Report on the investigation of

the engine room fire on board

the passenger cruise vessel

The Calypso

16 miles south of Beachy Head

6 May 2006

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This is a joint investigation report between MAIB and the Department of Merchant Shipping of the Republic of Cyprus (hereinafter referred to as Cyprus Maritime Administration). The MAIB has taken the lead role pursuant to the IMO Code for the Investigation of Marine Casualties and Incidents (Resolution A.849(20)).

Extract from

The United Kingdom Merchant Shipping

(Accident Reporting and Investigation)

Regulations 2005 – Regulation 5:

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

NOTE

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

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GLOSSARY OF ABBREVIATIONS AND ACRONYMS

ATSB	-	Australian Transport Safety Bureau
BA	-	Breathing Apparatus
CO_2	-	Carbon Dioxide
CPP	-	Controllable pitch propeller
cSt	-	Centistokes – a measure of fuel viscosity
DNV	-	Det Norske Veritas
DOC	-	Document of Compliance
ECR	-	Engine Control Room
EU	-	European Union
FSS	-	International Code for Fire Safety Systems
hp	-	High pressure
IMO	-	International Maritime Organization
ISM	-	International Safety Management Code - the “Code”
kW	-	kilowatts
LP	-	Low pressure
LR	-	Lloyd’s Register of Shipping
MCA	-	Maritime and Coastguard Agency
MIRG	-	Maritime Incident Response Group
MMSI	-	Maritime Mobile Service Identity
MOU	-	Memorandum of Understanding
MRCC	-	Maritime Rescue Co-ordination Centre
Nm	-	Newton metre
OOW	-	Officer of the Watch
PC	-	Passenger Ship Safety Certificate
PSC	-	Port State Control
QCV	-	Quick closing valve

RCC	-	Rescue Co-ordination Centre
RNLI	-	Royal National Lifeboat Institution
SAR	-	Search and Rescue
SIReNAc	-	Website giving information on PSC inspections
SMC	-	Safety Management Certificate
SMS	-	Safety Management System
SOLAS	-	Safety of Life at Sea
SOSREP	-	Secretary of State's Representative for Salvage and Intervention
TSS	-	Traffic Separation Scheme
USCG	-	United States Coast Guard
UTC	-	Universal Coordinated Time
VHF	-	Very High Frequency (radio)

SYNOPSIS

At 0330 ship's time on 6 May 2006, the Cypriot registered cruise ship *The Calypso* suffered an engine room fire while on passage from Tilbury to St. Peter Port, Guernsey, with 708 passengers and crew on board. Initial action by the watchkeeping engineer officer was effective in eventually extinguishing the fire although the vessel lost all but emergency electrical power and was left drifting in the south-west lane of the Dover Straits Traffic Separation Scheme (TSS), 16 miles south of Beachy Head. The vessel's starboard main engine had been very seriously damaged and she was towed to the port of Southampton by the Maritime and Coastguard Agency's (MCA) emergency towing vessel *Anglian Monarch.*

The subsequent investigation discovered that the fire had been caused by a failed low pressure fuel pipe flange on the starboard Wartsila Vasa32 main engine. The lack of an effective guard allowed fuel to spray onto the adjacent turbocharger and/or exhaust piping causing spontaneous ignition. Metallurgical analysis has shown that the two 10mm socket headed flange bolts had failed probably due to fatigue. Similar incidents had occurred in the past and, over 10 years previously, Wartsila had become aware of the weakness in the flange design. Wartsila had issued a technical bulletin in 1995 which, among other things, recommended modifications to low pressure fuel pipe flanges. The bulletin was circulated to service engineers and owners of vessels fitted with Wartsila Vasa32 engines. Possibly due to frequent changes in the vessel's ownership, that bulletin and another updated one, which was circulated in 1999, were not effective in ensuring that the necessary modifications were carried out on *The Calypso.*

The fire was intense, and the subsequent fire-fighting response highlighted flaws in the knowledge, experience and training of some of the senior ship's officers. Those on board believed that the fire had been successfully extinguished by the quick use of the fixed CO_2 fire smothering system. The fire had, in fact, died down mainly as a result of fuel starvation due to the quick action of the watchkeeping engineer officer. Those in charge of the fire-fighting response did not appear to follow recognised good practice. The attempt to release CO_2 was made from the CO_2 room, and not from the appropriate remote operating station, from where mistakes were less likely to have occurred. The person tasked to release the CO_2 was not the person designated on the muster list. On a number of separate occasions soon after they thought CO_2 had been released, senior officers re-entered the engine room without the proper equipment or back-up and with the consequent risk of allowing air to feed the fire.

The officer, who had attempted to release the CO_2, had mistaken timer bottles for pilot cylinders and it subsequently transpired that, unbeknown to anyone on board, no CO_2 had been released in the immediate aftermath of the fire. The CO_2 system was not checked and made secure after the fire, and it had been left in a dangerous condition with distribution and other valves open and all the cylinders still full. During the investigation into the cause of the fire, after the vessel's arrival in Southampton, CO_2 from a bank of cylinders was accidentally released into the engine room. In the event, three crew were lucky to escape without loss of life or serious injury.

During the fire-fighting efforts, the passengers were kept well informed, were quickly accounted for and, wearing lifejackets, mustered on the Boat deck. The boats were brought to the Embarkation deck without incident. Despite most passengers being elderly, and the cold temperatures experienced out on deck at night, it is to the credit of the master and the crew that nobody suffered anything more than discomfort. They were eventually allowed back into the accommodation only when the master was sure that the fire was out and it was therefore safe.

Recommendations have been made to the Cyprus and UK maritime administrations to co-produce, and take to IMO, papers regarding the need for clear identification of the controls of fixed CO_2 installations, and on improving crew knowledge of how to carry out pre and post use inspection checks of the CO_2 system.

Additional action has been taken by the vessel operator, the engine manufacturer, MAIB, the Cyprus administration, MCA, the vessel Classification society and the independent fire investigating company to address other safety issues identified in this report.

Figure 1

The Calypso

SECTION 1 - FACTUAL INFORMATION

1.1 PARTICULARS OF *THE CALYPSO* AND ACCIDENT (Figure 1)

Vessel details

Registered owner	:	Calypso Navigation Ltd, Marshall Islands
Manager(s)	:	Louis Ship Management Ltd, Cyprus
Port of registry	:	Limassol
Flag	:	Cyprus
Type	:	Passenger
Built	:	1967 Italcantieri, Italy
Classification societies	:	Lloyd's Register (Hull & Machinery) Det Norske Veritas (ISM)
Construction	:	Steel
Length overall	:	135.47m
Gross tonnage	:	11162
Engine power and/or type	:	Two Wartsila, Type 12V32, 4 stroke turbo charged 12 cylinder diesel engines, with cylinders arranged in Vee formation, developing 4500kW each
Service speed	:	16.3 knots
Other relevant info	:	Conversion to cruise ship - 1992 Refurbished – 1994 Re-engined 1994

Accident details

Time and date	:	0230 UTC 6 May 2006
Location of incident	:	50˚ 28.7N 000˚ 07.8E 16 NM South of Beachy Head
Persons on board	:	Crew: 246; Passengers: 462
Injuries/fatalities	:	None
Damage	:	Extensive fire damage to starboard main engine and starboard uptake, necessitating new engine block and various systems re-wiring.

1.2 BACKGROUND INFORMATION

1.2.1 Vessel history

The Calypso was originally designed and built as the car ferry, *Canguro Verde,* by Italcantieri, an Italian shipbuilder which has since changed its name to Fincantieri.

In 1994, *The Calypso* completed a major conversion program at the Avalis Shipyard in Greece where she was converted into a cruise passenger vessel and fitted with new engines.

The Calypso has changed ownership six times since she was built. At the time of the accident, she was operated by Louis Ship Management Ltd from its Cyprus offices.

The Calypso was laid up for the winter season in Piraeus on 18 November 2005 and was in re-fit from 7 March 2006 in preparation for the cruising season of 2006. During that time, she maintained a skeleton crew of 60. She came back into service on 17 April 2006, changed her flag from Greece to Cyprus and left Piraeus on 18 April.

The Calypso held a current passenger ship safety certificate, issued on 18 April 2006 by Lloyd's Register of Shipping (LR). It was planned that she should carry out a series of mini cruises around the UK and NW Europe.

After departing Piraeus, *The Calypso* called at Barcelona, where she embarked about 400 passengers for a mini cruise to Seville. A Port State Control inspection was carried out in Seville between 24 and 26 April. She then returned to Barcelona, arriving on 29 April where she embarked a riding team to carry out maintenance repairs.

She sailed from Barcelona without passengers and arrived at Zeebrugge on 4 May. During this voyage, the crew carried out a number of practice emergency drills. At Zeebrugge she embarked 462 passengers organised through a Dutch holiday cruise company. Before she left Zeebrugge, a passenger lifeboat evacuation drill was carried out, which incorporated an inspection of all the muster stations by the master.

She arrived in Tilbury at 0730 the following day, where a Port State Control inspection was carried out by two MCA surveyors between 0930 and 1645. Two Lloyd's Register surveyors also attended. She departed Tilbury in the early evening and the engine room fire occurred at 0330 ship's time the next day.

1.2.2 Vessel description

The Calypso was powered by two 4500kW Wartsila diesel engines which were located about amidships and produced a cruising speed of about 16 knots. She was fitted with bow and stern thrusters which were used for berthing and un-berthing. The vessel was also fitted with Denny Brown stabilizers to dampen her motion in heavy seas.

The Calypso was certified to carry up to 740 passengers but usually carried no more than 596 at one time due to cabin restrictions and/or guest combinations. The vessel was equipped with 243 passenger cabins and she could also carry about 246 crew members.

To facilitate identification, the ship's decks were given names as follows, starting from the lowest: **(Figures 2a/2b)**

Tank Top; Lower; Concerto; Bolero; Allegro; Rendezvous; Boat; Bridge; Calypso; Sun.

The engine control room (ECR) was sited at the Lower deck level **(Figure 7b)**, and the safety room **(Figure 7a)**, where engineer officers mustered in the event of an emergency, at the after end of the engine casing on Bolero deck on the starboard side. Bolero deck also housed the remote release station for CO_2 into the engine room **(Figure 7a)**. The CO_2 compartment was on the Rendezvous deck with its access one deck above on the Boat deck.

Following her conversion to a cruise ship in 1994, *The Calypso* met the SOLAS 1974 (as amended) requirements for thermal and structural subdivision of passenger ships carrying more than 36 passengers.

The vessel was divided into five fire zones separated by four vertical "A60" class divisions from the Tank Top to Allegro deck designed to withstand a temperature rise on the unexposed side of no more than 139˚C within an hour. These zones were further sub-divided by "A" class steel bulkheads from the Tank Top to the Lower deck. Watertight doors provided access through these boundaries. The ECR was not enclosed by an A60 class bulkhead.

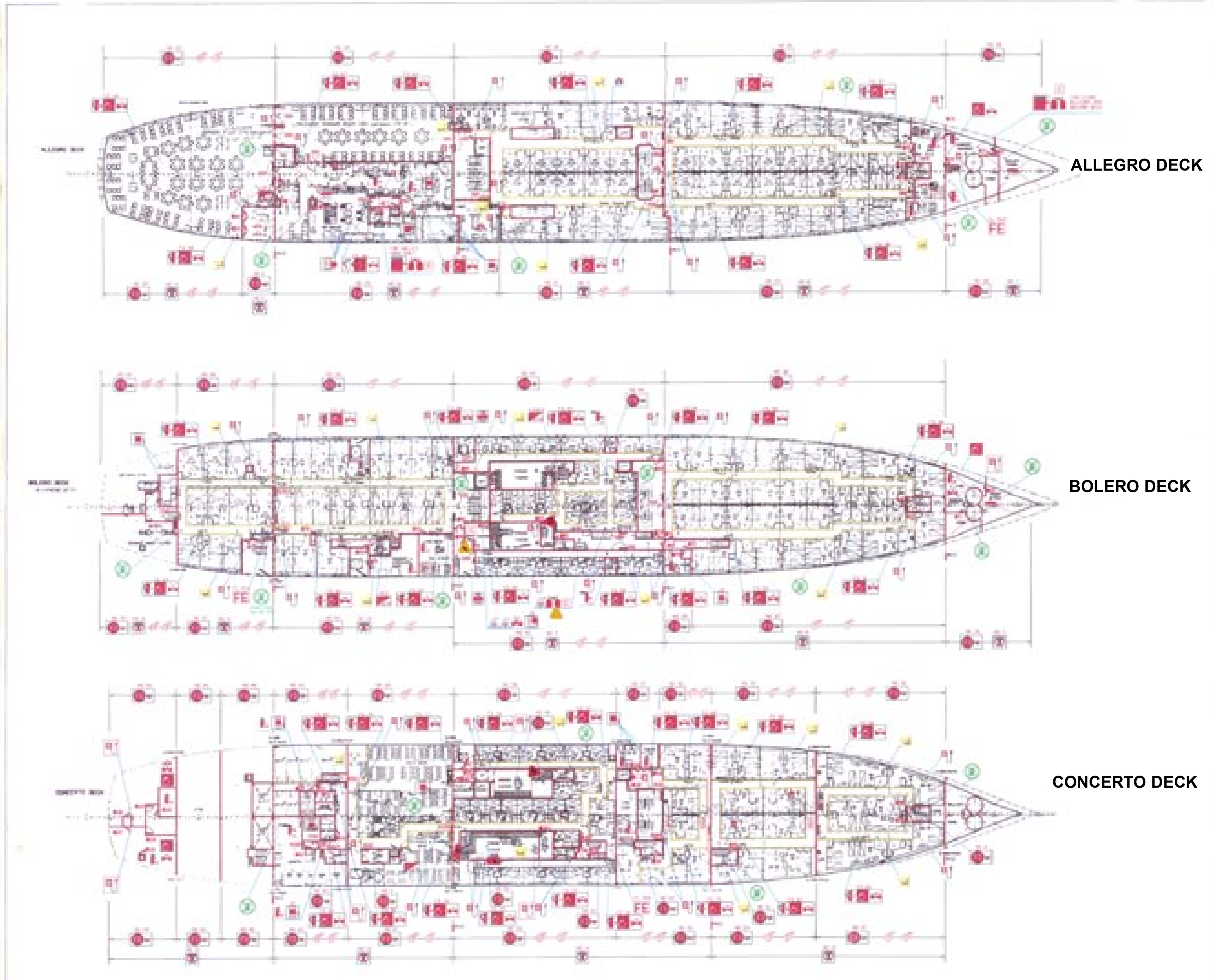
The main machinery spaces were in one horizontal fire zone, the boundaries of which were at the aft end of the engine room and the forward end of the stabiliser space. Above this space, at the Lower deck level only, a further fire zone boundary was introduced at the forward bulkhead of the generator room. The two fire zone bulkheads forming the boundary of the central machinery area continued vertically to the Calypso deck. Within this boundary, "A" class bulkheads surrounded specific machinery and access spaces, such as the port and starboard casings, air conditioning and ventilation rooms.

The quick closing valves for the fuel and lubricating oil tanks and the emergency stops for machinery and accommodation spaces ventilation fans, main engine, generator and boiler control panels were sited in the safety room on Bolero deck.

Manually-operated fire dampers and louvered closing devices were located around the vessel on various decks. The air conditioning engineer was in charge of the ventilation team responsible for closing these fire suppression devices.

The Calypso's classification society was Lloyd's Register of Shipping (LR), and her International Safety Management (ISM) certification was issued by Det Norske Veritas (DNV).

Figure 2a - Fire control plan



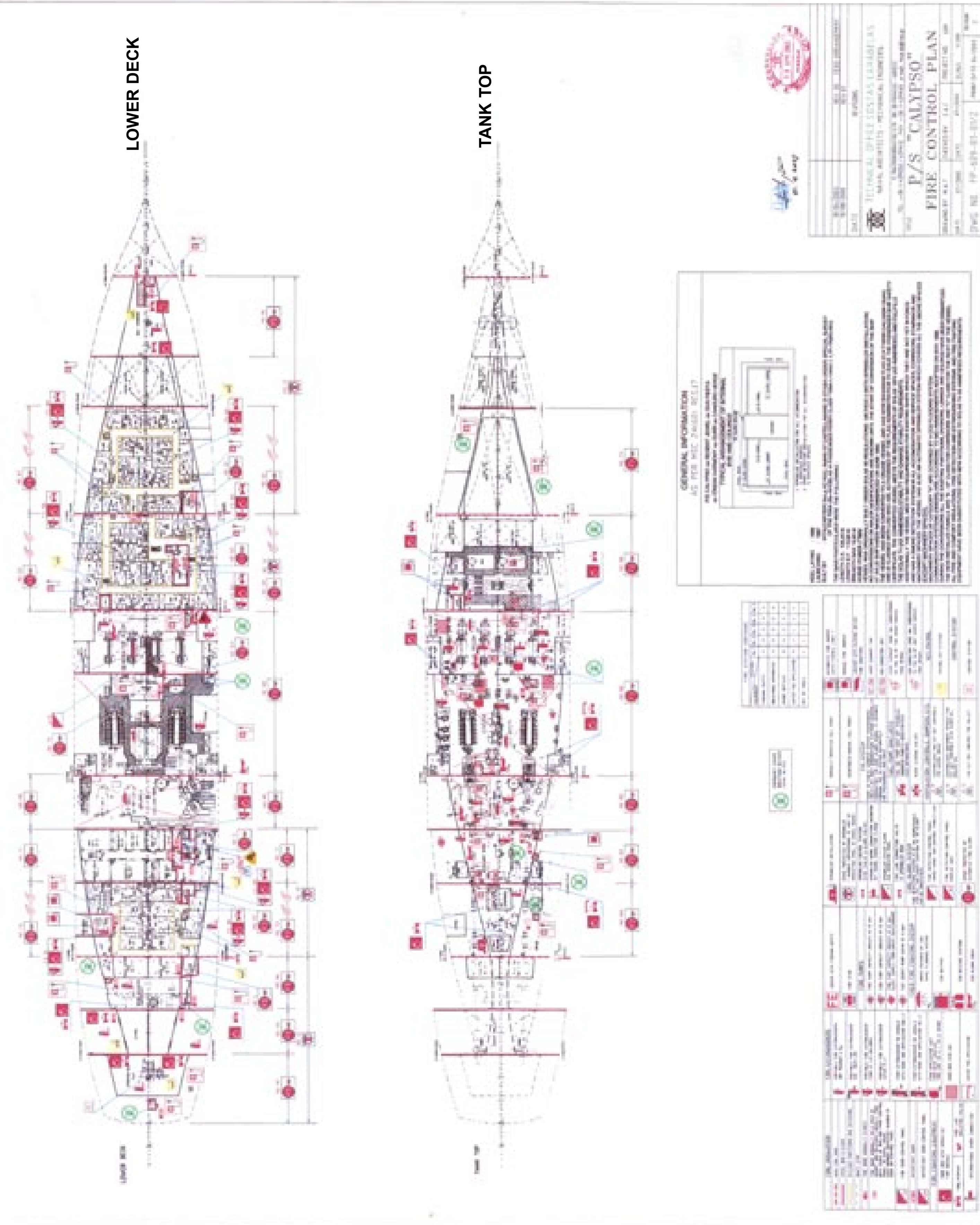
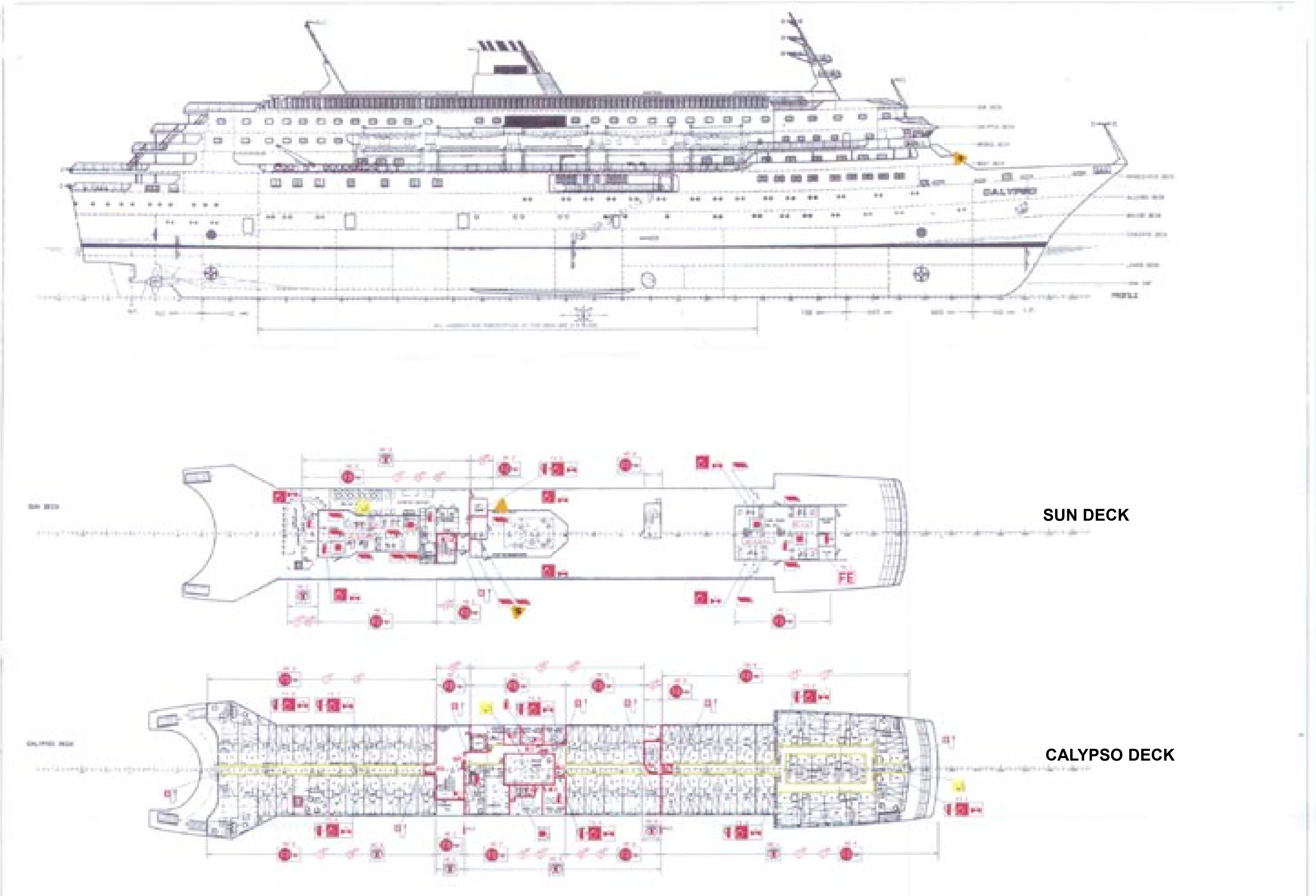
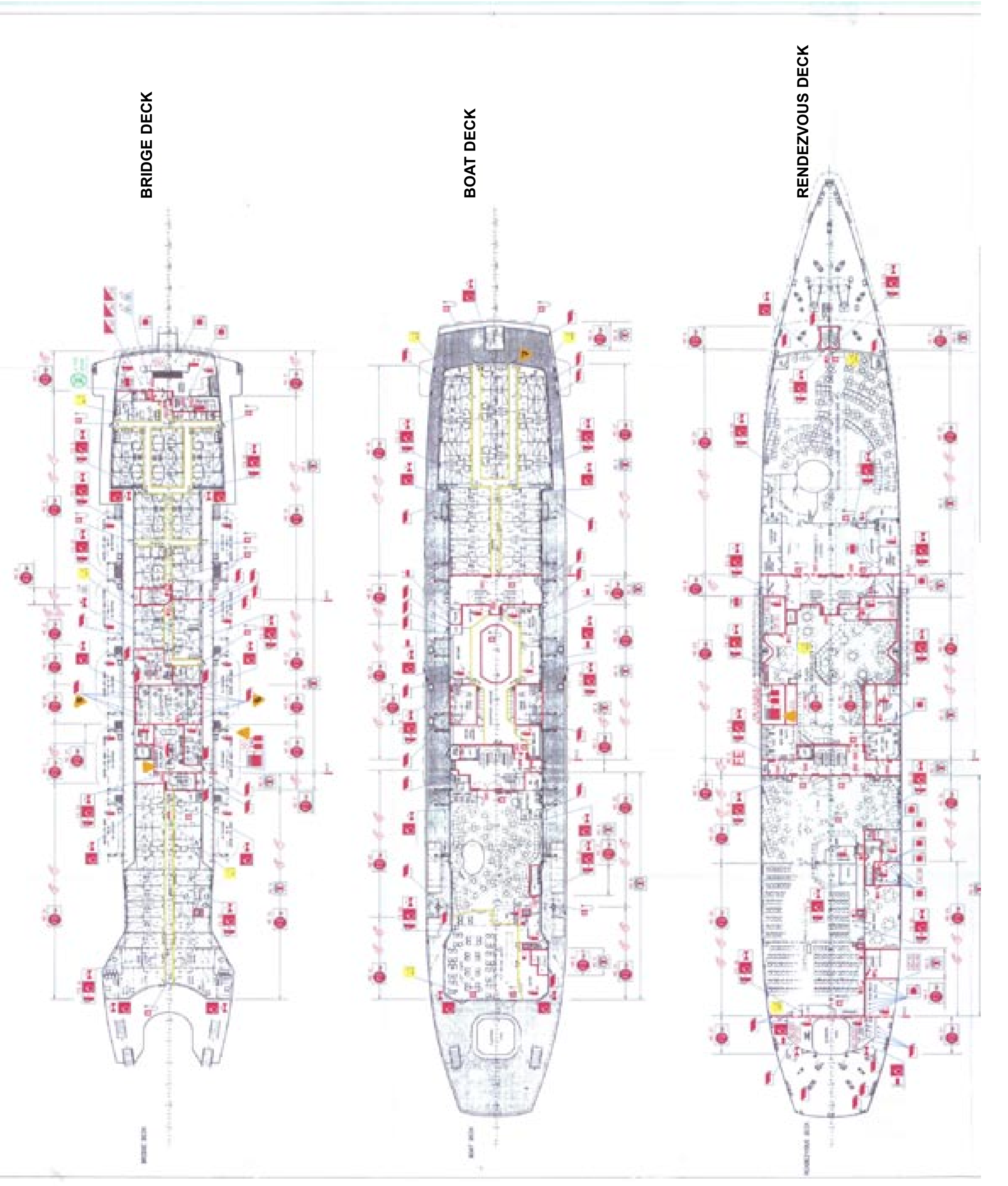

LOWER DECK
TANK TOP
GENERAL INFORMATION
P/S "CALYPSO"
FIRE CONTROL PLAN

Figure 2b - Fire control plan




BRIDGE DECK
BOAT DECK
RENDEZVOUS DECK

1.3 ENVIRONMENTAL CONDITIONS

When the vessel departed Tilbury, the weather conditions were reported to be partly cloudy with fair winds and good visibility.

At about the time of the accident, on 6 May, the weather was recorded as being clear skies with a slight breeze from a south-westerly direction. The tidal stream was flowing in a south-westerly direction at a rate of less than 1 knot. Visibility was reported to be good.

1.4 NARRATIVE OF ACCIDENT

All times are local (UTC +1)

The Calypso departed Tilbury Passenger Terminal at 1838 on 5 May 2006, with a pilot on board, bound for St Peter Port in the Channel Islands. She was carrying 462 passengers, mostly of Dutch nationality, and 246 crew members of mixed nationality.

The pilot was disembarked at the North East Spit pilot station at 2219. The vessel was clear and full away on passage at 2224 and, soon after, the master left the bridge. He returned briefly at 0030 on 6 May 2006 to check that everything was proceeding according to the passage plan which required them to use the SW lane of the Dover Straits TSS.

At 0330, the third engineer officer was writing up his logbook when he saw flames through the window of the engine control room (ECR). The flames appeared to be coming from between the 5 and 6 unit (inboard) of the starboard main engine. He immediately phoned the bridge and informed them of the fire, and asked for the engine control to be passed to the engine room. The second officer quickly complied with the request.

The third engineer brought the pitch of both controllable pitch propellers to zero, de-clutched both engines, and then stopped them both. He entered the engine room with a damp cloth over his face. Through the increasingly smoke-filled engine room, he went down one deck and stopped the fuel oil feed and booster pumps and closed the pump valves on the port forward side. He located his two assistants, a motorman and engine room wiper, and they evacuated the engine room and woke the chief engineer.

Soon after the third engineer's telephone call, the fire alarm panel on the bridge was triggered automatically, indicating a fire in the starboard engine casing on the Boat deck. The second officer, who was the OOW, called the master, staff captain and the safety officer to inform them. The master arrived on the bridge at 0334, followed soon after by the staff captain and safety officer who, after ascertaining the basic incident details, went to the safety room.

When they arrived in the safety room, located 2 decks above the ECR on Bolero deck, aft of the starboard engine casing, they found the chief engineer had already arrived. They all looked into the starboard engine casing from the access door. They saw flames, which they assessed to be between two to three decks high, and reported this to the master, who had remained on the bridge. The chief engineer operated the remote quick closing valves for the fuel and lube oil systems, and the stops for the engine room ventilation fans.

The master made an assessment of the situation based on the information he received and, at 0336, announced “Code Bravo” over the public address system. This was the signal for the crew to assemble at their fire response muster stations.

A number of crew mustered in the safety room, including three fire entry teams with BA sets.

Soon after this, the air conditioning engineer was ordered to close all the ventilation flaps to the engine room.

At about the same time, an attempt was made to fight the fire, with hoses. A fire entry team, comprising two crewmen wearing BA sets, entered the starboard casing from the safety room, on Bolero deck, aft. They found it very hot and withdrew after a few minutes.

At 0341, the chief engineer made a recommendation to the master that the fixed fire-fighting CO_2 system should be used to extinguish the fire. The master agreed to this proposal after receiving confirmation that the engine room had been evacuated.

Another fire entry team, led by the safety officer, went down one deck to Concerto deck and began boundary cooling of the starboard engine casing areas along the starboard and aft athwartship alleyways. The sprinkler system had already activated in the alleyways surrounding the casing areas affected by the fire. When the safety officer was informed of the decision to use the CO_2, he handed over the charge of his team to the staff captain and went to the CO_2 compartment entrance on the port side of the Boat deck.

The chief engineer instructed the chief electrician, who was in the safety room, to release the CO_2 into the engine room. The 8 -12 watch third engineer was the designated person to release the CO_2 in accordance with the muster list but, despite the fact that he was in the safety room, he was not sent to carry out this task.

In the meantime, a number of passengers, who had still been in the ship’s passenger bar and disco, went outside and smelt smoke. They returned inside and informed crew members and other passengers.

At 0344, the master made a general announcement for all passengers to proceed to their muster stations, wearing lifejackets.

The CO_2 compartment hatch was opened by the chief electrician and safety officer, but only the chief electrician entered and climbed down a vertical ladder below the hatch entrance to the Rendezvous deck where the CO_2 bottles were located **(Figure 3)**. The safety officer was unable to enter the space as he was encumbered by the breathing apparatus he was wearing. An engine room alarm sounded as a warning that the hatch had been opened.

At 0346, the master ordered the OOW to send a distress signal on VHF channel 16: this was received by MRCC Dover. At 0347, the safety officer confirmed that they were ready to release the CO_2. However, due to poor reception between the chief engineer, who was still in the safety room, and chief electrician, in the CO_2 room, on the portable VHF radios that they were using, the chief electrician was unable to clearly hear the subsequent instructions from the chief engineer. The chief engineer went to the CO_2 room entrance on the Boat deck and, through the hatch, ordered the chief electrician to release all the CO_2 into the engine room and boiler room.

Figure 3

CO_2 space hatch

The chief electrician opened the valves on two small bottles on the aft bulkhead, which he believed were the pilot cylinders **(Figure 4)**. He then operated the control levers for the engine and boiler room gas supply lines **(Figure 5)**, as directed by the posted instructions, and manually opened the distribution valves to the engine room and boiler room **(Figure 6a/6b)**. He left the CO_2 room within a few minutes and informed the chief engineer that the CO_2 system had been operated. At 0350, the safety officer contacted the bridge and confirmed that the CO_2 had been released. At about this time, an electrical blackout occurred and the emergency diesel generator started.

At about the same time as the distress call was made, the general alarm was sounded and the order was passed to prepare the lifeboats for embarkation of the passengers.

The cruise director, who had made his way to the bridge, supplemented announcements to the passengers, initially in English, with similar announcements in Dutch. The passengers had begun to muster with their lifejackets on and, at 0423**,** the bridge was told that they were all accounted for at their lifeboat stations and that the lifeboats had been lowered to the embarkation deck.

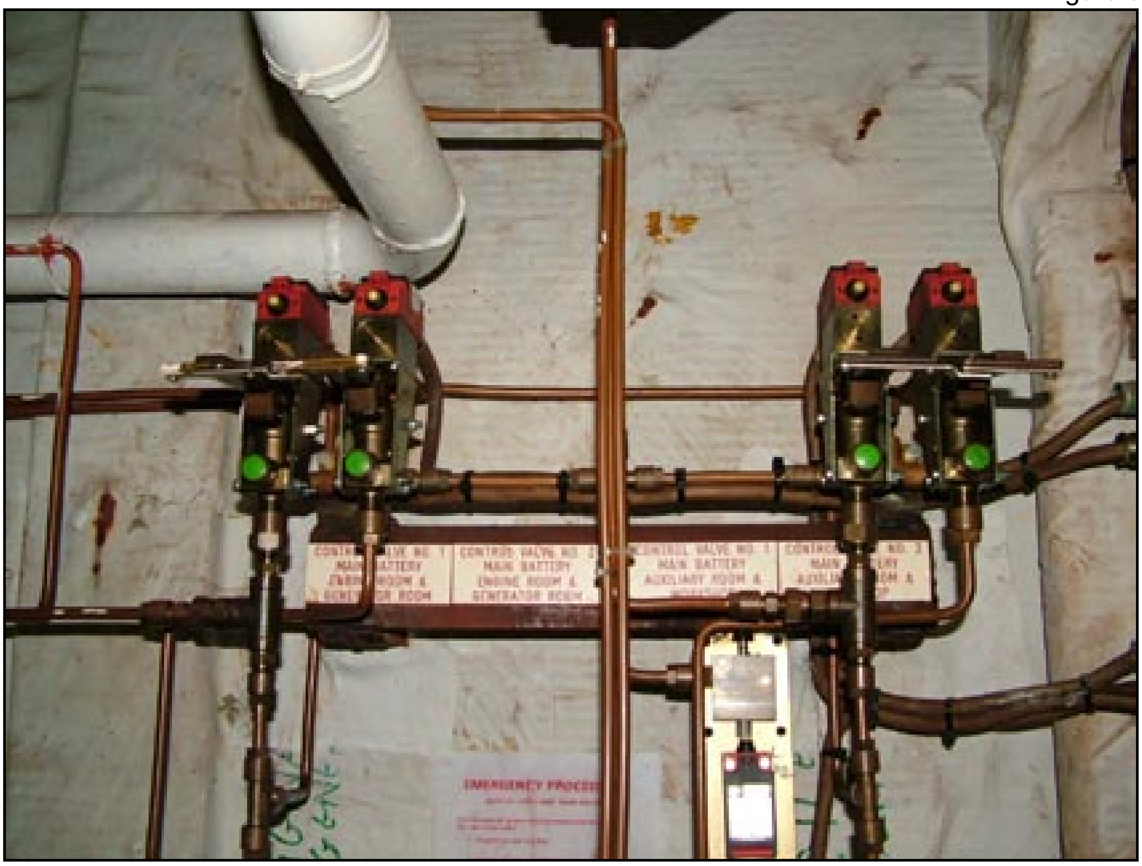
A cabin check was completed by the housekeeping department which confirmed that all cabins were empty.

A few minutes after the operation of the CO_2, the staff captain briefly entered the engine room, with a damp cloth over his face and no breathing apparatus.

Figure 4

Timer cylinders

Figure 5



Control levers - in released condition

Figures 6a and b

Distribution valves

About 10 minutes after the operation of the CO_2 system, the chief engineer and chief electrician donned BA sets and entered the engine room from the safety room to undertake an assessment. They found that the fire had depleted and advised the master at 0408. The chief engineer warned other crew members not to enter the engine room due to the danger posed by the CO_2.

At about the same time, the staff captain entered the engine room alone, wearing a BA set but without informing the chief engineer. The staff captain spent several minutes in the space before leaving and informing the master that the fire appeared to be out, but there were still very high temperatures within the space.

At 0416, *The Calypso* reported to MRCC Dover that the fire was under control, and that there were no injuries to the passengers or crew.

MRCC Dover offered the assistance of the newly formed Maritime Incident Response Group (MIRG), a multi-agency framework, comprising specialist fire-fighting teams and representatives from the MCA and the ambulance service. The master accepted the offer, and the East Sussex Fire and Rescue Service, who had been on standby since 0354, were deployed. Three other MIRG teams were alerted and stood by to support, reinforce or to relieve the East Sussex team as required. Four rescue helicopters were organised to transport the firefighters and other support personnel to the vessel. *Anglian Monarch*, the MCA's emergency towing vessel, was standing by as well as four French and three RNLI lifeboats.

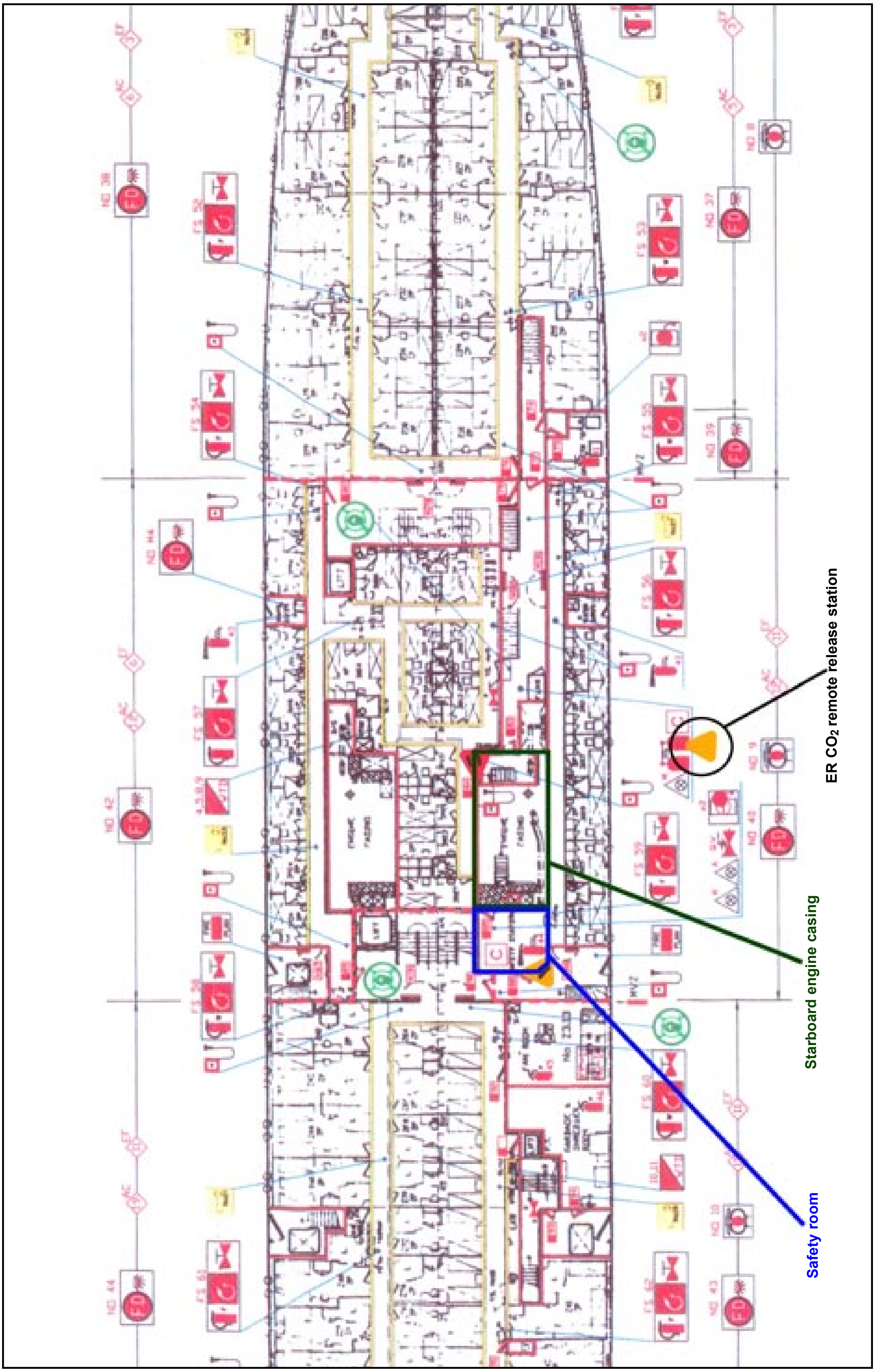
Two of the crew fire teams took turns in entering the starboard casing via the forward and aft entrances to spray water over the machinery. The other fire team continued boundary cooling and then, later, entered the engine room from the Lower deck (through the boiler room) to put out some of the remaining small fires **(Figures 7a/7b)**.

The chief engineer re-entered the engine room about 1 hour after the operation of the CO_2 system to find that the fire was out. He took off his BA mask to sniff the air which he judged to be breathable and decided to open the ventilation to the space.

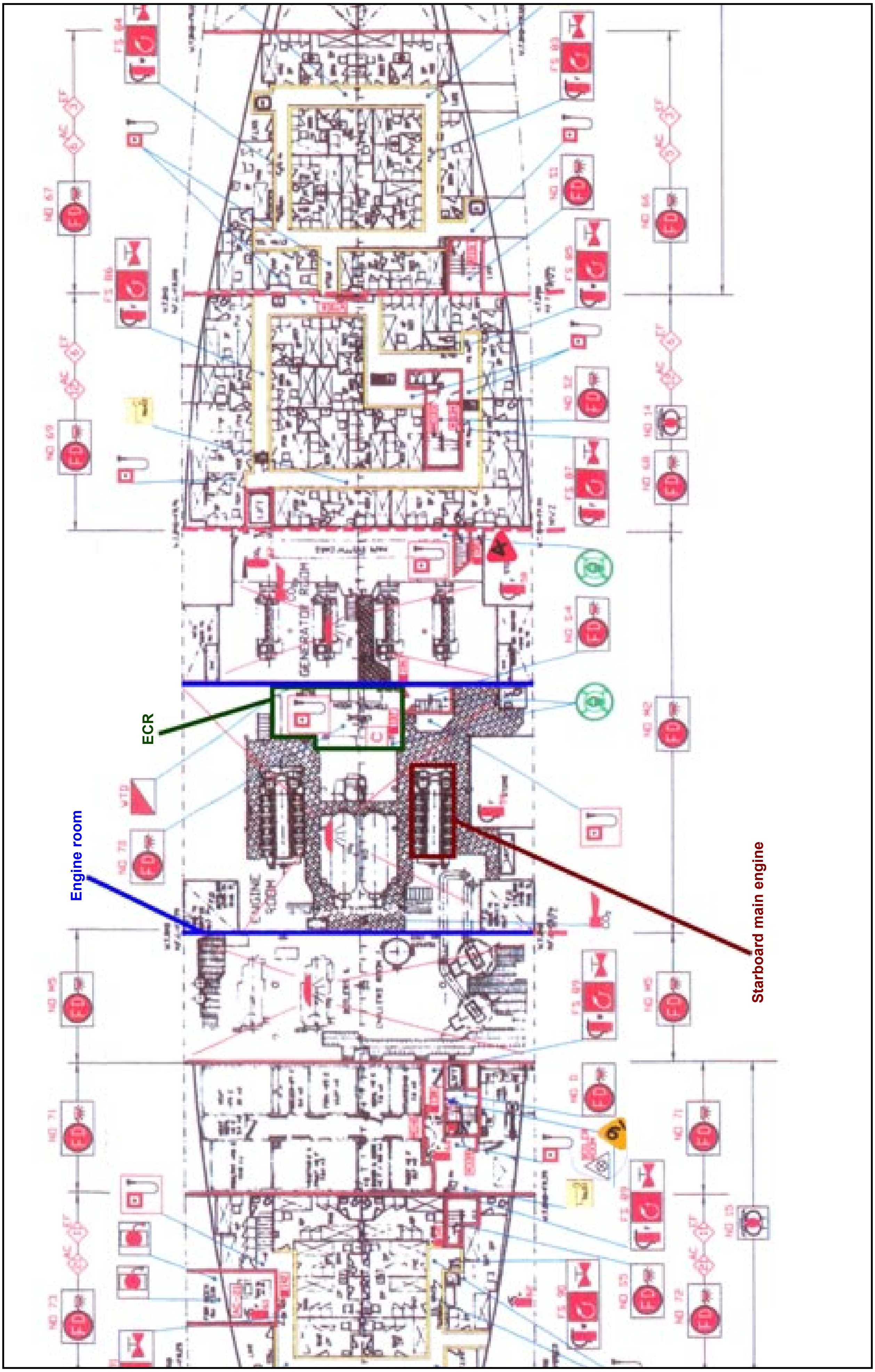
Starting at about 0542, two teams from the MIRG, totalling 18 firefighters, were airlifted and landed on the aft deck of *The Calypso*. The master informed the MIRG commander that all the CO_2 had been used. An assessment of the extent of the fire and the actions taken by the crew fire teams was made and, once their full complement had arrived, the MIRG teams entered the ER wearing BA sets at 0700 with the safety officer. Using a thermal imaging camera, they found that the fire had been extinguished.

By this time, the engine room crew had already re-entered the space and were cooling off the areas surrounding the base of the fire.

Other personnel were flown out to the vessel, including a coastguard liaison officer, to assist with communications, and a Maritime and Coastguard Agency (MCA) surveyor, to assess the damage and safety of the vessel on behalf of the Secretary of State's Representative (SOSREP). A team of ambulance service paramedics was also flown out.


ER CO_2 remote release station
Starboard engine casing
Safety room

Bolero deck



Lower deck

The Calypso was drifting in a busy traffic area, posing a risk to other shipping. An assessment of the fire damage by the surveyor, MIRG team commander and ship's master concluded that the vessel could not safely re-start her port engine to enable her to make for a safe haven. However, a main generator was re-started to provide further electrical services, mainly for hotel purposes, and the emergency diesel generator was stopped.

Following the total loss of propulsion, the SOSREP directed *Anglian Monarch* to tow *The Calypso* to Southampton. The tow was quickly connected and *The Calypso* arrived at the Queen Elizabeth Passenger Terminal in Southampton Docks later that day at about 2030 **(Figures 1 and 8)**.

No injuries to passengers or crew had occurred during or after the fire.

Copyright: Rod Kirkpatrick

Figure 8

The Calypso arrival

1.5 PASSENGER SHIP CERTIFICATION

Passenger ship certification **(Annex 1)** is covered by SOLAS, Chapter I, Part B: surveys and certificates, under regulation 7.

A passenger ship is subject to an initial survey before it can be certified and allowed to enter its intended service and, thereafter has to have a renewal survey once every 12 months. Passenger ship safety certificates (PCs) are generally valid for 1 year, except for some predefined limits as laid out in SOLAS.

The initial survey consists of a complete inspection of the ship's structure, machinery and equipment including the ship's hull. The survey also includes the radio installations, navigational equipment, lifesaving and fire-fighting arrangements and equipment.

All the above would need to comply with the relevant current national and international regulations for a PC to be issued.

The renewal survey is designed to ensure that the vessel continues to comply with the regulations and is in a satisfactory condition and fit for its intended service.

At the time the vessel was laid up in Piraeus in November 2005, *The Calypso* held a current PC issued on 28 April 2005 with validity until 24 July 2006. The certificate was issued by Lloyd's Register under the authority of the Government of the Hellenic Republic and enabled her to carry out international voyages.

As *The Calypso* prepared for the 2006 cruising season, she dry docked for routine repairs in February 2006 and was credited for the docking survey by LR on 22 February 2006. She then went on to complete her refit and preparations for the cruising season to come into service in April 2006. As the passenger certificate was still valid, no additional surveys were carried out.

However, LR did attend her again on 18 April 2006 at the owner's request, and carried out a general examination so that the PC could be re-issued under the authority of the Cypriot flag.

1.6 SAFETY MANAGEMENT

While under the Greek flag, *The Calypso* was managed by Core Marine Limited which has its offices in Piraeus. When she transferred to the Cypriot flag, the management of the company was taken over by Louis Ship Management Ltd, a sister organisation within the same group but based in Limassol.

Louis Ship Management Ltd manage a fleet of cruise passenger vessels which are operated by Louis Cruises. These vessels are managed under an existing Document of Compliance (DOC) issued by DNV on 27 May 2004. This is a prerequisite to operating vessels of this class under the ISM Code, and is subject to annual verification by the issuing authority, which had been completed and endorsed.

On the date *The Calypso* transferred to the Cypriot flag, she received a new Safety Management Certificate (SMC) as required by the ISM Code. The survey for this certificate was undertaken by DNV, who attended the vessel on 16 April 2006 and, when satisfied that she complied with the initial requirements of the ISM Code, issued an Interim safety management certificate on 18 April with a validity of 3 months until 17 July 2006. Thereafter, the vessel would have to undergo a rigorous full external audit before a full term SMC could be issued.

The safety management system (SMS) in use on board *The Calypso* was comprehensive and generally well written. It covered all areas that are required by the Code and was identical to the system used when the vessel was being operated by Core Marine Ltd.

1.7 PORT STATE CONTROL INSPECTIONS

Inspection overview

Port state control (PSC) inspections are carried out in the UK by the MCA under The Merchant Shipping (Port State Control) (Amendment) Regulations 2003. These regulations are explained in Merchant Shipping Notice 1775 (M) **(Annex 2)** which also takes into account various EU directives.

PSC inspections are also carried out by European Union member states under the Paris Memorandum of Understanding (MOU), which was adopted by all members to seek cooperation in order to standardise procedures, share information on inspections and to make effective use of their resources. The main objective was to create a harmonised system of ship inspection so as to eliminate the operation of sub-standard foreign flag merchant ships calling at members' ports. Each member agrees to inspect 25% of foreign flagged ships entering its ports each year. Member states can review previous vessel inspections on a website database called SIReNAc**.**

During the course of a PSC inspection, deficiencies may be identified which do not comply with international conventions. The attending inspectors then must use their professional judgment as to whether or not the ship is a hazard to safety, health and the environment and, if she is, the vessel is detained. However, before detaining a vessel, certain criteria must be applied as mentioned in the Merchant Shipping Notice 1775 (M), Appendix VI, or as given in the Paris MOU Port State Control procedures **(Annex 2)**.

Generally a vessel will be detained if the deficiencies found are serious enough to merit an inspector returning to the ship to satisfy himself that the deficiencies have been rectified. However, the guidelines also allow a combination of deficiencies of a less serious nature to warrant a detention.

The Calypso PSC inspections

The Calypso had been the subject of two PSC inspections since coming back into service from lay up on 18 April 2006.

The first port state control inspection occurred in Seville and was conducted by the Spanish Maritime authorities on 26 April 2006. *The Calypso* was identified as a high risk vessel due to her age and intended use as a passenger vessel. She had also not been inspected within the last 12 months, and thus was eligible for a mandatory expanded inspection under the Paris MOU procedures.

Expanded inspections are usually very rigorous, and involve inspection of the actual operation of critical equipment on board the vessel.

Additionally, for passenger ships, a fire drill is held, during which the fire detection and alarm system is tested. A check is also made on whether the crew are familiar with the use of firefighters' outfits.

The vessel managers took the opportunity to invite the MCA to inspect *The Calypso* while she was in Seville. This was because the vessel was to be employed in United Kingdom and North West European waters. Such invitations are not unusual, and the MCA views this type of inspection as an opportunity to identify and address issues that might be problematic, before the vessel arrives in a UK port. As these inspections are carried out abroad, the MCA does not have any enforcement jurisdiction but will advise the local port state control authority and the vessel operator if, during the inspection, they find any serious issues that might indicate a vessel is unsafe or a hazard to the environment.

The MCA contacted the Spanish maritime authorities as a matter of courtesy to advise them of the owner's request. The Spanish authorities had no objection, and agreed to MCA surveyors being present in Seville.

In excess of 35 deficiencies were identified during the PSC inspection in Seville. As a consequence of concern over these deficiencies, the MCA decided to conduct a further PSC inspection of the vessel upon arrival at its first UK port of call, Tilbury, on 5 May 2006. Thirteen deficiencies were identified during this second inspection, none of which were considered as detainable.

1.8 CREW TRAINING AND EXPERIENCE

Most of the officers had recent cruise ship experience and had previously sailed on *The Calypso*. The master had commanded the ship since 2001 and the chief engineer had also sailed on board *The Calypso* for the last 14 months. In addition to his chief engineer's experience, he had previously received training on Wartsila Vasa32 engines in 1997 / 1998.

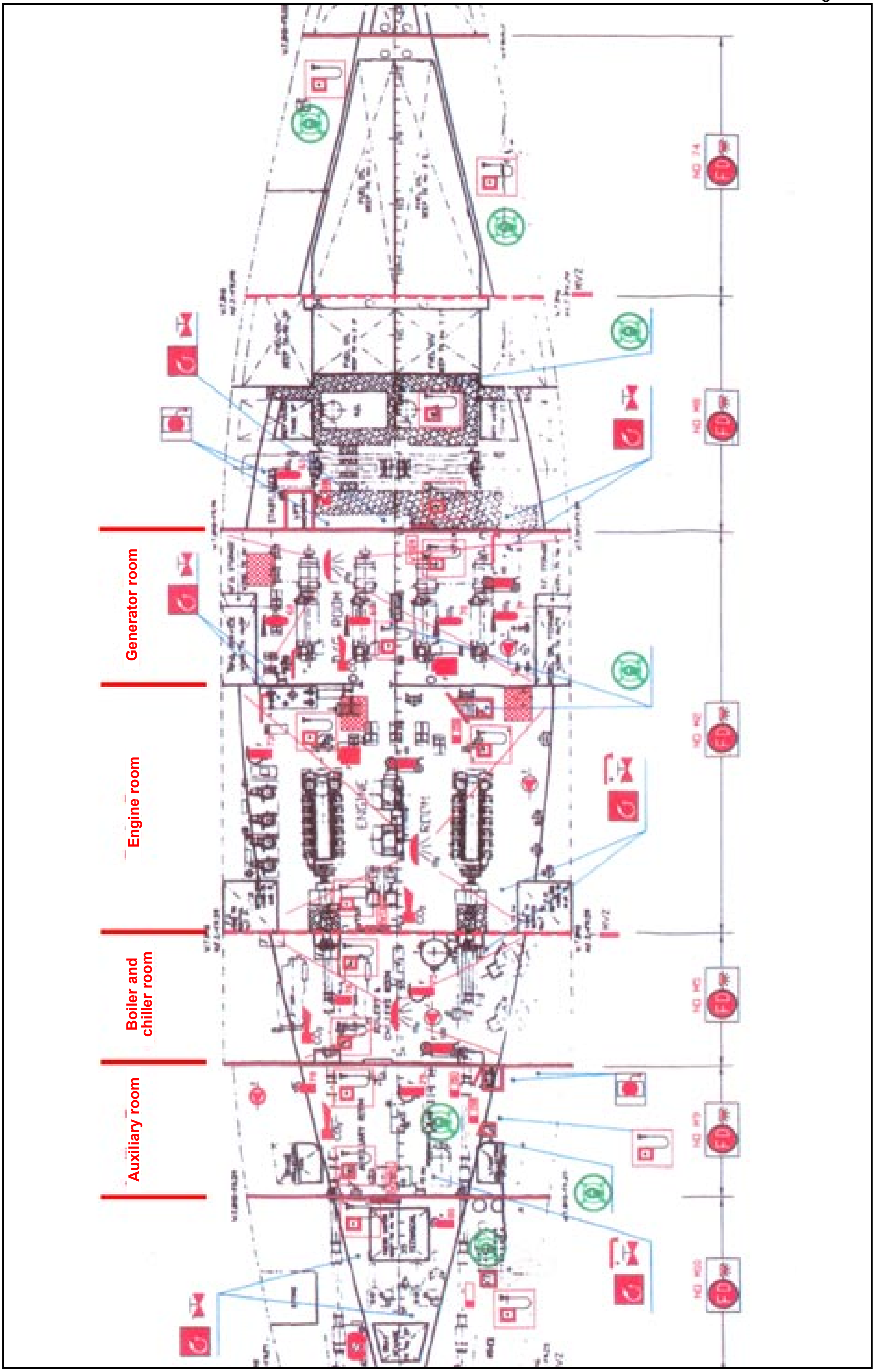
In line with the STCW 78 requirements (as amended in 1995), seafarers designated to control fire-fighting operations must complete an advanced fire-fighting course (Section VI/3-1). All senior officers whose duties involved such responsibilities on the muster list had completed this course in 1998 and 1999. The level of knowledge gained on this course should be sufficient to conduct effective control of fire-fighting operations on board ships.

The Calypso retained a skeleton crew of about 60 persons during her lay up over the winter period from November 2005. Records indicate that although the vessel was laid up, she continued to carry out the SOLAS requirements of conducting boat and fire drills with the crew present on board.

As the vessel geared up for the cruising season, and her complement came up to its full strength, she conducted full scale exercises as required by SOLAS and its SMS. Their first full scale major exercise was held on 18 April 2006, the day of their scheduled sailing from Piraeus.

The safety officer, who was in charge of crew training, scheduled a hectic training program in an attempt to get the crew to work as a team but, on 26 April 2006, the PSC inspection identified and recorded several deficiencies on fire-fighting issues.

In response to this deficiency, the ship's managers arranged for one of their safety superintendents to sail with the vessel for a few days in order to improve the crew's fire-fighting training capabilities. Nine days later, the MCA boarded the vessel in Tilbury on 5 May 2006 to find that the crew had improved and were deemed to be satisfactory.



Fire control plan – expansion of Lower Deck /Tank Top

1.9 DESCRIPTION OF RELEVANT MACHINERY AND MACHINERY SPACES (Figures 7b and 9)

1.9.1 Machinery spaces overview

The main propulsion and electrical generating machinery was in two separate, but interconnected spaces designated as the engine room and the generator room. The engine room was located amidships with the generator room forward. Aft of the engine room and separated by a transverse watertight bulkhead, was the boiler room, and aft of this space, through an ‘A’ Class bulkhead, was the auxiliary machinery room. Access through the bulkhead was by a watertight door which, except when being used for access, was kept closed at sea.

The engine room contained two, twelve cylinder “Vee” diesel main engines, each of which could be coupled to a controllable pitch propeller through a gearbox. Between the main engines were various motors, pumps and the main air bottles used for engine starting. Directly above both engines were the engine casings providing a route for the main and auxiliary engine exhaust uptakes and ventilation trunking.

At the forward end of the engine room, on the port and starboard sides, half level stairs led to the central, athwartships, engine control room (ECR), which contained machinery monitoring and control systems. A window facing aft from the ECR provided a view over the central/starboard side of the engine room bottom plates. The ECR also contained controls for operating the low fog water spray system **(Figure 10)**.

Figure 10

Low fog control panel

The fuel oil circulating and booster pumps for the main engines were sited on the bottom plates, port side and outboard of the ECR.

The low fog water spray fire-fighting control valves were sited at the aft end of the engine room, on the port side of the watertight bulkhead and adjacent to the watertight door.

The generator room contained four diesel engines driving electrical generators. A walkway, running centrally above the generators, provided quick access to the ECR from the crew accommodation forward of the generator room.

The boiler room contained various auxiliary machinery including boilers for fuel pre-heating and hotel services.

The auxiliary machinery room was aft of the boiler room. This space contained, among other machinery, the accommodation fresh water sprinkler system tank and associated pumps, and the pumps for the low fog water spray system.

1.9.2 Main engine – description and fuel system (Figure 11)

The Calypso was re-engined during her major refit in Greece, which concluded in 1994. She was fitted with a pair of Wartsila 12V32D medium speed four stroke, turbo charged diesel engines, each providing 4500kW at 750rpm. The 12V32D engine has been in production for over 26 years, and Louis Ship Management Ltd operated one other cruise vessel using Wartsila Vasa32 engines.

Each engine drove a controllable pitch propeller (CPP), via a clutch, and a gearbox coupled to the propeller shaft.

The engines operated on intermediate fuel oil of about 80cSt viscosity and a minimum flash point of 60ºC. It was heated to between 95ºC and 105ºC.

In the centre of each engine's 'Vee' were cylinder exhaust pipes, encased in lagged boxes leading to the twin turbo chargers (one for each bank of six cylinders) mounted at the forward end of the engine. Along the outer part of each cylinder bank was a "hotbox", within which were the high pressure fuel injection pumps, high pressure (HP) fuel pipes (connecting the HP pumps to the fuel injectors) and low pressure (LP) fuel rail **(Figure 12)**. The LP fuel pipes (supply and return) within the "hotbox" were joined using four bolt flanges. Covers enclosed the "hotbox" to prevent an escape of fuel should a leak occur and also to maintain temperatures within. The covers were secured in place. Leakage of fuel from any components within the hotbox was contained and collected at the lower part of the space, before draining, via a tundish, to a drain tank. A single high level alarm was fitted to this tank.

Leading from the forward end of the hotbox, the LP supply and return pipes passed through the end of the hotbox. From the inboard bank, the LP pipes ran outboard (under the turbochargers) and over the "Vee" to connect with the LP pipes from the outboard bank (see Annex 4 – Technical Bulletin). The LP pipes connecting the two banks used two, M10 bolt, flange connections, and were covered with thin "tin plate" spray covers to prevent fuel leakage droplets or mist (under pressure) from coming into contact with the hot surfaces of the turbo charger above, or the exhaust pipes in, the "Vee". The spray covers were intended to be screwed into LP pipe support brackets to hold them in position. The Wartsila supply, LP fuel pipes then connect to shipyard supply fuel pipework on the outboard side of the engine using four bolt flanges.

Figure 11

Port main engine

Figure 12

Hotbox

Forward end of hotbox of starboard engine

1.9.3 Regulations (Fuel System)

SOLAS regulations specify the arrangements of oil fuel pipelines to reduce the possibility of ignition of fuel which might escape. The following are the relevant extracts from SOLAS Chapter II-2 (Consolidated Edition 2001):

Regulation 15 – Arrangements for fuel oil, lubricating oil and other flammable oils.

> *2.10 All surfaces with temperatures above 200ºC which may be impinged as a result of a fuel system failure shall be properly insulated.*
>
> *2.11 Oil fuel lines shall be screened or otherwise suitably protected to avoid, as far as practicable, oil spray or oil leakages onto hot surfaces, into machinery air intakes, or other sources of ignition. The number of joints in such piping systems shall be kept to a minimum.*

1.9.4 Maintenance

The Wartsila manual held on board *The Calypso* provided maintenance information for the shipboard engineers and detailed the tightening torques necessary for the various sized bolts used in the engine construction. This method was used instead of detailing every individual bolt torque throughout the manual. For example, the bolt tightening torque for M10 (metric, 10mm) bolts was 50 Newton metres (Nm).

The maintenance schedule provided guidance on the regularity of inspections and tests to be carried out on the engine and was based, mostly, on the engine operating hours. Although the schedule detailed the work to be carried out up to 64000 hours, there was no requirement or guidance to inspect or check the torque on fuel pipe fittings (either low or high pressure). This requirement was actually highlighted in a previous safety bulletin.

1.9.5 Low fog water spray system

The Calypso was fitted with a Minimax local application low pressure water fog system in her engine room. This was installed in 2005 to meet a SOLAS 2002 requirement for special arrangements in machinery spaces, which required passenger ships of 2000 gross tonnage and above to have a system fitted not later than 1 October 2005. IMO's Maritime Safety Committee circulars 913 and 1082 define protected spaces and areas, and the location of operation controls **(Annex 3)**. In this respect, Circular 913 states, in part, that:

> *The operation controls should be located at easily accessible positions inside and outside the protected space.*

The International Code for Fire Safety Systems (FSS Code) was adopted in 2000 in order to provide international standards for the fire safety systems and equipment required by Chapter II-2 of the 1974 SOLAS Convention. It is mandatory and entered force in 2002.

Chapter 7 of the FSS Code – Fixed Pressure Water-Spraying and Water-Mist Fire-Extinguishing Systems states, at Section 2.12 – installation requirement:

> *The system may be divided into sections, the distribution valves of which shall be operated from easily accessible positions outside the spaces to be protected so as not to be readily cut off by a fire in the protected space.*
>
> *The pump and its controls shall be installed outside the space or spaces to be protected. It shall not be possible for a fire in the space or spaces protected by the water spraying system to put the system out of action.*

The Minimax low fog system comprised a fresh water tank and an 80 litre/minute pump providing 6.3 bar pressure to the nine distribution valves located at the aft end of the engine room. The distribution valves allowed water fog to be directed via nozzles at specific, high risk items of machinery. These were the two main engines, four diesel generators, two boilers and the fuel oil separator.

Local push button release control boxes were fitted around the engine room **(Figure 13)**. A main control panel, located in the ECR, could operate all the distribution valves **(Figure 10)**. An associated optical/acoustic alarm was also fitted to indicate when the system was being operated.

Figure 13

Local control

1.10 WARTSILA TECHNICAL BULLETINS

Wartsila Finland Oy issued Technical Bulletins where modifications to their products were considered necessary. These bulletins were sent out to their service agents around the world for onward transmission to vessel owners and operators, and to all major classification societies where relevant. Bulletins are also included within training courses for service personnel.

As a result of serious fuel leakages in the low pressure fuel system of Vasa32 engines, leading to fires in several cases, Wartsila issued a number of Technical Bulletins to the Wartsila NSD (New Sulzer Diesel) Service Network and to owners/operators of Vasa32 engines via the Wartsila global network.

In 1995, Bulletin 3217T011GB "Safety and maintenance of fuel supply system of Wartsila Vasa32 engines" was issued, and this was followed by an updated issue 3217T044GB (01) in 1999 **(Annex 4)**. The bulletins provided comprehensive advice and instructions on the recommended modification from two bolt to four bolt flanges on the LP fuel lines and advised that the fuel pipes to and from the fuel injection pumps were principally affected by:

- *Pressure pulses deriving from the fuel injection pump.*
- *Vibrations initiated by normal engine vibration.*
- *Static stresses caused by heat expansion.*

The aim of the modifications has been to dampen the pressure pulses and vibrations, and to strengthen the pipes, welding and screw connections.

The bulletin 3217TO44GB gave specific advice on the maintenance of the fuel supply system, with a recommendation that inspections are carried out every 2000 hours. It also provided advice on modifications to the engine fuel pipe clamps and the additional supports required.

Although a record exists of the distribution of the original Technical Bulletin (3217TO11GB), regarding modifications to the low pressure fuel pipe fittings, to a previous operator of *The Calypso* (then *Kalypso)* on 13 November 1995, there appears to be no record of it on board. This is probably due to the vessel owner becoming insolvent a short while later. An update of this service bulletin (3217TO44GB), issued in 1999, was also, possibly, not delivered to the vessel as Wartsila were unaware of who the owners were at that time. However, a subsequent safety bulletin which was sent to the owners in March 2003 made specific reference to the safety bulletin (3217TO44GB) highlighting the issue of proper maintenance in order to avoid a fire. On checking their records, the managers should have contacted Wartsila once they had realised that some bulletins were missing.

1.11 DESCRIPTION OF THE CO_2 SYSTEM

In the event of a fire in one of the machinery spaces, CO_2 could be released using controls in the CO_2 room **(Figure 14)** or from one of two remote release stations, one for the engine and generator rooms and one for the boiler room. The remote stations simplify the release procedure by providing a level of automation, and negate the need to activate the system from an enclosed space liable to exposure from CO_2 **(Figure 15)**.

CO_2 room

The CO_2 system in the CO_2 room originally comprised only the inboard (45 x 30kg) bank of cylinders, manufactured by "Minimax" **(Figure 16)**. As part of the major conversion from car ferry to passenger ship in 1993/94, the CO_2 system was altered and a further bank of 21 x 45kg CO_2 cylinders was installed by "Ginge-Kerr" on the outboard side of the space **(Figure 17)**.

The combined volume of the engine and generator rooms was 3613.4m^3. This required 2259kg of CO_2 to provide a concentration of 35% of the gross volume to meet SOLAS requirements and could be achieved by releasing the gas from all 66 cylinders (totalling 2295kg).

Figure 14

CO_2 space hatch and access ladder

Figure 15

Remote CO_2 release station for engine room

Figure 16

Minimax cylinders

Figure 17

Ginge-Kerr cylinders

The volume of the boiler room was 952m^3, which, for a concentration of 35%, required 595kg of CO_2, supplied from 14 x 45kg cylinders (totalling 630kg).

The Minimax cylinders had multi-link release valves fitted. The release linkages gave clear indication when they had “tripped” and the contents of the cylinders had been released. The Ginge-Kerr cylinders used a different release valve design incorporating a valve wheel, and which did not provide any indication that a cylinder had been released.

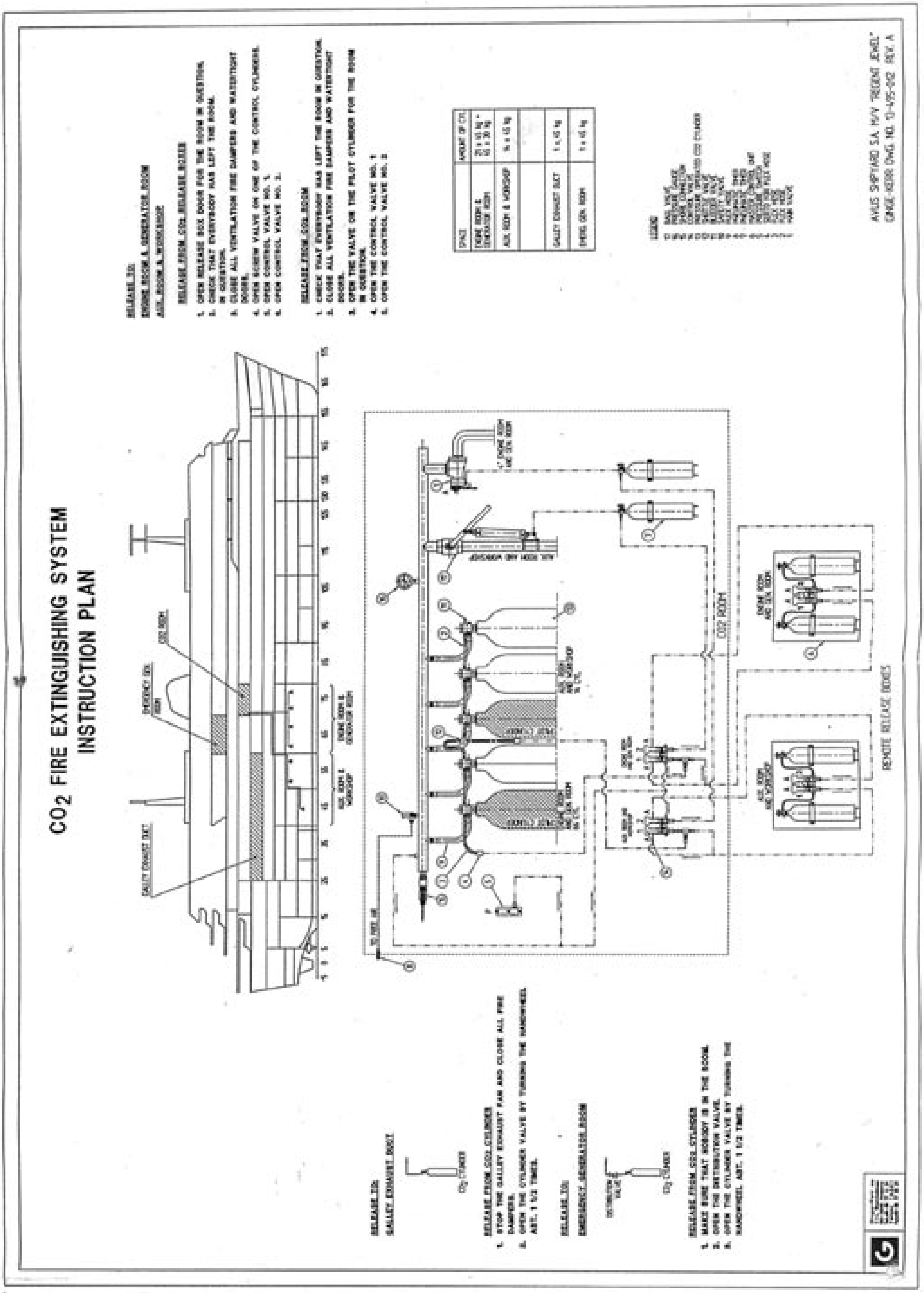
The modification to the system by Ginge-Kerr included two, 45kg, manually operated, pilot cylinders as part of the outboard bank of cylinders. Each pilot cylinder was intended to release the relevant number of cylinders for its specified protected space. Each pilot cylinder had a label identifying its purpose **(Figure 18)**.

The two systems were inter-linked so that the appropriate number of cylinders would be released depending on the space to be protected **(Figures 19a/19b)**.

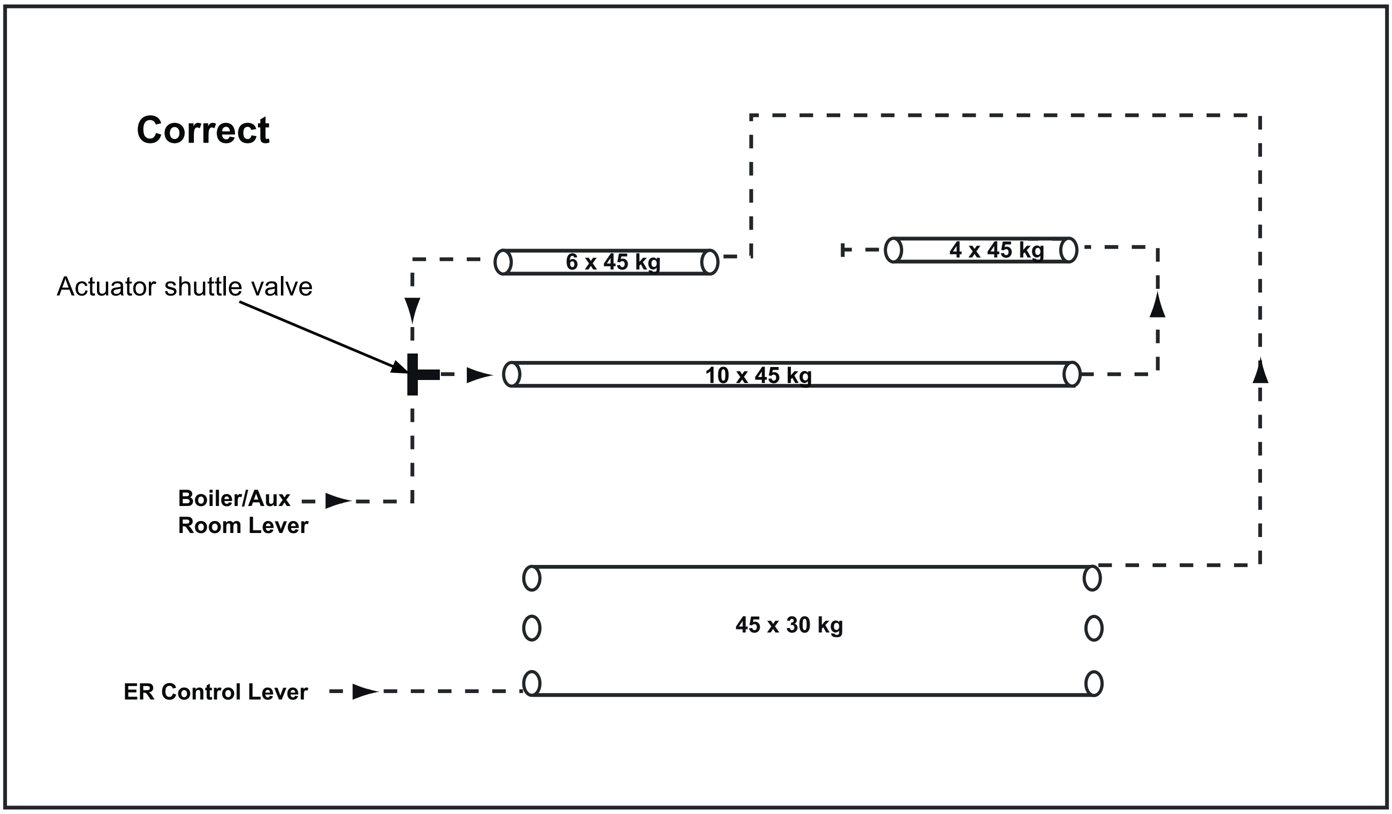
The two banks of cylinders were series linked together on the cylinder release lines by flexible high pressure hoses, and were also connected to the steel supply manifold running fore and aft above the two banks by flexible high pressure hoses. The two bank manifolds were further connected athwartships and, at the athwartship section, had two pipe connection lines leading aft. These two lines provided the gas supply to both the engine room and the boiler room. Attached to the outboard manifold were a pressure gauge, a compressed air connection and safety valve.

Figure 18

Pilot cylinder label



Instruction diagram



Simplified drawing of the system

The release of the CO_2 into the two spaces was subject to the operation of pneumatically controlled distribution valves in the two take-off lines from the manifold. The 90˚ distribution valve for the engine room was piston operated, had a working pressure of 100 bars, and was provided with an indicator pin and switch to show when open. In an emergency, the valve could be opened using a dedicated ratchet handle **(Figure 20)**. The distribution valve for the boiler room was opened by a pneumatically controlled cylinder specifically suited to open ball valves. The cylinder had a working pressure range of 10 -100 bar. In an emergency, a handle, extending from the ball valve pivot, could be used to operate the valve manually **(Figure 6b)**. Both distribution valves were labelled.

On the aft bulkhead of the CO_2 room were the manual/pneumatically operated levers for the release of the CO_2 from the bank cylinders into the manifold and for the operation of the relevant distribution valve. In manual mode, these levers (two per protected space) were pulled down to allow the pilot CO_2, from the manually operated pilot cylinders, to pass through internal orifices in the switch body and external small bore copper pipework to charge the system. The pilot gas also operated electrical switches for the CO_2 alarms and for ventilation shutdown of the protected space. In pneumatic mode, the pull down levers were automatically pushed open by small pistons behind each switch, pressurised by CO_2 gas from the remote pilot cylinders. Labels identified the levers **(Figure 5)**.

Below the control levers were two red pneumatic timer bottles linked to the control switches through small bore copper pipes. Timer devices are used to delay the opening of main or distributing valves until a short period after the CO_2 alarm has sounded. This is a common method of meeting the SOLAS requirement to provide a delay between the CO_2 release alarm and the release of the extinguishing medium **(Figure 4)**.

Figure 20

Engine room distribution valve with manual handle attached

In most circumstances, the timer bottles need not be touched, their operation being completely automatic. The timer bottles each have a capacity of 2.68 litres and work on a pressure differential between the inlet pressure and that achieved within the bottle. When the ratio between the two exceeds 1:0.66, a spring-loaded piston within the valve handle opens the bottle outlet valve, allowing the operating gas to pass through, and open the distribution valve to the space. A calibrated nozzle in the time delay valve could be changed to provide varying time delays between either 20 – 30 seconds or 60 – 90 seconds. If the delay valve failed to operate, or a shorter delay was required, the valve handle on the top of the bottle could be opened and the timer bypassed. The timers on *The Calypso* were set for a 90 second delay. The wooden support brackets for the bottles were labelled, however the stickers for attachment to the bottles were still in plastic wallets cable tied to the bottles.

The small bore copper control pipework linking the control switches and CO_2 cylinders included an actuator shuttle valve, in the form of a "T" piece, located near the pilot cylinders. This allowed control gas to pass from either end of the main line of the "T" and leave via the middle port. The shuttle valve was intended to allow the correct number of cylinders to be released depending on whether the engine room or boiler room was to be injected with CO_2 **(see Figure 28)**.

An extraction fan duct led to the lower inboard forward corner of the compartment.

Releasing CO_2 from the CO_2 room

The procedure for releasing CO_2 from the CO_2 room was as follows:

- Open the pilot cylinder valve (1) manually at handwheel
- Open control valve No.1 for main battery (switch will start alarm)
- Open control valve No. 2 for distribution valve.

The operating instructions and associated drawings for the system were posted on the forward bulkhead of the CO_2 room.

Remote CO_2 release stations

Each remote release box contained:

- Two red CO_2 pilot cylinders, each of capacity 2.68 litres and filled with 1.8kg of CO_2;
- Two control switches (similar to those in the CO_2 room): enabled pilot gas to operate the local control switches in the CO_2 room (via the pistons), the first to release the main CO_2 cylinders into the main manifold, and the second to operate the requisite distribution valve.
- A microswitch, which operated the CO_2 warning alarm in the relevant space and stopped the ventilation fans;
- A pressure gauge, to indicate the gas pressure in the remote control line.

The procedure for releasing CO_2 from the remote station was as follows:

- Open screw valve fitted to control cylinder (to pressurise the remote control system)
- Open control valve 1 (to actuate the cylinder valves via the remote control system)
- Open control valve 2 (to open the distribution valve via the pneumatic timer).

CO_2 System Certification

The CO_2 system was inspected on 22 March 2006 by Eurosafe, a Piraeus based ship safety equipment service agent. Eurosafe also carried out the previous inspection of the system in April 2005.

Eurosafe had been approved by the Greek authorities to carry out service and repair work on shipboard lifesaving appliances under the European Union Marine Equipment Directive. Under this directive, EU countries are required to accept approval certification of companies certified by other EU member states. However, Kidde, the parent company for the Ginge-Kerr CO_2 system, do not have Eurosafe listed as a certified service company.

Both the “Minimax” and “Ginge-Kerr” systems were inspected by Eurosafe. During the 2006 inspection it was noted that one of the 45 x 30kg cylinders was not connected, but no remedial action was taken. Neither the 2006, nor the 2005 inspections made any reference to the remote release station pilot cylinders.

Earlier inspection reports of the CO_2 system (2003 and 2002), by two different service agents, made reference to the four (1.8kg) pilot cylinders in the remote release stations. However, the 2001 inspection report (by a fourth service agent) referred to six pilot cylinders of 1.8kg capacity (presumably the four actual pilot cylinders and the two timer bottles) **(Figure 21)**.

1.12 INADVERTENT RELEASE OF CO_2 ON 7 MAY

On 7 May, following *The Calypso*'s arrival in Southampton the previous evening, a representative of Burgoynes, an independent fire investigation firm engaged by the vessel's P & I Club to investigate the cause of the fire, noticed that there was something odd about the inboard Minimax CO_2 cylinders which, according to the master and officers, had been fully discharged during the fire-fighting operation. Since the operation of the system by the chief electrician the previous day, the CO_2 system valves and controls had not been altered.

The Burgoynes investigator asked the chief engineer to meet him in the CO_2 compartment in the early evening to explain the system in more detail. From his experience, the cylinders' release mechanism clearly identified when they had been activated and, in this case, they did not appear to have been released. With tacit permission from the chief engineer, the representative therefore attempted to lift one of the cylinder release valves to, what he believed, was the open position.

As soon as the valve was tripped to the release position, they heard a rush of gas through the system. Within seconds, the other cylinder valves in the inboard bank tripped rapidly in sequence. The chief engineer tried to shut the valves which allowed the CO_2 to flow into the engine spaces, but was unable to do so due to the high pressure within the pipe system. The chief engineer and Burgoynes investigator saw a white mist develop within the space at the forward end and they quickly climbed the access ladder out of the CO_2 room to the Boat deck above.

The alarm was raised by the chief engineer when he ran to the bridge and issued a warning on the PA system to evacuate the engine room. However, the 8 -12 engine room watch, comprising the third engineer and watch assistant, had just begun their engine room rounds and quickly became engulfed in a white mist. Fortunately, both were near an exit point and, in near zero visibility, they managed to climb a stairwell and escape. They were met by other crew members who had heard the PA announcement, and the two men were evacuated to the ship's hospital. A third engine room crewman, having heard the announcement, went to the engine room to help and was also enveloped by the CO_2. He, too, was assisted to the hospital.

After assessment by the ship's doctor and treatment with oxygen for the effects of CO_2 inhalation, the three were taken to a hospital ashore for further checks to be made. They returned to the ship in the early hours of the following day.

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INFLATABLE LIFERAFT SERVICE STATION
Safety & Fire Fighting Equipment
Liferaft Servicing – Imports -Exports

DATE	15/05/2001

Inspection Report of CO2 Permanent Installation

Name of Ship	CMV CALYPSO - NASSAU BAHAMAS
Place of Survey	PIRAEUS

CO2 Installation consists of	21	Bottles each containing	45	KGS CO2
CO2 Installation consists of	45	Bottles each containing	30	KGS CO2
	06	PILOTS	1,8	KGS CO2

Location	1ST DECK UNDER L/B DECK
Lines lead to	ENGINE ROOM- E/ROOM-AUX/ENGINES-WORK SHOP-
Controls	LOCAL-ENTRANCE E/R-1ST DECK UNDER CONCERDO DECK

All CO2 bottles examined for fullness using KIDDE LIQUID LEVEL INDICATOR.

RESULTS

21	Bottles each containing	45	Kgs CO2 found full
45	Bottles each containing	30	Kgs CO2 found full
06	PILOTS	1,8	Kgs CO2 found full

-	Bottles each containing less than 90% of the correct amount of CO2
-	Bottles now recharged
-	Bottles supplied
YES	All manifolds ,valves and opening wires checked
YES	Lines blown and found free
YES	3 Electrical alarm checked

The Technician

NAFTILOS SAFETY LTD
68, DRAGATSANIOU STR. - 185 45
PIRAEUS - HELLAS

Inspection report

1.13 HUMAN PHYSIOLOGY AND USE OF CO_2

Carbon dioxide, a compound of carbon and oxygen, is a colourless gas with a slightly astringent smell causing coughing to occur when inhaled. As it is about 50% heavier than air, it will form a blanket over a fire and smother it.

To obtain "total flooding" of an engine room, a CO_2 concentration of about 35% by volume or more is required to be obtained within 2 minutes. This will reduce the oxygen content of the air in the space to less than 15%, at which level combustion will not be supported. Typically, it takes about 15 – 20 seconds after release of CO_2 before the concentration within the space reaches a dangerous level. It is therefore essential that personnel leave the space as soon as the warning siren sounds. Personnel caught in the space, when the CO_2 is released, are recommended to hold their breath and make their way to upper level exits where the concentration will be weaker.

Before a space is filled with CO_2 it must be properly closed and sealed. The space must be kept filled with CO_2 until it has been definitely established that the fire has been extinguished and heated materials or fixed equipment have cooled down. Consideration should be given to the possibility that the fire might re-ignite if fresh air is allowed into the space before adequate cooling has occurred. Where combustion has been incomplete, poisonous carbon monoxide may be released during extinguishing which could give rise to an explosion. As such, if air is suddenly allowed to enter a smoke-filled space, a "smoke gas explosion" could occur, potentially causing further outbreaks of fire.

Carbon dioxide must not be discharged into a space until all those within have left. Any re-entry into the space should be very carefully considered, and then only if the space has been thoroughly ventilated and the air quality tested or, alternatively, by suitably equipped and trained BA wearers with safety lines attached and sufficient back-up immediately available should difficulties arise.

Protection methods other than a clean source of air, such as smoke filters on an ordinary gas mask, should not be used as these will not protect the user against the effects of CO_2.

1.14 BACKGROUND INFORMATION ON SHORE-BASED EMERGENCY RESPONSE

The MIRG combines the forces of the MCA, fire and rescue services and the Ministry of Defence to provide specialised marine response units around the UK.

The system was launched in April 2006, and there are 15 fire and rescue MIRG teams in strategic locations around the UK, with each team comprising roughly 50 specially trained fire-fighters. Following an agreement with the NHS, paramedics also join the MIRG teams to provide medical attention at the scene.

MIRG teams work alongside the master and ship's officers during an incident, with the master retaining overall command of the vessel and the MIRG team commander providing technical support and command of his own personnel.

SECTION 2 - ANALYSIS

2.1 AIM

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

2.2 FATIGUE

The hours of work and rest experienced by the master, the chief engineer and the safety officer during the days preceding the accident were analysed using a software tool to establish whether fatigue might have affected their performance.

The analysis showed that:

- The master was potentially suffering the effects of fatigue brought about by recent navigational demands and duties associated with the port visits to Zeebrugge and Tilbury (including inspections by both MCA and LR in Tilbury). However, he performed effectively during the emergency.
- The chief engineer should not have been unduly affected by fatigue at the time of the accident.
- The safety officer would have been affected by fatigue, but not to a very great extent.

It is concluded that, although some senior officers would have been suffering the effects of fatigue in varying degrees, this probably did not have a significant effect on the performance and decisions taken during the emergency.

2.3 CAUSE OF THE FIRE

After the fire, an inspection of the starboard main engine quickly established that the cause of the fire was due to a loose flange connection on the LP fuel return line from the inboard cylinder bank.

The flanges had separated because the two, 10mm, socket headed flange bolts had failed. Their failure allowed the flanges to separate slightly, thus causing the "O" ring seal to become dislodged and fuel, at a pressure of up to 10 bar, to spray through the gap in the flanges **(Figures 22, 23a/23b)**.

The fuel, in both droplet and mist concentrations, would have found a number of hotspots in the vicinity of the failed flange, such as the exhaust manifold at the inlet to the turbo charger and the turbo charger itself. Ignition of the fuel would have occurred when a sufficient quantity of fuel to sustain combustion had come into contact with one of these hot spots. The continuing supply of fuel from the failed flange would then have fed the fire until the third engineer stopped the fuel oil booster pump and closed the valves in the line.

The short-lived fire eventually reduced due to this lack of fuel and a lack of oxygen after the engine room ventilation system was shutdown.

A qualified metallurgist carried out a preliminary metallurgical analysis of the failed 10mm socket headed flange bolts. Both bolts were marked as 8.8 indicating the grade of steel used in their manufacture. This was the required grade specified by Wartsila in their operating manual.

The hardness tests carried out during the analysis confirmed that they both possessed more than the minimum ultimate tensile strength of 800 N/mm^2 required of Grade 8.8 steel. The average equivalent ultimate tensile strength of bolt one was 880 N/mm^2 and that of bolt two was 885 N/mm^2.

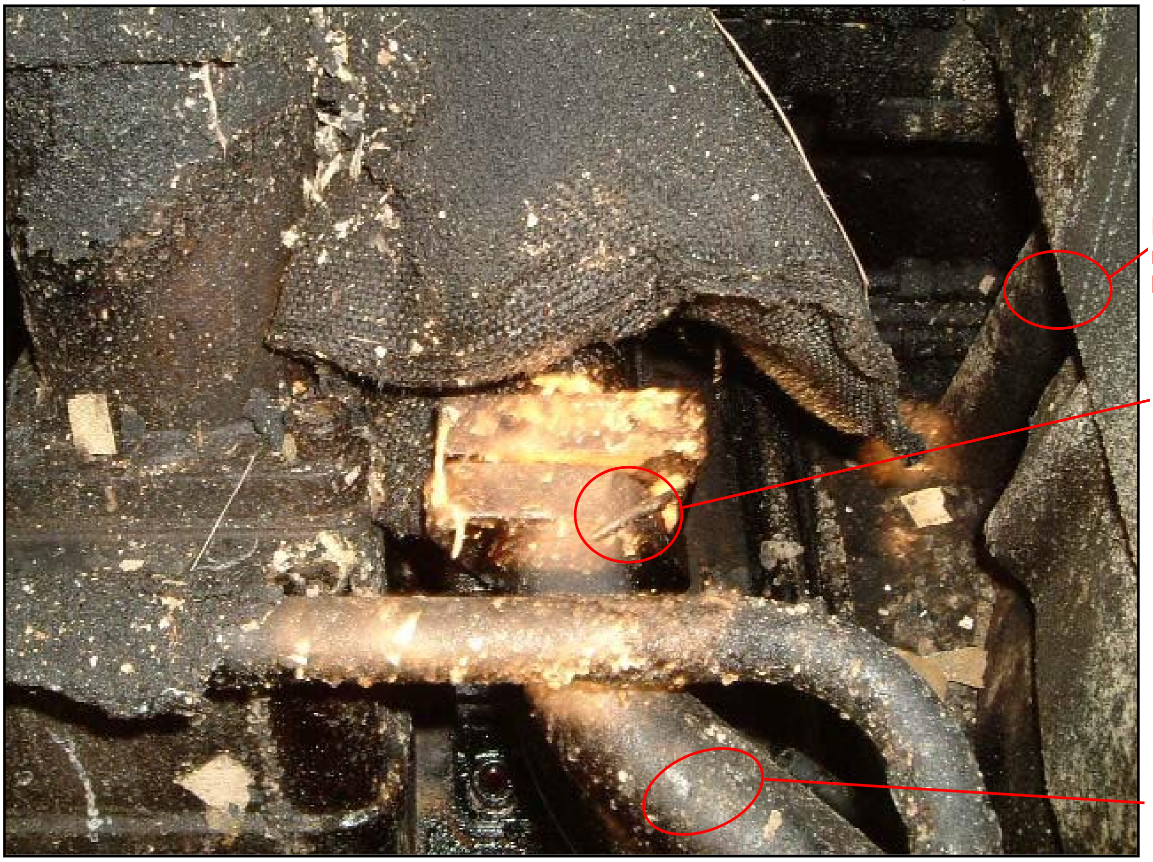
The analysis indicated that the fracture surfaces were very fine and difficult to resolve using stereo-optical microscopy. Nevertheless, one bolt showed some evidence of failure by fatigue. No evidence was found of over-tightening and the conclusion was, therefore, that they failed due to fatigue.

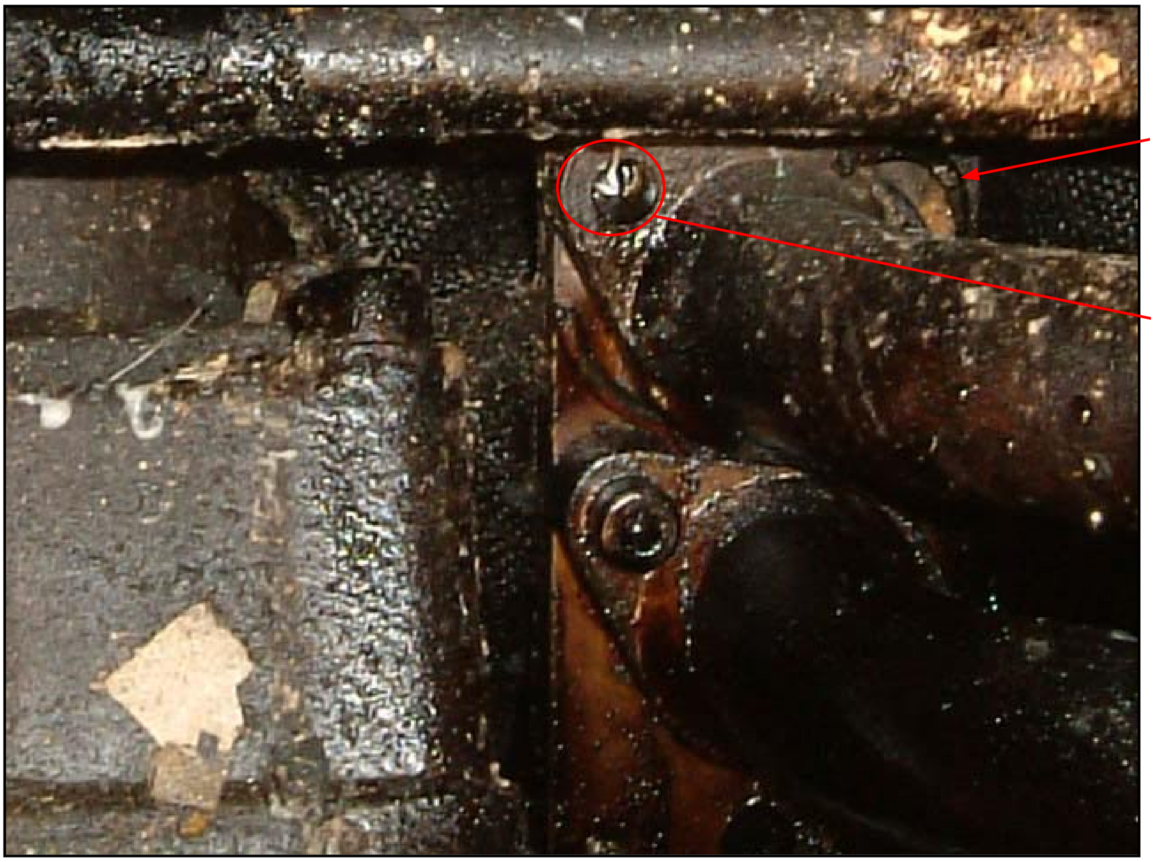
Fatigue is a long term metallurgical process which results in the development of a crack under oscillating loads, although the ultimate failure is likely to be sudden. The precise initiation of the fatigue failure was not identified during the analysis but can arise from a number of potential origins, such as localised material defects, manufacturing defects, localised areas of damage, normal engine vibration or pressure pulses from the fuel injection pumps.

Figure 22

Failed bolts

Figure 23a and b





Fuel pipe flange and “O” ring seal

The Wartsila technical bulletins 3217T011Gb and 3217T044GB(01) (see Sections 1.10 and 2.8 and **Annex 4**) provided relevant comprehensive advice including the replacement of two bolt flanges with four bolt flanges and other modifications aimed at dampening pressure pulses and vibrations in the fuel supply system. The recommended modifications had not been carried on *The Calypso.*

A sprayguard, above the failed flange had, at some time previously, been modified so that it was no longer able to be retained securely in position. The guard was intended to meet SOLAS requirements to prevent fuel from coming into contact with hot surfaces. The sprayguard was found a short distance away from the failed flange. However, it is not known whether the cover had become dislodged before, during or after the fire (when water from the fire-fighting might have dislodged it). It is considered probable that, even if it had been resting in position, it would have been ineffective in preventing fuel, under pressure, from spraying beyond the cover **(Figure 24)**.

It is concluded that a combination of factors, primarily the fatigue failure of the securing bolts on an LP fuel pipe flange and including a poorly fitting or loose sprayguard and the close proximity of hot spots to cause ignition, caused the fire. If the advice contained within the Wartsila technical bulletins had been followed, it is likely that this fire would have been avoided.

Figure 24

Spray guard

2.4 FIRE DAMAGE

The fire was short lived, primarily due to the response of the watchkeeping third engineer. However, the spray of fuel on to the hot surfaces of the engine provided an intense fire which caused considerable damage.

The intensity of the heat caused localised distortion of the engine block which, after laser alignment checks, had to be renewed. Both turbo chargers were fire damaged and required complete overhaul **(Figure 25)**. Several of the alloyed rocker covers, camshaft and crankcase doors had melted and required renewal **(Figures 26a/26b/26c)**. The starboard engine alarm system also required renewal.

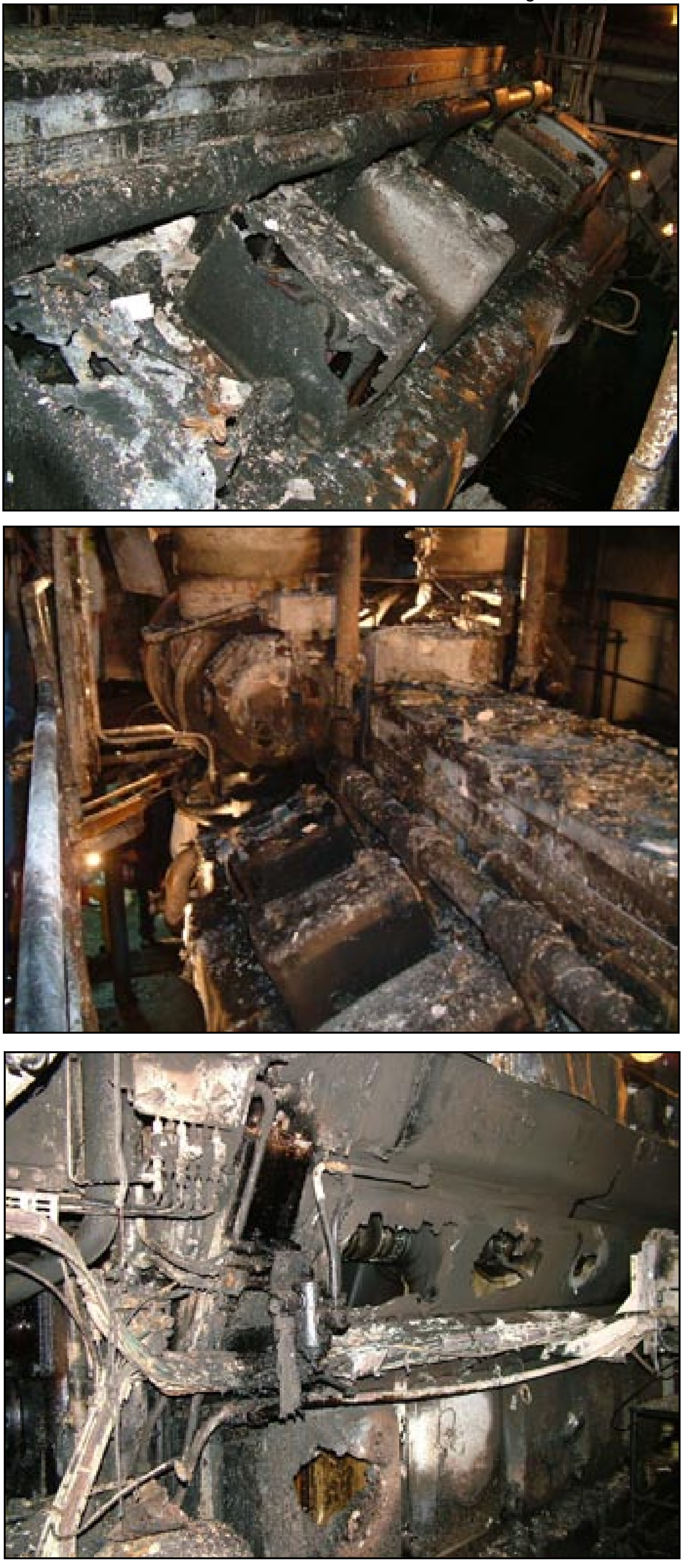
Insulation at the forward end of the starboard engine and up the starboard funnel casing, including exhaust lagging, required replacement along with wiring for lighting and various alarm systems **(Figure 27)**. Other wiring systems required almost total renewal back to the switchboard.

Various electric motors in the engine room required replacement and others required overhaul, and the deck screeding of cabins above the ECR required replacement.

Figure 25

Fire damaged turbo chargers

Figure 26a, b and c



Damaged rocker covers,
camshaft and crankcase doors

Figure 27

Damaged upper areas

2.5 LOW FOG SYSTEM

The low fog water spray system had been fitted in March 2006 to meet SOLAS requirements specifically designed for this type of incident. Unfortunately, the system was not activated on this occasion. If it had been, it might have helped reduce the level of damage sustained during the fire.

By the time the third engineer had brought the engines to stop, entered the engine room and stopped the fuel booster pumps and closed the associated valves, and then ensured that his two watch crew were safely out of the engine room, the engine control room had already filled with choking smoke. This necessitated his withdrawal from the space before he could operate the low fog system.

The fact that the ECR was not bounded on all sides by an A60 class bulkhead meant that it was within the protected space, as defined by MSC/Circ 1082. This meant that the low fog control point in the ECR did not meet the SOLAS requirement of being sited outside the protected space, as required within MSC/Circ 913, and possibly indicates a misunderstanding of the installation requirements for this invaluable equipment.

Had a low fog control point been fitted outside the engine room/ECR, perhaps in the safety room, it is highly likely that the chief engineer would have used it at an early opportunity.

2.6 CREW RESPONSE

The watchkeeping third engineer

The 12-4 watchkeeping third engineer reacted promptly once he saw the flames from his position in the engine control room. He recognised that it was probably a fuel fire and that he needed to stop the engines and fuel supply as soon as possible. He did so and, despite considerable risk, ensured his engine room staff were safe.

The third engineer's actions and speed of response are commendable and, taking into account the fact that the CO_2 was never released to fight the fire, probably had a major effect on the speed at which the fire depleted.

The master

The master arrived on the bridge shortly after receiving the call from the OOW, and dealt with this emergency in accordance with good practice and in a calm and considered manner. The passengers, in particular, were kept well informed and safely mustered, and he only stood down when it was completely safe to do so.

The staff captain

The staff captain acted as mobile co-ordinator throughout the accident in accordance with the muster list. He was active in many areas and contributed to the successful outcome. However, entering the engine room a few minutes after he thought that CO_2 had been released, with just a wet towel over his face, was dangerous and contrary to good practice and the training he had received. This action could have caused fresh air to feed the fire, heightening the emergency while also carrying the risk of his own death or serious injury from CO_2 poisoning. He was, perhaps, fortunate that in the event CO_2 had not been released. A few minutes later he again entered the space, this time wearing a BA set, but alone and without telling anyone what he was doing. This, once again, was contrary to good practice and could have caused problems and an escalation of the emergency.

The chief engineer

The chief engineer responded quickly when called. He went straight to the safety room, where he correctly took charge of the fire-fighting response. In organising the response he paid little heed to the muster list and chose to delegate high profile tasks to crew members he felt he could trust. For example, he ordered the chief electrician to take charge of releasing the CO_2, instead of the 8-12 watchkeeper who was the designated person on the muster list. This decision was a factor in the eventual failure to release CO_2 into the affected space. He also demonstrated a lack of knowledge of the system when he instructed the electrician to release the gas to both the engine room and boiler room. There was no fire in the boiler room, and this space was protected by an A60 class division. This decision would have seriously diluted the concentration of gas injected into the engine room. In common with the staff captain, the chief engineer decided to enter the engine room soon after he thought CO_2 had been injected into the space. He did so wearing a BA set and accompanied by the chief electrician, but without a safety line and without informing the master. This was a dangerous action that, under different circumstances, could have caused personal injury and an escalation of the emergency. While it is recognised that the chief engineer's motives for this action were to be able to restart the generators/engines as soon as possible to limit the discomfort for the passengers, he should not have disregarded the fire-fighting training that he had received.

About an hour later, the chief engineer re-entered the engine room alone and, while inside, decided to take off his BA mask and "sniff" the atmosphere. With hindsight, he recognised that this was a dangerous act. However, having discovered the atmosphere fit to breathe he did not appreciate the fact that he should have been affected by the CO_2 which had, supposedly, only recently been released into the space. Had he recognised that there was only smoke in the atmosphere, he might have questioned where the CO_2 had gone. Again, it appears his main concern was the re-activation of the engine room, and he took unnecessary risks to achieve that goal.

During the time the engine room was closed down, the chief engineer gave an instruction that no-one should enter the engine room without his knowledge or agreement. This instruction was either not clear enough, not heard, or not accepted by the staff captain. Whatever the reason, it is clear that the communications between two key members of the fire-fighting response team were ineffective.

In conclusion, the chief engineer was trying hard to respond to the emergency, but some of his actions were not helpful and could have exacerbated the situation. It is essential that a chief engineer has a good knowledge of his ship's fire-fighting systems; a full understanding of fire-fighting procedures; does not disregard emergency plans; and ensures that good practices are adhered to in an emergency.

2.7 THE MUSTER

"Code Bravo", which was used to alert the crew to respond to a fire situation, was announced by the master at 0336. At 0344 the master, following the assessment of the fire by the chief engineer, staff captain and safety officer, decided to alert the remaining crew and passengers with an announcement over the ship's PA system.

The crew reacted in accordance with the ship's emergency procedures, and in a calm and efficient manner they alerted any of the passengers who might have been asleep and had not heard the initial announcement. The designated teams then guided the passengers to their respective muster stations.

The evacuation team followed this up by searching all cabins and public places. Each space was then marked off to indicate that it had been searched and that nobody remained within.

As the passengers were being mustered, the cruise director, on instruction from the master, made an initial announcement over the PA system in English and Dutch on the nature and status of the emergency.

Under the guidance of the chief purser, who was the mustering controller, and his deputies, all passengers were accounted for at their respective muster stations.

During the course of the emergency, the passengers were kept fully informed of the developments by the cruise director who was relaying this information in English and Dutch on behalf on the master.

The master was aware that there was a majority of elderly people and some children on board and, although it was summer, it was cold at that time of the day on the open deck at the muster stations. However, justifiably, the master kept the passengers, and surplus crew who were not dealing with the emergency, at the muster stations long after the fire was extinguished even though he had been repeatedly requested by the passengers for permission to return to the accommodation. They were eventually allowed back, initially into the Bistro lounge, only when the master was absolutely certain that in doing so there was no risk.

During the investigation, the MAIB asked the passengers to provide feedback on how the emergency was handled from their point of view. As a result of the questionnaires put on board the vessel via pilot launch as she proceeded to Southampton, the investigation received 162 completed replies. The overwhelming opinion was that the muster was conducted in a calm and organised manner by the crew, and that the passengers were kept well informed.

2.8 THE ACTIONS OF THE ENGINE MANUFACTURERS

SOLAS requirements

The use of LP fuel pipe covers on Wartsila Vasa32 engines met the requirements of the SOLAS regulations which were applicable to *The Calypso* **(see Section 1.9)**. However, it is questionable whether the routing of the LP pipes, forward of the hotboxes and under the turbo charger, would comply with regulation 4 of the latest SOLAS [effective July 2002] arrangement which states:

> *2.2.5.3 Oil fuel lines shall not be located immediately above or near units of high temperature, including, …… exhaust manifolds, ….. or other equipment required to be insulated …….. As far as practicable, oil fuel lines shall be arranged far apart from hot surfaces, ……..*

Consequently, any release of fuel vapour, mist or spray from the LP pipes in this location would have a possible route towards a hot surface or other point of ignition. Surfaces of sufficiently high temperature to cause ignition were present in the vicinity of the engine's top on *The Calypso*; most notably the exhaust pipes within the engine's "Vee", with an exhaust temperature of about 420ºC. Although these pipes would have been lagged, imperfect lagging is not unusual.

Failure of low pressure pipes and connections is a common cause of fuel leakage which, on occasions, has resulted in engine room fires and loss of life. 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. Unfortunately, there is less awareness of the dangers posed by the failure of low pressure lines.

Bearing in mind the latest SOLAS requirements, Wartsila should consider the effectiveness of its recommended current modifications to the LP fuel pipe systems on Vasa32 engines built before July 1998, and what further improvements could be made to successfully eradicate any further opportunity for similar accidents to occur in the future.

Technical Bulletins

The weakness in the flange design had been known by the manufacturer for more than 10 years. The two bolt to four bolt flange modifications, recommended by Wartsila, were intended to solve the problem of flange failure as a result of rapid transient peak pressures.

Despite this important advice being incorporated in a technical bulletin, the information was not known to the owners of *The Calypso.* In 1999, attempts were made by Wartsila to locate the owners but, despite the lack of success, it made no further attempts. It is possible that there are a number of other vessels operating with Vasa32 engines which have not received this important information because Wartsila have been unable to locate the owners. Another passenger vessel operated by Louis Cruise Lines, *Sea Diamond*, which has four 12 cylinder Vasa32 engines, was also not in possession of these safety bulletins even though they had been sent to the previous owners.

A higher priority should be given to tracing these vessels and ensuring that these, and any other necessary modifications, are brought to the attention of owners as soon as possible. To achieve this, consideration should be given to seeking the assistance of flag administrations and/or classification societies.

It is also important that owners or technical managers, when acquiring second-hand vessels, should ensure that they are in receipt of the most up to date technical bulletins and, if they are not, they should take steps to contact the manufacturer to obtain them.

Whilst all engine manufacturers should take steps to ensure that owners receive relevant bulletins, owners should also have in place within their ISM system a way of ensuring that the vessel is kept up to date on all applicable rules and regulations, and that when they receive these bulletins they should have the opportunity to consider and understand the implications of the information they receive.

The chief engineer had trained on Wartsila Vasa32 engines in 1997/8, but was not aware of the manufacturer's technical bulletin, and therefore took no special precautions with the low pressure fuel lines on *The Calypso*'s main engines.

Wartsila technician(s) were on board the vessel for sea trials on the request of the yard, after she left the refit berth in April 2006, to oversee the operation of the engines. Although they were contracted by the ship repair yard and not the owners, they could have used this opportunity to check that the vessel had received all relevant technical bulletins. In addition, they might have noticed the damaged and inadequate cover for the LP fuel pipes on the starboard engine. During the investigation, it became apparent that a Wartsila engineer from its Greek office was not aware of any technical bulletins regarding fuel pipes or protective covers.

A review of the training requirements of Wartsila service engineers should be considered to ensure that they are sufficiently equipped with the information on recommended modifications.

Modifications to the fuel pipework were carried out on *The Calypso* prior to her leaving Southampton.

2.9 ERRORS IN UNDERSTANDING AND OPERATION OF THE CO_2 SYSTEM

Soon after *The Calypso*'s arrival in Southampton, an inspection of the CO_2 room was carried out. This was attended by several of the ship's senior officers (especially those involved in the fire-fighting), as well as Flag State representatives, investigators, legal and fire specialists.

The operation of the CO_2 system was analysed, and a consensus was reached on the correct operation and release procedure. It was generally accepted that the timer cylinders, which were painted red (the same as CO_2 cylinders) and connected to the release switches by small bore pipes, were the local release pilot cylinders.

During this preliminary analysis of the CO_2 system, some discussion occurred regarding the inboard (Minimax) cylinders and their release linkage. Although some doubts were raised about the status of the linkages (which were in their closed position), the insistence of the ship's officers that all of the CO_2 had been released limited this line of inquiry.

During the inspection, the distribution valves for the engine and boiler rooms were found to be in an open condition and all four of the control switches for these spaces had also been operated.

Before leaving the space, errors were noted on the instructional drawing, indicating that the relief valve pipework on the CO_2 supply manifold was listed as one of the pneumatic timers, another (more serious) error was found in the control pipework where the location of the shuttle valve was found to be incorrect, and one of the Minimax cylinders was found to be disconnected with an incorrect valve fitted.

Later in the investigation, it became clear that the ship's officers (involved in operating the CO_2 system to fight the fire) misunderstood the CO_2 system and the methods available to operate it effectively. This is illustrated in the following analysis of the operation to release the CO_2 which is based on witness evidence, physical evidence and subsequent system tests.

After the decision was taken to inject CO_2, the chief electrician appears to have been directed to the local release panel in the CO_2 room instead of to the engine room remote operating control panel, located only a short distance from the safety room. The CO_2 room was not only further away but its release would also have taken longer to operate than the remote release. It is unclear why the officers involved considered the CO_2 room to be the main operating point for release of CO_2, despite the instructions for remote release being given before the local release instructions on the instruction sheet. It is possible that they considered the remote stations to be "back up" locations in the event that the CO_2 room could not be accessed.

Even though no fire had been detected in the boiler room, the chief engineer made the decision to inject CO_2 into this space as well. This would have reduced the overall concentration of CO_2 in both spaces to about 20%. If the CO_2 had actually been necessary to put out the fire, this concentration might have been insufficient to extinguish the fire. Although the chief engineer was in a stressful situation, a thorough understanding of the CO_2 system should have prevented him from making this decision, and this further underlines his general lack of knowledge and training in the use of the fire-fighting equipment on board. Neither the chief electrician nor the safety officer realised his mistake, which further indicated a general lack of familiarity with the system.

The chief electrician did not know the correct method of releasing the gas from the CO_2 room. Despite the component parts of the CO_2 fire extinguishing system in the bottle room being correctly labelled, he managed to confuse the timer cylinders with the pilot bottles, and therefore opened the wrong valves. This resulted in the gas not being released as expected. The chief electrician's mistake might have occurred because the timer bottles were the same size and colour as the pilot bottles in the remote release stations.

The chief electrician did correctly (as instructed) use the operating switches for the engine room and the boiler room. However, without pilot gas, this was ineffectual. He then manually opened both distribution valves under the instruction of the chief engineer at the hatch entrance. This would have been unnecessary if the correct pilot cylinders had been opened because the distribution valves would have been automatically operated. This left the system in a precarious condition, which was made even more so because the access hatch was left unlocked after the chief electrician left. No subsequent checks were made to ensure the system was safe or to confirm how many CO_2 cylinders had been released. Basic system checks, after an incident requiring the operation of the CO_2 system, should be included in any fire-fighting procedures to ascertain the system condition and to prevent any possibility of a subsequent accidental release occurring.

The chief electrician had assumed the CO_2 had been released despite the fact that there had been no indication of this. Possible indicators might have included: hearing the sound of the escaping gas; frosting on the cylinders; or noticing the changes to the cylinder release mechanism on the Minimax bottles.

Within minutes of the chief electrician confirming that he had released the CO_2, senior officers decided to enter the engine room. They entered a known hazardous area, without agreement from the master, without suitable safety equipment (such as lifelines), and without good reason. By doing so, they risked personal injury, put others at risk in the event that a rescue was needed and, by admitting oxygen into the space, increased the chance of a "flashback" occurring.

From the foregoing, one can only conclude that the senior officers concerned did not possess sufficient knowledge on the safe operation of *The Calypso*'s fixed CO_2 fire extinguishing system.

The 8-12 watch engineer was the person designated on the muster list to operate the CO_2 system under the direction of the chief engineer. He had been on board *The Calypso* for a year and had received on board instruction on the system from two different safety officers. He had also attended the relevant fire-fighting courses ashore. The accident investigators questioned him about his knowledge of the system and he revealed that he had a reasonable knowledge of a generic CO_2 system. However, he appeared to lack detailed knowledge of the system on board *The Calypso,* and in particular he misunderstood the purpose of the timer bottles. It was concluded from this that the drills and on board training had been inadequate in this very important area of fire protection.

The vessel operator should review the quality of its onboard fire-fighting training and drills and make appropriate changes to ensure that it will be more effective in the event of another fire.

2.10 TIMER CYLINDERS

The use of time delay cylinders in CO_2 systems is commonplace. However, as has been demonstrated on *The Calypso*, confusion over their role, and their similarity to remote release pilot cylinders, can cause dangerous mistakes. In the past, even service engineers had apparently counted the two timer cylinders as pilot cylinders, and it is thought likely that crews on other similarly equipped vessels could make the same mistake.

It is considered that action should be taken to prevent this possible misunderstanding.

2.11 INADVERTENT RELEASE OF CO_2

The inadvertent release of CO_2 into the engine room on the evening of 7 May nearly caused the deaths of three crewmen. Had the two watchkeepers not been near an exit point it is unlikely they would have been able to hold their breath long enough to escape, assuming they could have found their way out in the poor visibility caused by the CO_2.

The release occurred because the system had been left in a dangerous condition despite the fact that nobody could be sure that all, or any, of the CO_2 had been discharged. The chief engineer allowed the fire investigator to tamper with the system to try to discover if the gas had been released, and it was this action that led directly to the inadvertent release of the gas.

The chief engineer was responsible for the system and he should not have permitted anybody to tamper with it unless he was sure that it was empty or in a safe condition. For his part, the fire investigator had some suspicions that at least some of the cylinders had not been released, and he should have been sufficiently aware of the potential risk to avoid experimenting with the mechanism.

Good practice dictates that a CO_2 fire smothering system, or any other safety critical equipment, should be inspected after use and valves, control switches and other control devices should be returned to secure settings.

2.12 POST ACCIDENT CO_2 SYSTEM INSPECTION

Fire-fighting and lifesaving equipment specialists “Unitor” were contracted to re-charge the CO_2 cylinders, in addition to overhauling the other fire-fighting equipment that had been used during the fire.

Service engineers arrived on 8 May and were advised of the inadvertent release of the CO_2 the previous day. They then made sure that the system was safe and that no further unexpected release of gas could occur.

The service engineers inspected the system and, as part of their system checks, removed and weighed the four pilot bottles from the two remote release stations. The results showed that they were full and had not been used.

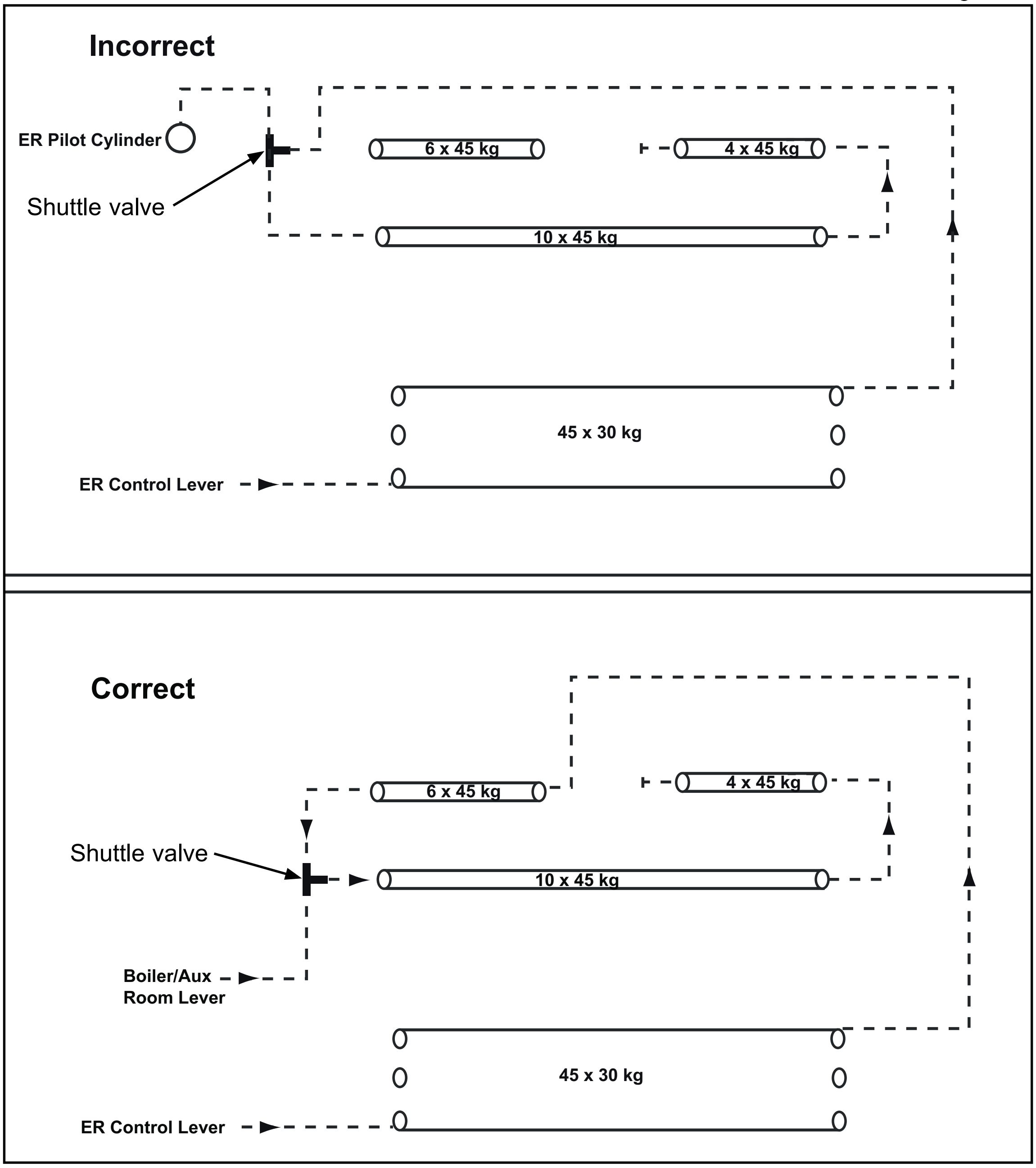
Further checks of the system showed that the outer bank of Ginge-Kerr cylinders was still full and the inner bank of Minimax cylinders was empty, and established that no CO_2 had been released during the fire-fighting attempt.

The inspection also revealed that the actuator shuttle valve ("T" piece) in the pilot line had been incorrectly fitted, probably from when the system was installed in 1994 **(Figure 28)**. This meant that, even if the system for the engine room had been activated correctly, only six of the outboard bank of cylinders would have been released instead of all of them (a total of 51 cylinders instead of all 66). The incorrect fitting of the shuttle valve had not been noticed in any inspections since the system was fitted in 1994. This indicates a general shortfall by both the service agents and ship staff.

Apart from the problem with the shuttle valves, the system appeared to have been fully operational prior to the fire.

During the inadvertent release of CO_2 it was noticed that gas was released into the CO_2 room (see Section 1.12). The Unitor representatives were able to confirm that this was probably due to the disconnected valve at the end of the inboard bank of cylinders.

Figure 28



2.13 PASSENGER SHIP CERTIFICATION

As *The Calypso* held a valid passenger certificate, there was nothing to stop her from commencing her cruising season following successful completion of her re-activation from her lay-up. However, because the vessel then re-flagged to the Cyprus Register, it was necessary for LR to inspect the vessel on behalf of the Flag State and reissue her certification. This occurred on 18 April 2006. To control the safety standards of vessels wishing to register under the Cyprus flag, the Cyprus Maritime Administration issued a circular letter 19/2002 instructing the Recognised Organisations on various guidelines **(Annex 5)**. Section 1 of this circular deals with Change of Flag surveys and outlines the requirements.

Of interest, is the requirement that where a change of flag is accompanied by a change of company, which happened in this case, LR was obliged to upgrade that survey from a survey of safety equipment to that of a renewal survey with the addition of basic International Labour Organisation items.

However, this did not happen, and records indicate that only a general examination was carried out. The degree of general examination of the vessel under such circumstances would depend on the date of completion of the last PC survey, and whether it had been an initial or renewal one. In the case of *The Calypso,* the last renewal survey had been completed nearly a year earlier, therefore the attending surveyor would be expected to examine the vessel quite thoroughly.

After the surveyor's inspection, a new passenger certificate was issued on 18 April 2006 based on the last completed survey of 28 April 2005 with validity until 24 July 2006. However, evidence suggests that the vessel was not ready to sail from Piraeus as a passenger ship and, although the owners had made arrangements for a riding crew to sail with her to carry out remedial work, it is suggested that she should have been issued with a cargo ship safety equipment certificate instead of a passenger certificate until such time as the remedial work was completed.

Subsequent PSC inspections in Seville and Tilbury, which resulted in 30 and 13 deficiencies respectively, substantiate the evidence above that the vessel should not have been allowed to sail with a passenger certificate.

2.14 PORT STATE CONTROL (PSC) INSPECTIONS

After coming out of the lay up period and into service, *The Calypso* was inspected by PSC inspectors in Seville and Tilbury under the Paris MOU prior to the accident.

The Seville Inspection

The Seville inspection was carried out by the Spanish maritime authorities in conjunction with the MCA inspectors. The inspectors commenced the inspection on 26 April 2006 and returned the following day to complete it.

During the course of the inspection, in excess of 35 deficiencies were identified **(Annex 6)**. Of these deficiencies, 12 were rectified prior to the inspectors leaving the vessel. When the vessel sailed from Seville, the number of deficiencies logged on the SIReNaC database was only 30 because some had been grouped under the same heading.

The number of deficiencies raised at this inspection caused some concern to the MCA inspectors, and the owners were advised to rectify them before they arrived in the UK to prevent the possibility of a detention **(Annex 7)**.

One of the main deficiencies that was a cause for concern to the MCA had been the quality of training the crew had demonstrated when a fire drill had been held on board.

Of the 30 deficiencies logged, it is debatable how many individual items could be classed as detainable items under the Paris MOU rules, which are identical to the EU directive 2001/106/EC. However, what is certain, is that under the criteria for detention of a ship, a combination of deficiencies of a less serious nature may also warrant the detention of the ship.

In the case of *The Calypso,* there were three areas under which these deficiencies could be classified and which could have lead to detention. They were:

(the ability of the ship/ship's staff to:)

- Fight fires effectively in any part of the ship
- Prevent pollution of the environment
- Provide safe and healthy conditions on board.

Given the nature and number of deficiencies identified during this inspection, and the fact that the vessel was going to be carrying about 400 passengers back to Barcelona, it is considered that there was a strong case for the PSC officer to detain the vessel. However, the deficiencies were not considered by the authorities sufficient to justify a detention, a decision which might have been influenced by the recently issued PC.

Tilbury inspection

As the MCA was concerned about the condition of *The Calypso* at Seville, surveyors boarded the vessel when she arrived in Tilbury on 5 May 2006, for the purpose of carrying out a port state control inspection.

Its surveyors found the vessel in a significantly improved condition, partly because the operators employed a riding crew on board during the passage between Barcelona and Zeebrugge to rectify most of the deficiencies identified in Seville. The MCA inspection discovered an additional 13 deficiencies, but none were of such a serious nature to warrant detention of the vessel.

Lloyd's Register (LR) also attended *The Calypso* at the request of the owners with a view to verifying satisfactory completion of the outstanding items raised by the PSC inspection in Seville. Most of the outstanding items were verified as complete to the satisfaction of the MCA and attending LR surveyor.

Previous PSC inspections

Records from previous PSC inspections prior to the Seville inspection indicate that during the period between the vessel being taken over in 2000 by the present owner, and the start of the cruising season of 2006, she was inspected four times as detailed below. At the time of these inspections, the vessel was registered under the Bahamas flag. She changed registration to the Greek flag in 2005.

Authority	Port	Date	Number of deficiencies
Greece	Eleusis	26.03.04	Nil
Greece	Rhodes Island	21.10.03	5
Greece	Rhodes Island	12.09.02	Nil
Greece	Piraeus	23.07.02	2

The numbers of deficiencies identified during these inspections were very low and, in two cases, there were none. This raises the question of what had happened to the vessel from the last inspection in 2004 to the ones conducted in Seville and Tilbury in 2006. The MAIB is unable to provide a satisfactory answer to this question.

It is also worth noting that two of the earlier PSC inspections highlighted the lack of fire-fighting training provided to the crew.

Post incident PSC inspection at Southampton

The MCA boarded *The Calypso* on 26 July 2006 for the purpose of inspecting her to ensure she was fit to proceed to sea following the fire on board the vessel.

This inspection was also attended by the Flag State representative and LR surveyors. It was also agreed with the MCA that the boat and fire drill which would be part of the inspection could be used towards crediting the vessel for her PC renewal.

The inspection highlighted 26 deficiencies. However, the inspection was suspended on the first day as the vessel's crew were unable to carry out a satisfactory fire drill. The MCA and Flag State eventually cleared *The Calypso* for further trading on 28 July 2006 once most of these deficiencies had been rectified.

2.15 ISM IN OPERATION ON *THE CALYPSO*

The ISM Interim Audit

DNV carried out an ISM Interim audit of *The Calypso* commencing 16 April 2006, on behalf of the Cyprus authorities. The scope of an ISM Interim audit is designed to establish the following:

- The vessel holds a valid copy of the DOC issued to the 'company' for the relevant ship type (ie passenger ships).
- The 'company's' SMS is on board the vessel and incorporates the functional requirements required by the Code.

- The ship's staff are familiar with the SMS and how it is to be implemented on board.
- The SMS is written in the working language(s) of the crew.
- The company has a planned internal audit schedule.

With the interim audit successfully carried out, an SMC was issued on 18 April 2006. However, because the vessel had been out of service for several months without a full crew on board, it was the opinion of the auditor that only a 3-month interim SMC (instead of 6 months) should be issued.

It should be noted that the issuance of a 3-month interim SMC did not imply or indicate that the vessel was considered not to be fully compliant with the ISM Code's interim SMC provisions. This was a standard precaution taken by DNV toward ISM certification of passenger vessels as a means of assuring effective maximum safety management compliance of this ship type. At the end of the 3-month period, the auditors would return to the vessel to verify the effectiveness of the planned implementation.

The ISM system in operational practice

To fulfil the objectives of the ISM Code, the safety management system should provide for safe practices in ship operation, a safe working environment and should also include provisions to continuously improve safety management skills including the vessel's emergency response preparations. The SMS on board *The Calypso* covered these areas.

These policies are implemented and come about by the commitment of the management at a high level. In the case of *The Calypso*, there is evidence to suggest that a safety culture was not present among the crew and management and can be confirmed by the findings of the initial SMC audit of the vessel and the annual verification of the DOC, both of which occurred after the accident.

As with all systems, there is a need for the ship's staff to maintain records, reports and complete checklists. However, the records collected by MAIB inspectors during this investigation often lacked the necessary detail to enable them to form a complete picture on the subject being recorded.

For example, although *The Calypso* was laid up during the winter season 2005 - 2006, she still retained a crew of about 60 people. Whereas the SMS requires the vessel to have regular meetings of the safety committee, the vessel was unable to provide any records for this period. In fact, the only record the vessel could provide was for one held in April 2006 following the PSC inspection in Seville. The report of this meeting covered only aspects of the PSC inspection carried out in Seville, and no other health and safety issues appeared to have been discussed despite specific guidance being provided on this in the shipboard SMS.

Another requirement of the ISM Code is that *valid documents are available at all relevant locations*; the vessel did not fully comply with this as it was discovered that the fire control plans, dated April 2003, had not been updated to show the installation of the local fog applicator fitted in March 2006. Additionally, on the same plans, the boiler room remote CO_2 station was not labelled and the auxiliary machinery space was not shown to be covered by the CO_2 system.

Within the vessel's *Shipboard Drills and Exercises* Manual*,* Section 7.8 detailed the drill to be carried out on the fixed CO_2 system. The requirement was for the system alarms and automatic ventilation shutdown to be tested monthly. The test was intended to take place at the *local* release cabinets. No mention was made of testing the system from the CO_2 space.

An enclosed space entry permit was also available in the SMS. However, this was not used on re-entering the engine room to check the fire after CO_2 was thought to have been released. This may be understandable in the circumstances, but nevertheless, the precautions required for entry into an enclosed space should have instinctively come into play.

In terms of emergency preparedness as required by the ISM Code, the chief engineer and the staff captain did not follow the company's established safety procedures when they knowingly entered a high risk enclosed space. The staff captain, wearing a BA set, entered alone, and the chief engineer, along with the chief electrician, also went in the engine room shortly after the operation of the CO_2 system. Although there are no detailed guidelines on re-entry times, these officers' actions are contrary to generally accepted methods of entering enclosed spaces during, or shortly after, a fire.

One of the shipboard emergency procedures on fighting an engine room fire clearly states that the chief engineer is responsible to the master for any crisis action involving the engine room. It also states that the chief engineer, in collaboration with the staff captain, should check the extent of damage, and/or rectify or minimise the effect of damage. However, there is no evidence to suggest any collaboration, despite the master instructing them to carry out an assessment of the fire. In fact, both officers appear to have acted independently of each other and took unnecessary risks that ran counter to the safe working practices that should have become second nature as a consequence of their mandatory STCW training.

The SMS documentation covered a wide range of drills and exercises that were required to be carried out periodically. The crew training records were found to be up to date, but the accompanying emergency exercise reports were found to be lacking in detail to the extent that it was impossible to establish what quality of training had been delivered during specific drills or exercises.

This is also reinforced by two previous PSC inspections held in Seville and Tilbury where the drills conducted in the presence of the PSC inspectors had been found deficient in this particular area.

The Initial SMC Audit (after the accident)

The interim SMC certificate expired on 17 July 2006 and, as the vessel was still laid up at Southampton for repairs to the fire damage, DNV took this opportunity to audit her. This initial SMC audit was completed on 12 July 2006.

The audit identified two non-conformities under the ISM Code, namely Section 7 (*Development of plans for shipboard operations*) and Section 9 (*Reports and analysis of non-conformities, accidents and hazardous occurrences*). These non-conformities on their own do not warrant particular concern as it is usually accepted that, for *The Calypso*'s type and age of vessel, a small number of non-conformities is normal.

However, the auditor also identified 18 observations. This is a cause for concern as the auditors' observations were subjectively worded, and some of the observations might have been classed as non-conformities by other auditors.

It is also usual, when non-conformities have been identified, for the vessel to be allowed time to rectify the deficiency. This period is usually mutually agreed upon between the auditors and the master or company's representative, and can be a period of up to 3 months. In this case, the period allowed was only 18 days. Although the exact reason for this is not known, it is probably no coincidence that the expiry of the period coincides with the date the vessel was expected to return into service.

Based on the evidence of this initial SMC audit, the fire, the inadvertent release of the CO_2 system, and the last two PSC inspections, the MAIB believes that, although *The Calypso* had implemented the safety management system on board to satisfy legal requirements, it fell short of applying it in the actual spirit of the ISM Code, whose basic objective is to promote safety at sea as outlined in Section 1.2 of the Code.

The DOC Annual Audit (after the accident)

It is a coincidence that the annual verification of the company's DOC was due soon after this accident and, to this effect, it was carried out on 27 July 2006 by DNV in Limassol. The audit identified seven non-conformities.

Compliance with the ISM Code should not usually be judged on the number of non-conformities but, rather, on their severity. However, a large number of non-conformities usually indicates an underlying problem. The MAIB believes that the number of non-conformities identified on *The Calypso* was too high for a passenger ship where exceptional standards are required.

Of the seven non-conformities, three are particularly significant and are discussed below. As non-conformities are based on objective evidence, the auditors concluded that, as many of the company's vessels were usually laid up during the off season, the company should develop and implement a re-activation procedure for laid up vessels. This would have been beneficial in the case of *The Calypso* as there is evidence to suggest that she was not ready to enter the cruising season when she did.

The auditors also found evidence of the ineffectiveness of the implementation of the SMS on board three of the company's passenger ships. Within a period of 3 months, these ships were inspected by PSC, which identified a number of deficiencies. One vessel in particular picked up deficiencies on two separate occasions within 1 month, which resulted in the auditors asking for a third party additional audit on board this vessel.

In six separate incidents the company also failed to investigate and analyse non-conformities and incidents to various vessels. This, too, resulted in a request for an additional third party audit of the company's offices in Limassol and Athens.

It was also noted, that the last time the SMS was reviewed by the company was in 2000. Under the ISM Code, the SMS is considered to be a live document and should, therefore, be subject to periodical review to evaluate its effectiveness. It appears that the company did not appreciate the importance of this requirement. The auditors found that, given the size of the fleet, the company's safety department could not effectively cope with the responsibilities assigned to it and considered that there was a resource issue.

ISM conclusions

Given the above factors, it appears that, although the owners had implemented an ISM compliant SMS on board *The Calypso* to satisfy regulatory requirements, it was not applied in a way which generated an effective safety culture within the company's staff ashore and afloat.

2.16 SEARCH AND RESCUE OPERATION PLAN

Under the SOLAS regulations, one of the requirements for a passenger vessel is to have on board an SAR cooperation plan developed between the ship, the operating company and the search and rescue services. This requirement is explained and expanded upon in an IMO circular, *MSC/Circ. 1079, Guidelines for preparing plans for co-operation between search and rescue services and passenger ships.*

The SAR cooperation plan is held as a controlled document on board the ship, with the company, and also with an SAR data provider. The SAR plan is not meant to replace more detailed emergency response plans developed for use on board and by the company, but rather serves as a link for a tripartite response to an emergency on board.

As passenger ships transit many Rescue Co-ordination Centre (RCC) regions during their voyages, administrative difficulties occur in maintaining SAR plans in all regions. These can be overcome by using a designated SAR data provider who acts as the contact point between global SAR services and the cruise ship operators, and who would release the co-operation plan when required.

To meet these requirements, an International SAR co-operation plans index has been set up and is maintained by MRCC Falmouth (UK). This can be accessed via the internet on the MCA website or by telephoning the MRCC directly.

Information required on this international index is limited, but enables users to look up a ship by three means of identification (name, callsign, or MMSI) to identify the SAR data provider for that ship. Once contact is established, the SAR services can have access to the vessel's co-operation plan.

In the case of *The Calypso*, MRCC Dover, which was the RCC for this accident, did not find any details of any SAR data providers on the international index and were thus unable to establish contact with the owners. As they had no details of the SAR data provider, they had no information on the vessel's capabilities with respect to rescue and safety equipment. This meant that, should the passengers and crew have had to abandon ship, valuable time would have been lost trying to establish what equipment or assistance was required.

It is the responsibility of the company to submit a copy of the SAR co-operation plan to an SAR data provider, and if the company takes it upon itself to be the data provider (which is allowed) then it should have made arrangements to submit the required details for inclusion in the international SAR co-operation plans index.

In this case, there were no consequences, however, should the incident have escalated to a more serious one, in a more remote location, valuable time might have been lost in providing rescue services to the vessel.

2.17 MIRG DEPLOYMENT

The deployment to *The Calypso* was the first test of the capabilities of the MIRG teams and, although the fire had been mainly subdued by the actions of the ship's staff, in the event, they provided much needed support and advice to the ship's master and to the rescue authorities.

2.18 SIMILAR ACCIDENTS

A number of similar incidents involving low pressure fuel pipes have occurred over the years, some of which have been investigated by MAIB.

In August 1994, the ro-ro passenger vessel *Sally Star* was on passage across the Dover Straits when a fire broke out in her engine room. The fire was caused by the failure of a bolted flange joint on the low pressure fuel system of her No 4 main engine. This failure allowed flammable fuel oil vapour to come into contact with part of the engine exhaust system. The fire was eventually extinguished about 3 hours after the onset of the emergency.

The two socket headed bolts, holding the flanges of the LP fuel pipe together within the hotbox of the Wartsila Vasa32 12 cylinder engine, had fractured (a conclusion arrived at after expert metallurgical examination). A slowly progressing fatigue crack, over many loading cycles, caused the failure. The fatigue loading was probably induced by high frequency cyclic loadings induced by peak pressure pulses of short duration within the low pressure fuel rail adjacent to the high pressure fuel pumps.

Wartsila carried out transient pressure measurements on the Vasa32 engine and, on connection pipes of the type used on *Sally Star*'s engines, these were found to be approximately 45 bar. Continuous product development resulted in a modification to a four bolt flange for the LP fuel pipes and the safety bulletin 3217T011 being issued.

As a result of this accident, the MAIB report (www.maib.gov.uk) issued recommendations to various parties. To the Marine Safety Agency (now the MCA), the following was given:

- *Give consideration to undertaking a research programme to establish whether there is a need to introduce clearer or more stringent requirements for the low pressure fuel systems of medium speed diesel engines to assure that the fuel supply pipes can withstand expected peak pressures in service.*

On 14 January 1999, *Aurora Australis,* an Australian Antarctic research vessel, suffered a similar incident to *The Calypso,* involving an LP fuel pipe leak and subsequent fire, on one of her Vasa 16V32 engines. However, in the case of *Aurora Australis,* the recommended four bolt flange modification had been carried out and the spray cover had been securely fitted.

The investigation, by the ATSB, found that the upper two securing bolts on the flange had broken and, of the remaining two, one was quite loose and the other had lost its preload. It could not be determined whether or not the bolts had been over tightened. The cover was not of a Wartsila supply, and had been fabricated by a shore contractor. It was not a good fit and was damaged. The fuel spray had escaped past the cover through a narrow gap in the aft side which was in line with the flange.

No recommendations were issued from the investigation.

On 15 June 2001, a serious fire broke out in the engine room of the passenger vessel *Nordic Empress* while she was enroute to New York. The accident was investigated by the United States Coastguard (USCG). The fire originated at the forward end of the number three, Wartsila 12 Vasa32, main engine. Bolts holding the LP supply pipe flange connection to the supply/return support bracket, forward of the hotbox on one side of the engine, had failed, allowing fuel to spray on to the exhaust manifold.

The vessel had been in receipt of Wartsila technical bulletins outlining failures of two bolt fuel pipe flanges, and the recommended modification to four bolt flanges had been carried out by Wartsila technicians in 1999.

The failed bolts had been on one of the modified flange connections, and the investigation found that several of the bolts were of an incorrect size and of different quality.

The report conclusions included the following:

- *Without scientific metallurgical analysis it is impossible to identify the exact manner in which the fuel line flange screws failed. The post fire inspection revealed that the components of the failed flange assembly did not comply with arrangements outlined in the 1995 technical bulletin.*
- *Different size screws with different qualities were used. The use of different screws would have demanded more specific and varying tightening procedures thus increasing the likelihood of improper installation.*
- *The 1995 Wartsila technical bulletin does not indicate that a torque wrench be applied to each fastener during the 2000 hour inspection. A visual inspection is inadequate in determining the tightness of various connections or torque values associated with the screws.*
- *There were no defenses (sic) minimizing the effect of the fuel release or preventing it from reaching an ignition source. The fuel ricocheted and atomized under the cover and instantly contacted the high temperature surface of the number one cylinder exhaust pipe. The fuel was heated to its autoignition temperature, combusted and the fire propagated in the immediate area near the front of both engines.*

The incidents highlighted above, and including *The Calypso,* have shown that prompt and effective action by ship's crews have prevented a dangerous incident from developing further, potentially resulting in loss of life, the loss of the vessel and the consequent pollution.

It is clear from the Wartsila technical bulletin issued in 1999 that the incidents are just a few of possibly many such bolt/flange/fitting failure incidents on the LP fuel pipes on Wartsila Vasa32 engines, with probably not all resulting in fire and, therefore not being reported. It is therefore important that technical bulletins successfully reach the intended recipients.

On 2 September 2002, the ro-ro ferry *Norsea* suffered an engine room fire caused by leakage of fuel from the fretting failure of a low pressure fuel pipe on her aft, diesel driven, Wartsila Vasa32 generator, as a result of incomplete securing arrangements. MAIB carried out the investigation.

Wartsila were recommended to:

- *Offer explicit advice to engine users on routine checking of the security of low pressure fuel pipes in the hotboxes of the Vasa32 range of engines.*

The actions taken by Wartsila, as a result of previous recommendations, should be re-visited and further improvements made to ensure that all owners and operators using Wartsila engines have received relevant technical bulletins and that a positive status report on actions taken by the owner/operator should be implemented.

SECTION 3 - CONCLUSIONS

3.1 SAFETY ISSUES IDENTIFIED DURING THE INVESTIGATION WHICH HAVE LED TO RECOMMENDATIONS

1. Despite instructions to release the CO_2 having been carried out, unbeknown to the officers and crew at the time, no CO_2 was released into the engine room to fight the fire. [2.9]

2. The location, signage and similarity between the timer bottles and the pilot gas cylinders led to confusion about their purpose. [2.9;2.10]

3. After the fire, the CO_2 system was left in a dangerous condition and this led directly to the inadvertent release of CO_2 into the engine room on the evening of 7 May which nearly caused the deaths of three crewmen. Good practice dictates that a CO_2 fire smothering system, or any other safety critical equipment, should be inspected after use, and valves, control switches and other control devices returned to a safe condition. [2.11]

3.2 SAFETY ISSUES IDENTIFIED DURING THE INVESTIGATION WHICH HAVE NOT RESULTED IN RECOMMENDATIONS BUT HAVE BEEN ADDRESSED

1. The fire was caused by the metal fatigue failure of the two 10mm socket headed bolts that had secured a flange on a low pressure fuel line on the vessel's starboard main engine. The fuel sprayed onto the adjacent turbocharger and/or exhaust piping causing spontaneous ignition. [2.3]

2. A sprayguard, which was meant to prevent fuel from coming into contact with hot surfaces, had been modified and was ineffective. Owners should ensure that any modifications to shipboard equipment are carried out in accordance with manufacturer's recommendations. [2.3]

3. The ship's low fog water spray system was not used to fight the fire because its controls were sited in the engine control room, which quickly became filled with smoke. [2.5]

4. The staff captain and the chief engineer on separate occasions re-entered the engine room soon after they thought that CO_2 had been released. This was contrary to good practice and could have escalated the emergency. Additionally, neither of them was properly equipped, indicating a serious shortfall in their knowledge and training. [2.6]

5. The manufacturer had known the weakness in the flange design for more than 10 years. Despite the important advice to replace two bolt flanges with ones with four bolts being incorporated in manufacturer's technical bulletins, the information was not known to the owners of *The Calypso.* [2.8]

6. Many of the senior officers on board misunderstood the CO_2 fire smothering system and how to operate it. This indicates a weakness in the training and experience of the officers concerned and in the effectiveness of the on-board drills. [2.9]

7. Although the chief engineer remained responsible for the CO_2 system, he allowed the independent fire investigator to tamper with it and this led directly to the inadvertent release of the CO_2. The fire investigator's own risk assessment should have informed him of the dangers associated with tampering with equipment with which he is not familiar and which may be in an unstable condition. [2.11]

8. Faults were discovered with the ship's CO_2 system which had probably been present but undetected for over 10 years. This calls into question the effectiveness of earlier service engineer and ship's crew inspections. [2.12]

9. A passenger certificate was issued at the completion of the vessel's refit and lay up period, and very soon afterwards PSC inspections in Seville and Tilbury resulted in 30 and 13 deficiencies respectively. The results of the PSC inspections substantiate the MAIB's opinion that the vessel should not have been allowed to sail from her refit port with a passenger certificate. [2.13]

10. Given the nature and number of deficiencies identified during the PSC inspection in Seville, and the fact that the vessel was going to be carrying about 400 passengers back to Barcelona, it is considered that there was a strong case for the Port State Control officer to have detained the vessel. [2.14]

11. There were a number of serious shortfalls in the way that the ISM Code was operated on *The Calypso*. It appears that, although the owners had implemented an ISM compliant SMS on board *The Calypso* to satisfy regulatory requirements, it was not applied in a way which generated an effective safety culture within the company's staff ashore and afloat. [2.15]

12. MRCC Dover could not find any details of any SAR data providers on the international index, and were thus unable to establish contact with the owners. They had no information on the vessel's capabilities with respect to rescue and safety equipment which meant that valuable time would have been lost trying to establish what equipment was required. [2.16]

3.3 OTHER FINDINGS

1. The overwhelming opinion of the majority of the passengers was that the crew conducted the muster in a calm and organised manner and that they (the passengers) were kept well informed throughout the accident. [2.7]

SECTION 4 - ACTION TAKEN

Louis Ship Management Ltd has:

- Issued a fleet circular to remind ship's staff of the actions to be taken when a fire is discovered in a machinery space including reference to: the precautions to be taken in regard to fixed CO_2 systems; a crew competency verification form for the operation of safety/emergency systems; an entry permit form when CO_2 has been discharged; and safety precautions when using CO_2 **(Annex 8)**.
- Reviewed its processes with respect to fire fighting drills to ensure that they are thorough, effective and meet Flag State requirements; relevant drills will include suitable CO_2 system checks and hazardous space re-entry procedures.
- Introduced new measures to improve the safety culture in the company and on board managed vessels.
- Incorporated procedures in its SMS for obtaining and distribution of manufacturers' technical bulletins.
- Demonstrated to Det Norske Veritas satisfaction that an effective safety culture exists throughout its organisation.
- Fitted a low fog system control station in the safety room to comply with SOLAS.
- Submitted a Search and Rescue co-operation plan to MRCC Falmouth.

Lloyd's Register of Shipping has:

- Carried out an in-depth internal investigation into the circumstances relating to the issuance of the Passenger Ship Safety Certificate to *The Calypso* in Piraeus on 18 April 2006, and taken action to ensure that in such circumstances in the future only Cargo Ship Certification should be considered, taking into account the relevant Flag Administrations' requirements.
- Recommended to the vessel's owner to fit a low fog system control station in the safety room.
- Reviewed its systems for transmitting technical bulletins to confirm their effectiveness, and proposed to IACS that similar actions should be taken by the other classification societies.

Wartsila Finland Oy has:

- Reissued technical bulletin 3217T044GB(01) to shipowners who have not yet confirmed that relevant modifications have been completed.
- Reviewed its processes for classifying technical bulletins to ensure that they are effectively distributed to all relevant parties.

MAIB has:

- Widely circulated a 2-page flyer containing the main lessons to be learned from this accident, including the need for post operation inspection of fixed installation CO_2 systems.

- Sent a copy of *The Calypso* report to the Ministry of Transport, Public Works and Water Management Transport and Water Management Inspectorate Secretariat of the Paris Memorandum on Port State Control for them to consider any lessons that can be learnt.

Burgoynes, Scientists and Fire Investigators, has:

- Reviewed its internal health and safety guidance and issued a high priority reminder to staff engaged in investigative work on board vessels that "no system should be assumed to be "dead" unless positively proved to be so".

SECTION 5 - RECOMMENDATIONS

The Maritime Administration of Cyprus, in co-operation with the Maritime and Coastguard Agency, are recommended to:

M2007/135 Draft and present to the appropriate IMO sub-committee, a paper proposing the production of an IMO circular on:

- *The design of control stations for CO_2* systems covering:
  - *Identification of critical system components (eg distinguishing between timer and pilot bottles)*
  - *The location and identification of any non-essential system components (which are not required to release the CO_2) to prevent confusion;*
  - *The need for clear indication that the discharge mechanism of each reservoir has been activated.*
- *The required crew actions following the use of fixed installation CO_2 systems, aimed at improving the general knowledge of these systems, including inspections and checks of the system status after use.*

Marine Accident Investigation Branch
April 2007

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