party red. Working party red. Working party red. Proceed to deck………There is a fire reported…..in……….on…….deck. Emergency teams muster and stand by for further instructions. First aid party muster and standby for instructions. If passengers enquire, explain that a minor incident has occurred that is being dealt with by the ship's crew.*

Following this announcement, the procedures and checksheets for that particular area are to be followed **(Annex A)**. The chief officer is to investigate and report back to the bridge. In addition to this, both drenchers and CO_2 cabinets are to be manned and first-aid fire-fighting is to be initiated.

The master is to assess wind flow over the vessel, adjust course and speed accordingly, as well as consider taking ballast, and consult the plans for fans, vents, and damper controls.

If necessary, the alarm for general emergency stations will be sounded, and passengers mustered in safe areas as per the assembly station planning chart, located at various points throughout the vessel, **(Annex C)**, and the crew are to make ready lifesaving appliances (LSA) equipment.

Following general emergency stations, the following announcement will be made:

> *Attention please. Attention please. Please be quiet and listen carefully.*
>
> *An incident has occurred which is being dealt with. However, as a precaution, it has been decided to assemble all passengers at their assembly stations. Therefore on hearing the signal of seven short and one long sounds on the alarm siren followed by the same signal on the ships whistle, all passengers must dress warmly and assemble at the nearest muster station.*

At assembly stations the ships staff will, if necessary, issue lifejackets and give further instructions. For your own safety the instructions must be obeyed calmly and promptly.

It is very important that you remain quiet so that instructions can be clearly heard.

Thank you for your co-operation.

An audio recording of the above message is available in several European languages.

The coastguard will then be informed, followed by the broadcast of a *Safety* or *Urgency* message. The company will then be informed. All information and actions to be recorded.

If the accident is brought under control, instructions will be given to stand down when all clear. If out of control, instructions to be given to abandon ship, followed by the sending of a distress message.

1.16 BRIDGE EMERGENCY PROCEDURES (AFT ENGINE ROOM FIRE)

Specifically, in the case of a fire in the aft engine room, initial actions for the master or officer in charge of the watch will include communication with the emergency teams to obtain available information in respect to the nature and location of the fire, who reported it, and whether containment has been achieved.

The C/E is to control the engine room procedure and the deck emergency team is to act as a back-up. The engine room will try to give motive power. Deliberate shutdown of all motive power must have the master's consent.

Either the officer in charge of the watch, or the master, is then to organise deck emergency teams to man the CO_2 release cabinets, F deck drenching stations for boundary cooling, and place a BA team on standby.

If nobody is trapped in the aft engine room, or if the fire is anything other than small and localised, the shutdown of the aft engine room and flooding with CO_2 must be carried out within 15 minutes of fire breakout. The master is to give the chief engineer this order.

In respect to secondary action, the chief officer is to continue with boundary cooling and, from within the emergency teams, members are to be delegated to monitor hot spots/bulkheads for cooling or otherwise.

1.17 PASSENGER CONTROL TO AND FROM ASSEMBLY POINTS

In each passenger assembly party, crew members are allocated a deck, by colour, and are issued with high visibility vests and either a torch or pass key for passengers' accommodation areas. They are then to direct passengers to various muster points according to the deck on which they have a cabin **(Annex C)**. Thereafter, a thorough check of all accommodation spaces on that deck is made.

Torches and high visibility waistcoats are available from the purser for door and alleyway marshals. Marshals' lifejackets are available at the assembly stations.

Crew members, allocated section clearing duties, collect emergency pass keys and high visibility waistcoats from the purser's office before clearing sections. When a section is cleared, the purser is informed and the key returned to the board. When all keys have been returned, the purser can then report to the bridge that all sections, including cells, are clear. Lifejackets for section clearers are then available at the assembly stations.

At the assembly stations, if deemed necessary, passengers are issued with lifejackets and crew members are available to assist passengers with donning them.

Crew members, instructed to escort passengers to boats or rafts, assist passengers in boarding survival craft and will then board the craft to be lowered when instructed by the master.

1.18 ENGINE ROOM MANNING

On 1 March 2002, the MCA issued *Norsea* with a Safe Manning Document.

This document specifies, when the vessel operates in near coastal waters, the following minimum manning levels for the engineering department:

Chief engineer officer
Second engineer officer
Two other engineer officers (watchkeepers)
Two engine ratings

Near coastal service is defined on the certificate as operating within 150 miles from a safe haven in the UK, or 30 miles from a safe haven in Eire.

This certificate states the system of manning to be "conventional". No mention is made that the machinery spaces of the vessel are classed as UMS (Unmanned Machinery Spaces). A schedule of conditions attached to the certificate sets out one relevant to the operation of the machinery spaces:

> *A lone watchkeeper must not attend the machinery spaces unless a suitable watch alarm is fitted and an operational or an alternative system is in place.*

An engineers' watch alarm system is fitted to *Norsea.* In addition to this hard-wired system, each engineer carries a portable, personal, alarm for use in case of difficulty.

Regulation 54 of Chapter II-1 of the Safety of Life at Sea Convention (SOLAS) sets out the following for the manning of machinery spaces of passenger ships:

> *Passenger ships shall be specially considered by the Administration as to whether or not their machinery spaces may be periodically unattended and if so whether additional requirements to those stipulated in these regulations are necessary to achieve equivalent safety to that of normally attended machinery spaces.*

During the vessel's voyage of 1 and 2 September 2002, she carried the following engineering staff:

Chief engineer officer
Second engineer officer
Four third engineer officers
Electrotechnical officer
Three engine room ratings

Engine room watchkeeping duties at sea were performed by the second engineer and two of the third engineers. In addition, one of the remaining third engineers was designated as the call-out engineer in the event of the watchkeeping engineer needing assistance. Otherwise, in the normal course of events, these two third engineers and the three ratings worked daywork hours.

1.19 FIRE DETECTION AND ALARM SYSTEMS

Two fire detection systems are fitted to the vessel. One is an addressable system, where each detector head can be identified and interrogated, which primarily covers the accommodation spaces. This system also covers some spaces in the upper parts of the machinery casing.

The second system covers the machinery spaces and vehicle decks. This is not an addressable system, but is divided into zones for identification purposes.

Both systems have an alarm panel on the bridge and a slave panel in the MCR. The machinery space system also has a slave panel in the safety control room on F deck.

Relevant to this accident is the engineers' fire alarm. This is a dedicated system to indicate a fire in the machinery spaces. It is activated only by manual buttons in the machinery spaces, and sounds sirens only in the accommodation of the engineer officers. As this accommodation is continuous with that of the deck officers, the alarm also alerts them. It can also be clearly heard from the bridge.

It should be noted that this fire alarm is separate from the engineers' call alarm, or 'panic alarm'.

1.20 ACCESS TO MACHINERY SPACES

The engineer officers' accommodation is at the forward end of the uppermost accommodation deck, A deck **(Figure 3)**.

Access to all machinery spaces is normally from the main vehicle deck, F deck.

In the event that an engineer is called from his cabin to the machinery spaces, such as when the on-call engineer is requested to attend, he needs to pass down through the three passenger decks, blue, red and green.

The forward stairway, at the aft end of the engineers' accommodation, is normally used in these events. This is a passenger stairway. The lift adjacent to these stairs is used only for routine access. It is never used during any emergency, or when a loss of electrical power is likely.

At sea, the doors between the lowest passenger deck, green deck, and the vehicle decks, are normally locked closed. Each engineer officer has a key to these doors. They, therefore, have to unlock and open a door to gain access to the vehicle deck spaces.

Normally, engineers take this route into the vehicle deck spaces and then walk aft to the aft end of the central citadel, to the MCR's escape door. Because portable transverse flood barriers are normally in place on F deck, the engineers usually walk aft on E deck, the deck above the main vehicle deck (F deck), and climb down a ladder adjacent to the MCR door, or use one of the nearby vehicle ramps. An access door is set in the middle of each flood barrier, which could be used to move aft on F deck. However, when vehicles are on the deck, use of these doors makes the route very tortuous and time consuming; hence the preferred use of E deck and the aft ladder or ramps.

All doors of the machinery spaces on F deck are locked against being opened from F deck. However, the arrangement allows for keyless opening of any door from inside the respective machinery space.

Each engineer officer is issued with the necessary keys to open all doors for access.

1.21 LIFESAVING APPARATUS

Norsea carries five lifeboats, which have a total capacity of 596 persons. The lifejackets are stowed in davits fitted between the uppermost passenger deck, B deck, and A deck, the deck housing the officers' accommodation. Lifeboats need to be lowered to blue deck (B deck) level for embarkation by passengers.

Two of the lifeboats are stowed on the port side and three on the starboard side. The forward-most lifeboat on the starboard side is also a designated rescue boat.

In addition, the vessel carries a fast rescue boat stowed forward of the port lifeboats.

Additional lifesaving capacity is provided by 36 inflatable liferafts served by launching appliances. These have a total capacity of 900 persons.

The number of lifejackets carried is 1356. Lifejackets for passengers are stowed in lockers at each assembly station.

The number and distribution of lifesaving appliances allowed the vessel to be allotted a passenger capacity of 1050 persons by the MCA.

1.22 WEATHER CONDITIONS

The conditions recorded by the vessel between 0100 and 0300 on 2 September were easterly wind force 3, giving slight sea conditions and good visibility. The tidal stream was southerly at 1 knot.

1.23 NOTES ON THE INVESTIGATION

As passengers disembarked from *Norsea* following her arrival in Zeebrugge on 2 September 2002, each party was handed an MAIB questionnaire. This asked for details of each passenger's experience during the accident.

The response to this request for information was good. A total of 83 completed questionnaires were returned to the MAIB, covering 176 of the 460 passengers on board. In addition, a number of letters and telephone calls from passengers were received by the MAIB in response to its request for information.

Passengers raised a number of concerns and queries. Where the issues raised have been within the MAIB's remit, they have been considered in the investigation and, generally, covered within this report. Other matters raised have been subjects for commercial negotiations between individual passengers and the owners of *Norsea*, and are not considered here.

A second source of information has been the vessel's VDR. This system continuously recorded voices in the wheelhouse, radio communications, radar display, engine speed, ship's speed and position throughout the accident.

Carriage of VDRs has only recently become a requirement for certain types of vessels. This is the first time the MAIB has investigated a non-navigation type accident where a VDR has been fitted to the casualty vessel. The information it provided has proven a most valuable supplement to witness recollections and written log records.

1.24 PREVIOUS RECENT FIRE ON *NORSEA*

Shortly after leaving Hull on 14 August 2002, a fire started in *Norsea*'s forward engine room.

During routine testing, the quick closing valve on the exhaust gas economiser of the starboard nine-cylinder main engine, was found to be defective. In planning the repair, it was quickly realised that, because it was not fitted with a drain valve and line, the casing of the economiser could not be completely drained of thermal heating oil.

Best efforts were made to drain the unit throughout the night of 13 and 14 August. From measurement of the quantity of oil that drained into the drain tank, it was concluded that the majority of the thermal heating oil had been removed from the economiser.

However, precautions against possible spillage were taken before the defective quick-closing valve was removed for repair. In spite of these efforts, and partly because of the extremely cramped conditions making access very difficult, some oil was lost on to adjacent lagged pipework and the floorplates below. All visible oil was mopped up and the area was considered free of oil.

The valve was repaired and the economiser was refilled with thermal oil.

Norsea cleared the lock of King George Dock, Hull, at 1943 on 14 August 2002. At 1948, an alarm was indicated on the fire alarm panel for the starboard main engine economiser space, upper level. This was investigated by the 2/E who tackled some glowing embers on the lagging above the starboard nine-cylinder main engine. As he did so, a much larger fire broke out, which extended up the funnel casing.

The 2/E activated the engineers' fire alarm and returned to the MCR to report to the C/E. The C/E and master agreed, by telephone, that emergency procedures should be activated, and a 'working party red' announcement was made.

Both nine-cylinder main engines in the forward engine room were stopped and the six-cylinder main engines, in the aft engine room, were started and clutched on to their respective shafts. However, after the main generator in the forward engine room was stopped, the port six-cylinder main engine was de-clutched to power its generator.

The vessel continued down the Humber River on the remaining six-cylinder main engine at slow speed, sufficient to maintain steerage way.

Meanwhile, two of the third engineers tackled the fire using CO_2 extinguishers. These did not knock back the fire. Seeing these results, the C/E ran out a fire hose to tackle the fire from the lower level, while the two 3/Es abandoned their efforts with CO_2 and tackled the fire from above using a fire hose. These combined efforts successfully extinguished the fire and it was reported out at 2001.

However, checks of the uptakes for hot areas and boundary cooling continued.

Unfortunately, during their fire-fighting activities, both the C/E and one of the 3/Es suffered from the effects of debris and other foreign bodies in their eyes. These injuries were considered sufficiently serious for the master to arrange for a helicopter evacuation of these two engineers. They were lifted from the vessel at 2121 for transport to hospital ashore.

The port six-cylinder main engine was clutched in at 2154, and the vessel continued passage to Zeebrugge, arriving at her berth at 1300 on 15 August 2002.

During the vessel's stay in Zeebrugge, the port nine-cylinder main engine was restored to service. However, the starboard nine-cylinder main engine could not be used for the passage to Hull. Indeed, this engine had not been returned to service at the time of the fire on 2 September 2002.

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 in the future.

2.2 RESPONSE OF THE WATCHKEEPING THIRD ENGINEER

From the watchkeeping 3/E's perspective, the early stages of this accident were little more than routine. However, from what appeared a simple investigation of a fire alarm, he was rapidly thrust into a position where he was tackling a fire, alone, in a safety critical space on the vessel; the aft engine room.

Working alone, he alternately tackled the fire with extinguishers and attempted to update the 2/O on the bridge using the telephone in the MCR. He was unable to do either task properly.

Most probably because he was attempting to perform both of these critical and, to a degree, stressful tasks, his reports to the wheelhouse did not give an accurate reflection of the situation. The 2/O accepted his reports of there being a tremendous smell of burning as just that, a smell only. In none of the 3/E's reports to the 2/O did he state there was a fire in the machinery spaces.

However, once the 3/E had activated the engineers' dedicated fire alarm, he gave the clearest possible indication that there was a fire.

He then continued his efforts to control the fire, and to change over generators to maintain electrical power, to the extent that he probably began to be affected by smoke and fumes when he attempted to close the fuel supply valve to the generator's engine. An indication of the degree to which he was affected is given by his failure to locate the fuel valve, an item he knew very well in both operation and position, and a later medical examination identifying carbon monoxide poisoning.

At that stage, it was fortunate that he recognised all was not well, and decided to evacuate the space. Had he not done so, it is possible that these events would have concluded with his fatality.

That he reached this state is partly a reflection of what he perceived was expected of him, as set out in standing orders. It is also an indication of his determination and professionalism as a marine engineer.

A means of closing the generator's quick closing fuel valve from the MCR might have had some benefit. It would then have been possible to completely shut down the affected generator from the MCR. This would have allowed the engine's fuel system to be completely isolated without a need for the 3/E to go to the lower level of the aft engine room. His exposure to smoke would have been reduced as a result.

Following this accident, the owners have installed a facility that allows the fuel supply to all engines to be individually isolated from the MCR. This is a worthwhile modification and one that, with other features, allows any engine to be shut down and isolated from the MCR.

This capability might have value on many other vessels. With this objective, the MCA is recommended to consider making a proposal to the International Maritime Organization (IMO) that the fuel supply to each main and auxiliary engine should be capable of isolation from the MCR, in addition to present requirements.

2.3 RESPONSE OF THE WATCHKEEPING SECOND OFFICER

The 2/O's quite reasonable expectation was that the 3/E would investigate the space indicated by the alarm condition on the fire detection and alarm system. Again, his expectation was that the 3/E would call the bridge if there was any problem. Indeed, this happened when the 3/E asked the 2/O to alert the duty call-out engineer to go to the engine room.

The first reports to the 2/O from the 3/E mentioned only the smell of burning. There was no indication that there was a fire, and the 2/O had no reason to take action.

However, once the 3/E activated the engineers' fire alarm, an alarm that was audible on the bridge, the 2/O should have been in no doubt that there was an engine room fire.

He did not interpret this alarm in that way, or take the action required by standing orders, suggesting that he was not sufficiently familiar with those orders.

The watchkeeping 2/O is a highly experienced and qualified mariner. However, he was not a permanent member of the ship's staff and was on a short-term appointment to the company. His failure to follow standing orders is not seen as a question of his competence, but rather one of inadequate induction procedures for new staff. The owners have recognised this shortcoming in procedures and have strengthened their induction training for new staff.

2.4 STANDING ORDERS

When a machinery space fire is discovered, standing orders require the watchkeeping engineer to tackle the fire, raise the alarm and remain in the MCR, to report to the C/E on his arrival. With a single watchkeeper, these are obviously impossible tasks.

The wording of the standing order suggests it was composed at a stage in the life of the vessel when at least two persons kept each engineering watch. The wording has not been altered to match the new manning arrangements. Clearly, either the standing orders need to be reworded, or engine room manning needs to be reviewed.

The response required from the bridge watchkeeper, when the engineers' fire alarm sounded, was clearly set out in the written emergency procedures. Primarily, the master should have been called and emergency procedures initiated. None of this was done at the stage required.

In the event, the delay in calling the master and initiating emergency procedures did not seriously affect the handling of the fire. Because all the engineers responded quickly to the engineers' fire alarm, and initiated the shutdown of the aft engine room, the important task of tackling the fire was not delayed. Alerting the deck and hotel crew was delayed very slightly but, being in the order of just 9 minutes at the most, this had no adverse effect. Notwithstanding this conclusion, the fundamental causes for the delay, namely the induction training of new staff, needs to be addressed. This should be satisfied by the new procedures to be adopted by the owners.

2.5 ENGINE ROOM MANNING

The accident of 2 September 2002 on *Norsea* was an engine room fire which was limited in extent, largely because of the small amount of fuel involved. It resulted in the vessel being disabled for several hours. In the event, good weather conditions and a favourable tidal stream resulted in only a gentle drift towards the south or south-west. Only towards the end of the accident did this drift take the vessel towards any position of concern, prompting the master to anchor.

Some of the circumstances are very similar to the accident on the passenger vessel RMS *St Helena,* on 25 August 2000 **(MAIB Report 19/2001)**. That vessel had a fire break out on the top of a main engine. It was caused by lubricating oil leaking from the engine on to its exhaust manifold, where it ignited.

It was fortunate that, at the time, some ratings were in the engine room to assist the watchkeeping engineer. While they tackled the fire, the engineer went to the MCR where he stopped the engine and raised the alarm. The ratings were successful in their efforts to extinguish the fire, and no serious damage resulted. The vessel was able to continue her voyage without interruption.

It is difficult to avoid the suggestion that had a second person been available in *Norsea*'s aft engine room, to tackle her fire, while the 3/E raised the alarm, changed over generators, and stopped the offending machine, the events might have followed more closely those on *St Helena.*

For several decades, large numbers of seagoing vessels have operated with unmanned machinery spaces outside daywork hours. This practice has become the norm on many types of vessels.

The confidence to operate in this way has grown from the general reliability of machinery monitoring systems and the effectiveness of safety systems, such as those for fire detection. Typically, any engineer attending the engine room alone, does so outside daywork hours and for only a brief period, in the order of 20 minutes, to check machinery before retiring to bed. During these visits he activates a watch alarm that will alert others if he does not regularly reset the alarm to show that he is well. Failure to reset the alarm will indicate he is in difficulty and will alert others. This was the original concept of watch alarms for machinery spaces.

It might be argued that machinery spaces which are manned are likely to provide an enhanced level of vessel safety. However, when attended by a lone watchkeeper, who is protected only by a watch alarm designed for short inspection visits, any improvement in vessel safety might be at the price of placing that watchkeeper at an elevated level of risk.

In this accident, *Norsea*'s 3/E came close to being seriously affected by smoke during his later efforts to tackle the fire. A second person would, at the very least, have been able to pass situation reports to the bridge without interrupting fire-fighting efforts. He might even have assisted with the fire-fighting and shutting off the fuel supply to the generator.

In the event, the 3/E had to wait several minutes for assistance to arrive in the form of other engineers.

The engineers' accommodation is forward in the vessel, while the engine room is aft. The engineers' accommodation is also separated from the engine room by several passenger and vehicle decks. In an emergency it is necessary for the engineers to use a passenger stairway to F deck and the MCR's door. For routine engine room visits they can use a passenger lift, but in an emergency they, properly, use the stairs in case of power failure.

The distance and number of passenger decks between the engineers' accommodation and the machinery spaces is a factor in the time required for any of the engineers to respond to an emergency.

A further slight delay might be caused by the need to unlock the door between green deck and the vehicle spaces.

Another potential cause of delay is that the access doors from D deck to F deck, and from F deck to the machinery spaces, are also locked closed at sea. This is for security purposes.

Standing orders recognise these delays and suggest it might take 4 to 5 minutes for emergency assistance to arrive in the machinery spaces.

This response time may not be significantly different to that achieved on other types of large merchant vessels, such as tankers, containers vessels etc. However, it must be recognised that the machinery spaces of such vessels normally operate in the unmanned state, and any alarm is usually an indication that wellbeing of machinery might be in the balance. As there is no watchkeeper, it is not an indication that the safety of personnel might be under threat.

The machinery space of such vessels is also normally a single large space containing engines, generators and fuel systems. Thus, only one major space needs to be searched in the event of a lone engineer getting into difficulty or being trapped by a fire. Machinery spaces having several compartments, each containing systems having a high fire risk, is a much more difficult arrangement in which to locate a lone watchkeeper in difficulty. A full risk assessment might show that, given the conditions at the time of the accident, a single watchkeeper in the machinery space of *Norsea* would be subjected to unnecessary risk if expected to carry out first-aid fire-fighting.

This, and other accidents investigated by MAIB, has shown that the safe number of people on machinery space watches is dependent on a number of criteria: level of automation, type of and accessibility of fire-fighting systems, and control etc. Accounting for these criteria would enable a risk assessment to be made on the number of watchkeepers required. Recalling the experience of the engine room fire on RMS *St Helena, Norsea'*s safety might be improved by having engine room watches comprising two people. The second person does not necessarily have to be an engineer. Bearing in mind the lengthy and tortuous route that needs to be followed by off-duty engineers responding to an alarm, the safety of watchkeepers might also be improved.

It is recommended that the MCA reconsiders its acceptance of conventional single-handed watchkeeping practices in machinery spaces. In particular, its acceptance of watch alarm systems as providing a level of safety, for ship and personnel, equivalent to having a second watchkeeper, should be reviewed. As a minimum, a suitable risk assessment should be performed before the MCA agrees to issue a safe manning document that specifies single person manning of multi-compartment, Category A machinery spaces.

2.6 MACHINERY SPACE SECURITY

Engineers arriving at one of the doors on F deck in an emergency, need to unlock a padlock and swing aside a cover to reach the door's handle. This might cause no more than a few seconds delay, if the engineer(s) have remembered to bring his/their key(s).

It is recognised that, should escape be necessary, these doors can be opened from the machinery space side without the need for keys.

Greater awareness of the need for security has resulted in extra barriers being placed between the engineers' accommodation and the machinery spaces; barriers which could delay the arrival of assistance for watchkeepers. These barriers are locked doors, which might generate an increased risk to the safety of engine room watchkeepers. These risks need to be assessed when judging the safety of a lone watchkeeper, particularly in multi-compartment machinery spaces. If the risks are unacceptable, control measures need to be introduced. Any alternative system proposed should also be subjected to a risk assessment.

General concerns for security were not so great at the time of the vessel's construction in 1986 as at present. As a result, little thought was given to the need to make critical spaces of ships, particularly machinery spaces, secure. This is reflected in the lack of a direct access route between the engineers' accommodation and the machinery spaces on *Norsea,* an arrangement which is common to many similar vessels.

Recognizing the changes in demand for security, responses during some emergencies on ro-ro vessels might be enhanced, if their engineers had a direct and uninterrupted route between their accommodation and the machinery spaces. The MCA is recommended to note this need when reconsidering the future designs of ro-ro vessels.

2.7 DEPLOYMENT OF CO_2 SYSTEM

Shortly after the 3/E left the aft engine room, following his final efforts to tackle the fire, all the engineers arrived in the MCR complex in response to the engine room fire alarm sounding in their accommodation.

At that stage, the visibility in the aft engine room was already poor because of smoke. From the 3/E's report, and the images on the CCTV, the C/E was clearly faced with a fuel oil fire in the area of the diesel generator in the aft engine room. Because of the dense smoke, he was unable to assess the extent or intensity of the fire.

He was left with little option other than to deploy the CO_2 system. This decision was reached commendably early in the sequence of events, and the preliminary actions necessary for its deployment were begun. CO_2 was released at 0116, just 10 minutes after the decision to use it was made.

2.8 MALFUNCTION OF CO_2 SYSTEM

Once the aft engine room was closed down, a 3/E and the C/E activated the CO_2 system for the aft engine from its dedicated release cabinet. It was clear, from the cooling of the section of manifold in the cabinet, that gas was being discharged into the aft engine room. However, there was no local indication of the quantity released.

Further, once the frost had melted from the activated CO_2 bottles, there was no clear or obvious indication in the CO_2 room of which cylinders had been released. The indication available was a small plunger on the actuator head of each cylinder. Unless a close examination was made of each actuator head, it was not possible to assess which cylinders had been released. There is no diagram or written instructions in the CO_2 room to assist in judging whether these plungers are in the 'gas released' position. The 2/E later went to the CO_2 room to identify the cylinders that might be needed for a second injection of gas. Nevertheless, without a reason to make a close examination of all, or a majority of, the cylinders, it is unreasonable to have expected him to identify the system's failure.

The C/E, understandably, assumed only 34 cylinders had been released and that the balance of 62 was available to him should a second injection of gas be necessary. He considered this possibility, as set out in the standing orders, when he sent the 2/E to the CO_2 room to identify the cylinders that could be used and which could be released from within the CO_2 room.

Had the C/E been aware that he effectively had no spare cylinders of CO_2, his plans might have been made and executed differently. The most obvious likely difference is that he might have delayed re-entering the aft engine room a little longer. Whether or not the C/E's decisions would have been different, had he known the true state of the CO_2 system, it was clearly essential for him, as the person in control, to have reliable information. Without simple, easily interpreted indications of activation, accurate information on the status of the CO_2 system was not easily obtainable.

Knowing how many cylinders remained full, the C/E made decisions based on the assumption that spare CO_2 was available. The lack of accurate information might have been critical to the handling of the fire and the safety of the vessel.

Consideration could possibly be given to modifying the system so that there is a clear and prominent mechanical indication of whether or not cylinders have been released. This might not be practicable on existing systems. However, a requirement that new systems have this facility could be introduced. Thus, the MCA is recommended to consider making a proposal to the IMO that all fire-fighting systems, of the gas smothering type, should give a clear indication that the discharge mechanism of the storage cylinders have activated.

In the meantime, the MCA is recommended to issue advice, in a Marine Guidance Notice (MGN) or similar, that the method of assessing the activated state of existing CO_2 systems should be posted up in CO_2 rooms of vessels.

In the event, a second release of CO_2 was not required, and the malfunction of the system was not discovered until the vessel's arrival in Zeebrugge.

Clearly, the single release of CO_2 into the aft engine room, was of a far greater quantity than required by design or that necessary to extinguish the fire. It was obviously effective and, in that sense, the system served its purpose. However, the inadvertent loss of what was 'spare' CO_2 for a possible second injection of gas, is of concern.

The system's failure was attributed to the effects of water and dirt on non-return valves in the gas distribution lines. In turn, the presence of water was attributed to the use of humid air during system testing.

These problems have now been recognised and, following the replacement of all systems' non-return valves, the vessel's owners propose to use dried air for system testing.

Other vessels might also test their CO_2 systems with compressed air that is neither clean nor dry. Until these systems are needed to tackle a fire, the consequences of this practice might never be identified; a very unwelcome time to find the problem.

Staff on some vessels, and in some shipping companies, may be alerted to this problem by reading about this accident. However, to reach the widest possible audience, the MCA is recommended to issue an MGN, or similar, highlighting the dangers of testing CO_2 systems using humid compressed air.

2.9 ASSEMBLING OF PASSENGERS

In general, all passengers were alerted and vacated from their cabins very efficiently.

A very few reported that they could not hear the PA announcements clearly inside their cabins. However, crew ensured that all passengers vacated their cabins in case any did not hear, or understand, the announcements.

When the passengers arrived at their assembly points, some were allocated lifejackets, others were not. The problem that arose then was that passengers who were not issued lifejackets, were able to see others who were. This caused some concerns, which were then expressed to assembly point controllers. However, it appears these staff were unsure at what stage lifejackets should be issued to passengers.

The decision whether to issue lifejackets was at the discretion of the assembly point controller. Had a policy been in place as to when and who should authorise their issue, the uncertainty and concern experienced by some passengers would have been avoided.

2.10 PASSENGER COMMUNICATIONS

A common factor in many accidents of this nature is that those on the bridge are very often heavily occupied in handling events. In such circumstances, it is necessary to prioritise what is required. It may be that keeping the passengers informed is not necessarily considered to be of the highest priority at the time.

It is also possible for those on the bridge to temporarily lose their judgment of the passage of time. What they believe is an interval of only 1 or 2 minutes may in fact be 5 to 10 minutes. It is not, therefore, a case that those on the bridge are unaware of the need to inform people of what is happening; more one where the intervals between announcements are misjudged.

Usually the person best placed to make an initial calm and authoritative broadcast is someone not directly involved in handling the accident or its immediate aftermath. The potential difficulty with this, however, is that such a person may not be fully familiar with all the necessary facts to enable them to make such an announcement. They might, therefore, lack the very necessary sound of authority.

During these events, the master did make a number of public address announcements. However, they were at irregular intervals and were often in response to an event, such as the approach of a helicopter. Because passengers were at their assembly stations for several hours, these announcements were perceived, by a number of passengers, to be insufficient in number. A common comment made by a number of passengers was that regular and more frequent announcements would have been appreciated, even if only to say there had been no change in the situation.

The announcements made by the master had the tone of authority necessary to reassure. However, by being just a little more informative, and more frequent, they would have dampened concerns and rumours that were partly generated by some passengers watching news programmes on television.

A number of people were shaken by events. Everyone wanted to know what had happened, whether they were safe, and what was going to happen next. In the aftermath of this accident, such information was, at least from the perspective of some passengers, patchy.

Providing regular and accurate information, in an authoritative and calm manner, is among the most important of all requirements in any passenger-carrying vessel involved in an emergency. The need is extremely well known, but is often overlooked. The difficulties of making adequate provision are recognised, especially when the communication channels are likely to be clogged. It does, however, need to be addressed by management.

2.11 THE FUEL LEAK

After the vessel's arrival in Zeebrugge, a simple pressure test on the low-pressure fuel lines on the generator's engine, confirmed the reports of the watchkeeping 3/E, that the fire was caused by a fuel oil leak. A low-pressure fuel pipe clamped to the inside of the engine's hot box had fretted against its clamp and housing, so wearing a small hole in the pipe's wall.

The limited amount of fire and smoke damage to the aft engine room suggests the quantity of fuel involved was small. The fuel was heated to between 120°C and 130°C, for satisfactory combustion in the engine, yet its flashpoint was 60°C. Therefore, however small the leakage of fuel, its release into the engine's hot box ensured that an associated amount of flammable vapour was also released. As the movement of this vapour was uncontrolled, unconfined and unpredictable, the source of ignition for this vapour is uncertain but was probably the engine's exhaust manifold.

Before this accident, there was no formal procedure for checking the security of the fixing arrangements on low-pressure fuel lines on the engines and generators of *Norsea.* Following their own investigation of the accident, the owners have introduced a monthly procedure for checking the security of these pipes, clamps, mounting bolts and inspection of pipework for chafing. They have also fitted additional clamps to this pipework. As a result, it is judged that MAIB needs to make no further recommendation to the owners.

In MAIB's experience, failure of low-pressure fuel lines is a common cause of engine room fires. Recognition is usually given to the dangers presented by high-pressure fuel lines, often running at high peak pressures, and the effects of high pressures and pressure pulses. There has been less awareness of the dangers of failure of low-pressure lines. To a degree, this has been changed by the lessons learned from accidents and the improved guidelines on the design of low-pressure fuel systems offered by the International Maritime Organization (IMO). However, the general level of awareness of the dangers of low-pressure fuel systems remains uneven within the marine industry.

Because of this patchy level of awareness, Wartsila, the manufacturer of the Vasa 32 engines, is recommended to consider including instructions in its engine user manuals that the security of fuel lines should be checked during hot box inspections. Although this recommendation is directed at Wartsila, it should not be assumed that other types and makes of diesel engines are immune to the problem of failing low-pressure fuel lines.

2.12 INVOLVEMENT OF SHORE-BASED FIREFIGHTERS

Several groups of shore-based firefighters boarded *Norsea*, or prepared to board her, during the accident of 2 September. One group was made up of Ministry of Defence staff, the others were staff from civilian fire brigades.

In the event, although they made up a portion of the party that made the first re-entry into the aft engine room, none was required to tackle the fire. The procedures put in place and activated by ship's staff proved sufficient to contain and extinguish the fire. However, the presence of additional, experienced, fire-fighting personnel, and their advice, was of great support to ship's staff.

It must be recognised that fire brigades maintained by fire authorities having powers under The Fire Services Act, 1947, have no obligation to attend any ship at sea. Those brigades that elect to make themselves available for offshore operations, declare their availability to the MCA, which may then call for a brigade's assistance during an offshore accident.

The Merchant Shipping and Maritime Security Act 1997 (c.28) amended The Fire Services Act, 1947, by inserting after paragraph (d) in subsection (1) of Section 3 (the Section covering supplementary powers of fire authorities):

> *(dd) to employ the fire brigade maintained by them, or use any equipment so maintained, at sea (whether or not within the territorial sea of the United Kingdom)..*

It would appear that this amendment formalised a situation that has been accepted by a number of fire authorities, and brigades, for several years.

However, it is apparent that since this amendment was made, a number of fire authorities have withdrawn their brigades from the list of declared resources available to the coastguard during a maritime emergency. Available figures suggest the 20, or more, brigades willing to operate offshore in 1995, had decreased to 13 in 2002.

One brigade which attended the *Norsea* accident on 2 September 2002, is one of the 13 listed, but has indicated that it, too, will soon no longer respond to offshore accidents.

The reasons for these brigades to withdraw from offshore activities is not clear, but to do so after the 1947 Act was amended would appear to be inconsistent with the philosophy of the amendment. It might also result in uneven responses to emergencies around the UK coast.

Since this accident on *Norsea* in September 2002, the MCA has started a project titled 'Sea of Change'. This project began in January 2003 and is expected to address the issue of offshore fire-fighting around the UK coast. Therefore, no recommendation is made on this matter.

2.13 THE EARLIER FIRE

The fires on board *Norsea* on 14 August and 2 September 2002, have no obvious relationship. They were in different compartments, had different causes, different fuel, and were extinguished using different techniques.

However, there is little doubt that the events of 14 August brought the issue of fire and emergency procedures to the forefront of the minds of all crew members. The experience gained by them during this accident was, at the very least, sufficient to place emergencies in an altogether different category to routine emergency drills, and the possible perception that these events happen only to other ships and other people. This effect was observed by senior officers during subsequent emergency exercises, and was seen as a clear benefit during events of 2 September 2002.

The lessons from this experience were applied by many of the crew during the fire on 2 September, even by those not on board for the first; such is the power of lessons being passed on to colleagues by those who have first-hand experience.

The most obvious demonstration of this effect is the level of confidence shown by the crew members having direct contact with passengers. The volume of praise for the crew's professionalism, as stated by many passengers in their questionnaire responses, is a credit to the crew.

SECTION 3 - CONCLUSIONS

3.1 CAUSES AND CONTRIBUTING FACTORS

The fire was caused by leakage of fuel from the fretting failure of a low-pressure fuel pipe on the aft diesel-driven generator, in the aft engine room, because of incomplete securing arrangements. Ignition of the associated vapour was probably from contact with the diesel engine's exhaust manifold.

The routine inspection regime for this area of the engine did not include a check of fuel pipe securing arrangements.

3.2 OTHER FINDINGS

1. During his attempts to tackle the fire, the watchkeeping third engineer was affected by smoke.

2. The bridge watchkeeping second officer was not fully conversant with correct emergency procedure because of weaknesses in his induction training.

3. Although effective in extinguishing the fire, the CO_2 smothering system malfunctioned and discharged too much gas into the aft engine room.

4. There was no clear and obvious indication that CO_2 bottles had been discharged.

5. The acceptance of a watch alarm as a substitute for a second machinery space watchkeeper might place personnel at risk.

6. When attending the machinery spaces in an emergency, off duty engineers might be delayed by the need to pass through several passenger decks, at least two locked doors, and walk over half the length of the vehicle deck.

SECTION 4 - ACTIONS TAKEN

Following this accident, P&O Ferries, the owners of *Norsea,* performed their own investigation. This identified several issues that the owners considered warranted attention. As a result, the following actions have been taken, or are planned:

1. The enhancement of induction training for new or temporary staff.
2. Fitting a system that allows the closing of fuel supply valves to each engine from within the machinery control room.
3. Renewing all one-way check valves on the manifold and pilot lines of the CO_2 smothering system.
4. Explicit requirement that, during routine examinations, the security of low-pressure fuel lines in hot boxes of all engines should be checked.
5. Fitting additional security clamps to low pressure fuel lines in engine hot boxes.
6. A second person to attend machinery spaces with the watchkeeping engineer. This may be reviewed when a hi-fog fire extinguishing system is installed in the machinery spaces.
7. Clean and dry compressed air to be made available for future testing of the CO_2 system.

SECTION 5 - RECOMMENDATIONS

The Maritime and Coastguard Agency is recommended to:

1. Consider making a proposal to the International Maritime Organization that, in addition to present requirements, the fuel supply to each main and auxiliary engine should be capable of isolation from the machinery control room.

2. Consider requiring a risk assessment be performed before agreeing to any application for a safe manning document that specifies single person manning of multi-compartment, category A machinery spaces.

3. Consider making a proposal to the International Maritime Organization that all fire-fighting systems, of the gas smothering type, should give a clear indication that the discharge mechanism of each reservoir has been activated.

4. Consider issuing advice on the importance of using clean and dry air for testing CO_2 gas smothering fire extinguishing systems, if air is the medium used for testing.

5. Consider issuing advice that the method of assessing the activated state of CO_2 system storage bottles should be posted up in the CO_2 rooms of all vessels using these systems.

6. Consider that future designs of ro-ro vessels include a direct and uninterrupted route, which does not pass through passenger or vehicle spaces, between the machinery spaces and the engineers' accommodation.

The manufacturer of the generator's engine, Wartsila, is recommended to:

7. Offer explicit advice to engine users on routine checking of the security of low-pressure fuel pipes in the hot boxes of the Vasa 32 range of engines.

Marine Accident Investigation Branch
June 2003

ANNEX A

Fire Procedures Checklists

ENGINE ROOM CHECKLIST – AFT ENGINE ROOM (Blue Section)

IMMEDIATE ACTION

ACTION	*PERSON RESPONSIBLE*
On hearing the Engine Room fire siren, sound crew accident alarm and call Emergency teams. Call Master	**Officer in Charge, Bridge**
Initiate Engine Room fire fighting procedure aft engine room	**Chief Engineer**

INITIAL ACTIONS

ACTION	*PERSON RESPONSIBLE*
Communicate with Emergency Teams Deck and Engine Room; obtain available Information re: Nature and location of fire Persons reported missing Containment achieved. Chief Engineer controls Engine Room Procedure and Deck and Emergency Team acts as back-up	**Officer in Charge/ Master**
Engine Room will try to give motive power and electrical power from forward engine room.	**Officer in Charge/ Master**
Carry out alarm and pitch procedure in preparation. ***Deliberate shut down of all motive power must have the Master's consent.***	
Engine Room fire procedure covers:	**Chief Engineer**

Ventilation fans shut down.
If requested, Bridge operate No7 remote stop

Fire flaps shut
Vent control team close Engine Room Fire Flaps.
It may be prudent to allow heat and gases to escape until ready to flood with CO_2.

Remote Stops Shut
If requested, Bridge operate
Nos 2,4,5 and 6 remote stops

Operate Quick Closing Valves
To shut off fuel supplies

Organize Deck and ER Team to man CO_2 release cabinets 'F' Deck and Drenching Room. 'F' Deck. Drenching sections Nos 3,4,7,8 and 9 to be operated for boundary cooling. BA teams on stand-by	**Officer in Charge/ Master**
If nobody is trapped in aft engine room, or The fire is anything other than small and Localised, shut down of aft engine room And flooding with CO2 MUST be carried out within 15 minutes of fire breakout.	**Officer in Charge/ Master**
Order Chief Engineer to carry out CO_2 flooding procedures.	**Chief Engineer**

SECONDARY ACTION

ACTION	***PERSON RESPONSIBLE***
Continue with boundary cooling. Emergency teams to delegate members to monitor hot spots/bulkheads for Cooling or otherwise.	**Chief Officer**
Discharge top-up CO_2 into aft engine room until satisfied re-entry can be safely made under strict control of Chief Engineer or Second Engineer.	**Chief Engineer**

FURTHER ACTION

ACTION	***PERSON RESPONSIBLE***
Carefully examine whole aft engine room for hot spots, smouldering items. Keep fire teams on stand-by until shore assistance is obtained.	**Chief Engineer**

ANNEX B

Engine Room Checklist – CO_2 Flooding Procedure

IMMEDIATE ACTION

ACTION	***PERSON RESPONSIBLE***
On hearing the Engine Room fire siren, sound crew accident alarm and call Emergency teams. Call Master	**Officer in Charge, Bridge**
Initiate Engine Room fire fighting procedure aft engine room	**Chief Engineer**

INITIAL ACTIONS

ACTION	***PERSON RESPONSIBLE***
Communicate with Emergency Teams Deck and Engine Room; obtain available Information re: Nature and location of fire Persons reported missing Containment achieved. Chief Engineer controls Engine Room Procedure and Deck and Emergency Team acts as back-up	**Officer in Charge/ Master**
Engine Room will try to give motive power and electrical power from forward engine room. Carry out alarm and pitch procedure in preparation. ***Deliberate shut down of all motive power must have the Master's consent.***	**Officer in Charge/ Master**
Engine Room fire procedure covers:	**Chief Engineer**

<u>Ventilation fans shut down.</u>
If requested, Bridge operate No7 remote stop

<u>Fire flaps shut</u>
Vent control team close Engine Room Fire Flaps.
It may be prudent to allow heat and gases to escape until ready to flood with CO_2.

<u>Remote Stops Shut</u>
If requested, Bridge operate Nos 2,4,5 and 6 remote stops

Operate Quick Closing Valves
To shut off fuel supplies

Organize Deck and ER Team to man CO_2 release cabinets 'F' Deck and Drenching Room 'F' Deck. Drenching sections Nos 3,4,7,8 and 9 to be operated for boundary cooling. BA teams on stand-by	**Officer in Charge/ Master**
If nobody is trapped in aft engine room, or The fire is anything other than small and Localised, shut down of aft engine room And flooding with CO2 MUST be carried out within 15 minutes of fire breakout.	**Officer in Charge/ Master**
Order Chief Engineer to carry out CO_2 flooding procedures.	**Chief Engineer**

SECONDARY ACTION

ACTION	***PERSON RESPONSIBLE***
Continue with boundary cooling. Emergency teams to delegate members to monitor hot spots/bulkheads for Cooling or otherwise.	**Chief Officer**
Discharge top-up CO_2 into aft engine room until satisfied re-entry can be safely made under strict control of Chief Engineer or Second Engineer.	**Chief Engineer**

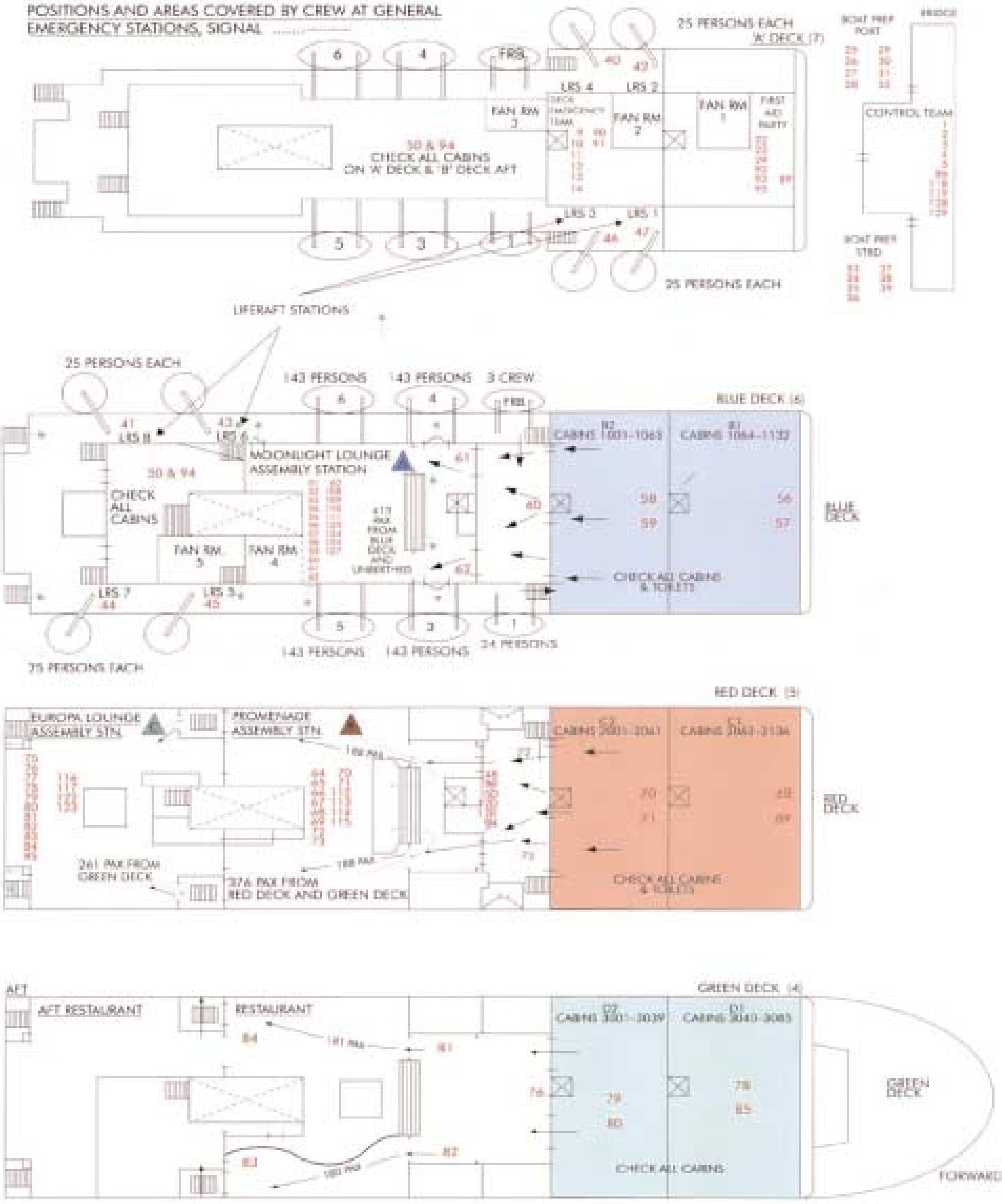
FURTHER ACTION

ACTION	***PERSON RESPONSIBLE***
Carefully examine whole aft engine room for hot spots, smouldering items. Keep fire teams on stand-by until shore assistance is obtained.	**Chief Engineer**

ANNEX C

Assembly Station Planning Chart

M.V. NORSEA ASSEMBLY STATION PLANNING CHART



ENGINE ROOM CONTROL TEAM:
6, 7.
E/R EMERGENCY TEAM: 15, 16, 17, 18.
PLUS 87, 88.
VENTILATION BACK-UP TEAM: 19, 20, 21.

NOTE: WHEN SECTIONS & RESTAURANTS ARE CLEAR OF PAX, DOOR & ALLEYWAY MARSHALLS & STEWARDS CLEARING SECTIONS SHOULD PROCEED TO THEIR ASSEMBLY STATIONS. ESCAPES FROM ASSEMBLY STATIONS TO SURVIVAL CRAFT ARROWED IN GREEN.