ACCIDENT REPORT

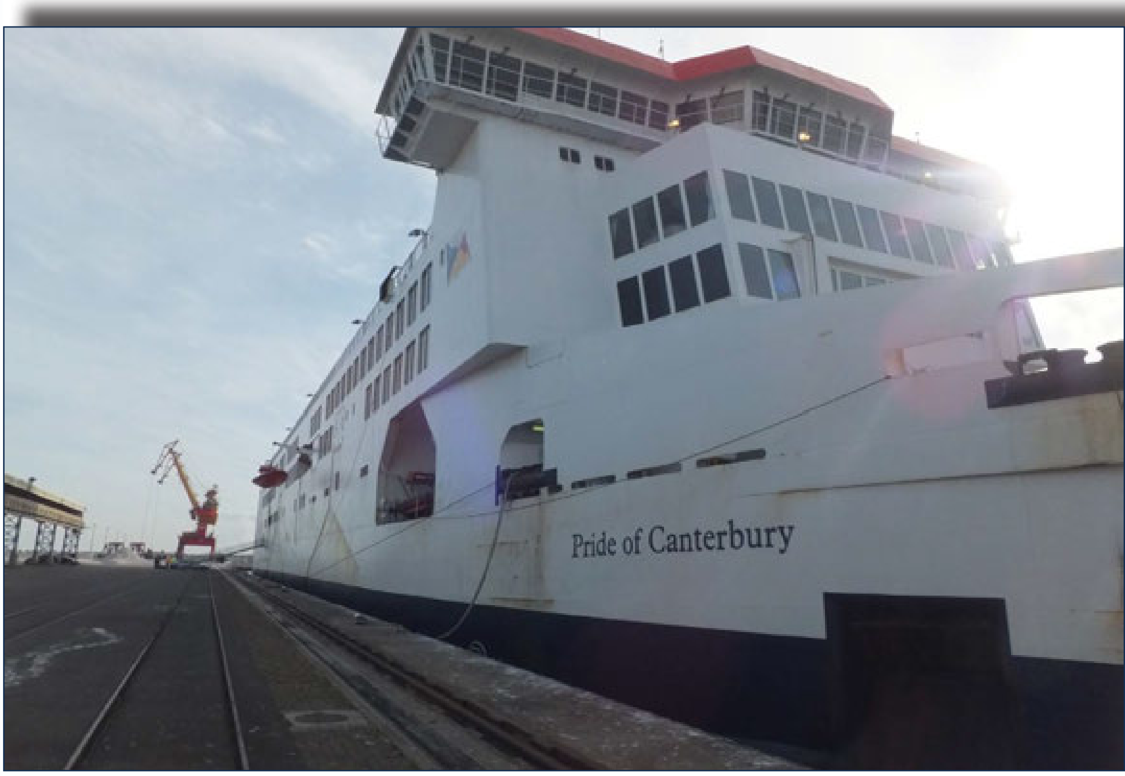
Report on the investigation of

a main engine room fire on board

Pride of Canterbury

while berthing in Calais

on 29 September 2014



MAIB

MARINE ACCIDENT INVESTIGATION BRANCH

SERIOUS MARINE CASUALTY | REPORT NO 22/2015 | OCTOBER 2015

Extract from

The United Kingdom Merchant Shipping

(Accident Reporting and Investigation)

Regulations 2012 – Regulation 5:

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

NOTE

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

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GLOSSARY OF ABBREVIATIONS AND ACRONYMS

BA	-	Breathing Apparatus
ºC	-	Degrees Celsius
CCTV	-	Closed Circuit Television
CPP	-	Controllable Pitch Propeller
ECR	-	Engine Control Room
ETO	-	Electrical Technical Officer
IACS	-	International Association of Classification Societies
IMO	-	International Maritime Organization
kW	-	kilowatt
LR	-	Lloyd's Register
MSC	-	Maritime Safety Committee
NRV	-	Non-return valve
OD	-	oil distribution (box)
OOW	-	Officer of the Watch
psi	-	pounds per square inch
PSV	-	pressure safety valve
PTO	-	power take-off
SOLAS	-	International Convention for the Safety of Life at Sea 1974, as amended
STCW	-	Standards of Training, Certification and Watchkeeping for Seafarers 1978, as amended
UK	-	United Kingdom
UTC	-	Universal Co-ordinated Time
VDR	-	Voyage Data Recorder

TIMES: All times used in this report are British Summer Time (UTC +1) unless otherwise stated

SYNOPSIS

On 29 September 2014, the roll on roll off passenger ferry *Pride of Canterbury* suffered a major fire in the engine room while berthing in Calais. There were no injuries but the main engine room was significantly damaged.

It had been established that the starboard controllable pitch propeller was not responding to the controls as *Pride of Canterbury* was approaching Calais. The shaft was therefore declutched and the two starboard main engines stopped. The prevailing weather conditions were such that the master was content to proceed using one propeller shaft and one bow thruster. The chief engineer manually started the starboard controllable pitch propeller system stand-by pump to maintain oil circulation. Shortly afterwards, a pipework joint in the system ruptured, spraying oil onto the exhaust uptakes. The oil ignited, causing a significant fire in the main engine room, which was then evacuated. The general emergency alarm was sounded and the passengers were mustered at emergency stations. The ferry berthed safely, the fire was extinguished using the ship's hi-fog system and then a fire hose, and the passengers and cargo were disembarked normally.

The investigation determined that:

- The back pressure valve in the starboard controllable pitch propeller hydraulic system had jammed shut, causing the oil pressure in the return line from the oil distribution box to rise.
- A flanged joint in the return line from the oil distribution box was unable to withstand the high pressure that resulted when a back pressure valve jammed shut.
- Some of the joints in the return line from the oil distribution box, including the one that failed, were not shielded to prevent a spray of oil in the event of joint failure.
- The back pressure valve had not been tested for functionality during the 23 years it had been in service.
- Although the manufacturer's manual specified the back pressure valve was to be tested annually, the manual did not specify how this was to be achieved.
- While Lloyd's Register Rules and Regulations required a high temperature alarm and a low pressure alarm to be fitted in the controllable pitch propeller system, there was no requirement for a high pressure alarm.

P&O Ferries has completed modifications to *Pride of Canterbury'*s controllable pitch propeller systems, and is continuing a programme of similar modifications to its sister ships as they attend refit. Associated procedures to prevent a future similar accident, including testing of pressure safety valves at least every 5 years, have also been introduced. Wartsila has issued a technical bulletin instructing that back pressure valves should be replaced after 15 years. Lloyd's Register has been recommended to propose to the International Association of Classification Societies a unified requirement for high pressure alarms to be fitted in controllable pitch propeller systems.

SECTION 1 - FACTUAL INFORMATION

1.1 PARTICULARS OF *PRIDE OF CANTERBURY* AND ACCIDENT

SHIP PARTICULARS	
Vessel's name	*Pride of Canterbury*
Flag	UK
Classification society	Lloyd's Register
IMO number/fishing numbers	9007295
Type	Roll on roll off passenger ship
Registered owner and manager	P&O Ferries
Construction	Steel
Year of build	1991
Length overall	179.7m
Length between perpendiculars	170m
Gross tonnage	30,635
Minimum safe manning	20
Authorised cargo	Vehicles and passengers
VOYAGE PARTICULARS	
Port of departure	Dover, UK
Port of arrival	Calais, France
Type of voyage	Short International
Cargo information	Vehicles and 337 passengers
Manning	113
MARINE CASUALTY INFORMATION	
Date and time	29 September 2014 0803
Type of marine casualty or incident	Serious Marine Casualty
Location of incident	Calais, France
Place on board	Main engine room
Injuries/fatalities	None
Damage/environmental impact	Extensive fire damage in the area of the starboard main engines
Ship operation	Manoeuvring
Voyage segment	Arrival
External & internal environment	Wind: variable F2-3 Sea state: calm Visibility: good
Persons on board	450

Pride of Canterbury

1.2 NARRATIVE

1.2.1 Events leading up to the fire

At 0530 on 29 September 2014, the day master completed his handover from the night master while *Pride of Canterbury* was loading alongside in Dover, UK. An hour later the ferry sailed with 337 passengers embarked for the 90-minute crossing to Calais, France. For the purposes of economy, the ship's port inboard main diesel engine was shut down for the passage.

Once the ferry was full away on passage, the master instructed the officer of the watch (OOW) to call him 20 minutes before the ship's arrival off the Calais pierheads, which corresponded to about 10 minutes before arrival at the start of the buoyed channel.

At 0729 **(Figure 1)**, just as the second engineer in the engine control room (ECR) received a call from the bridge giving him 15 minutes' notice of end of passage, the starboard controllable pitch propeller (CPP) hydraulic oil system high temperature alarm sounded. The senior third engineer left the ECR for the main engine room to investigate **(Figure 2)**.

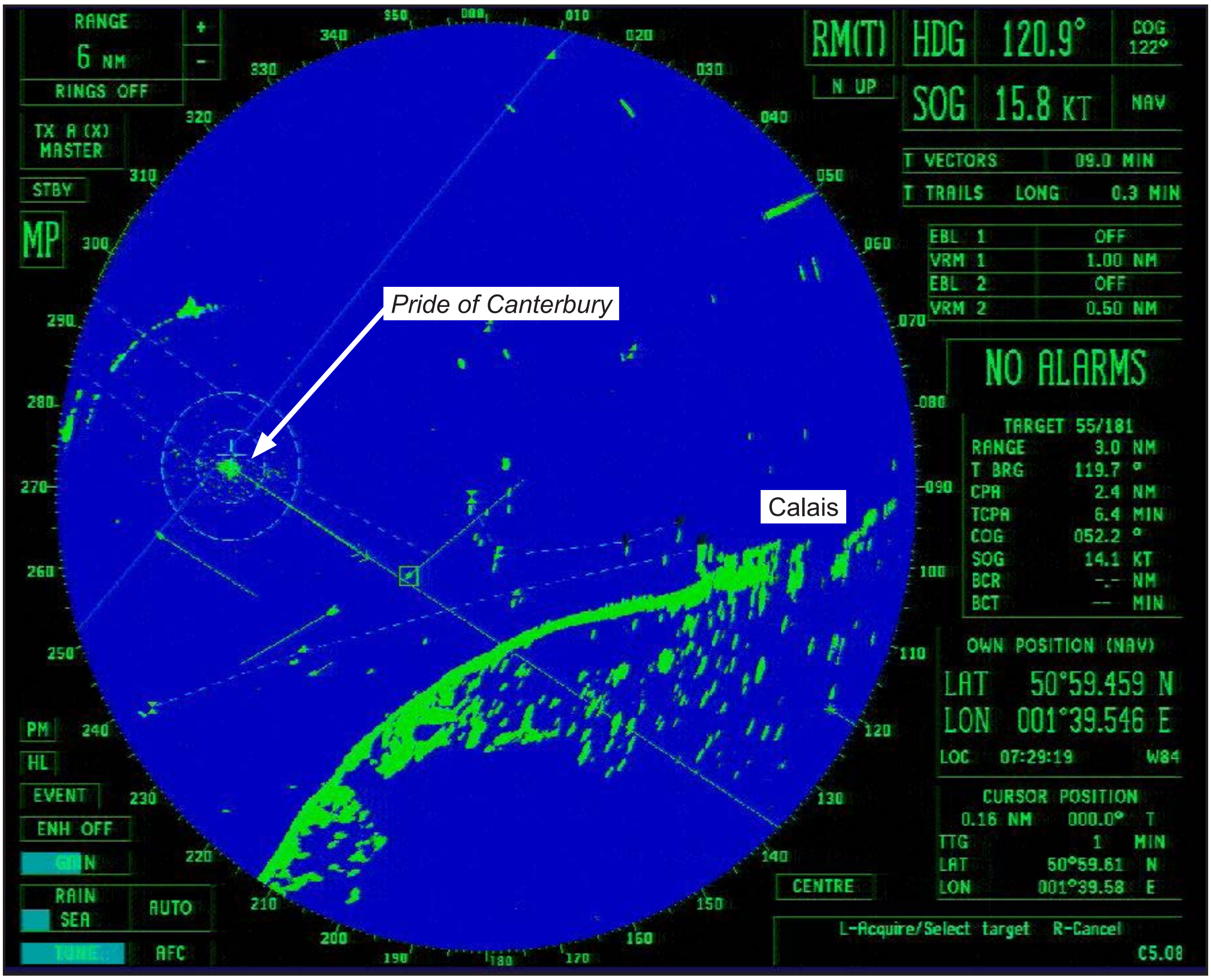

Figure 1: Radar display at 0729 on approach to Calais

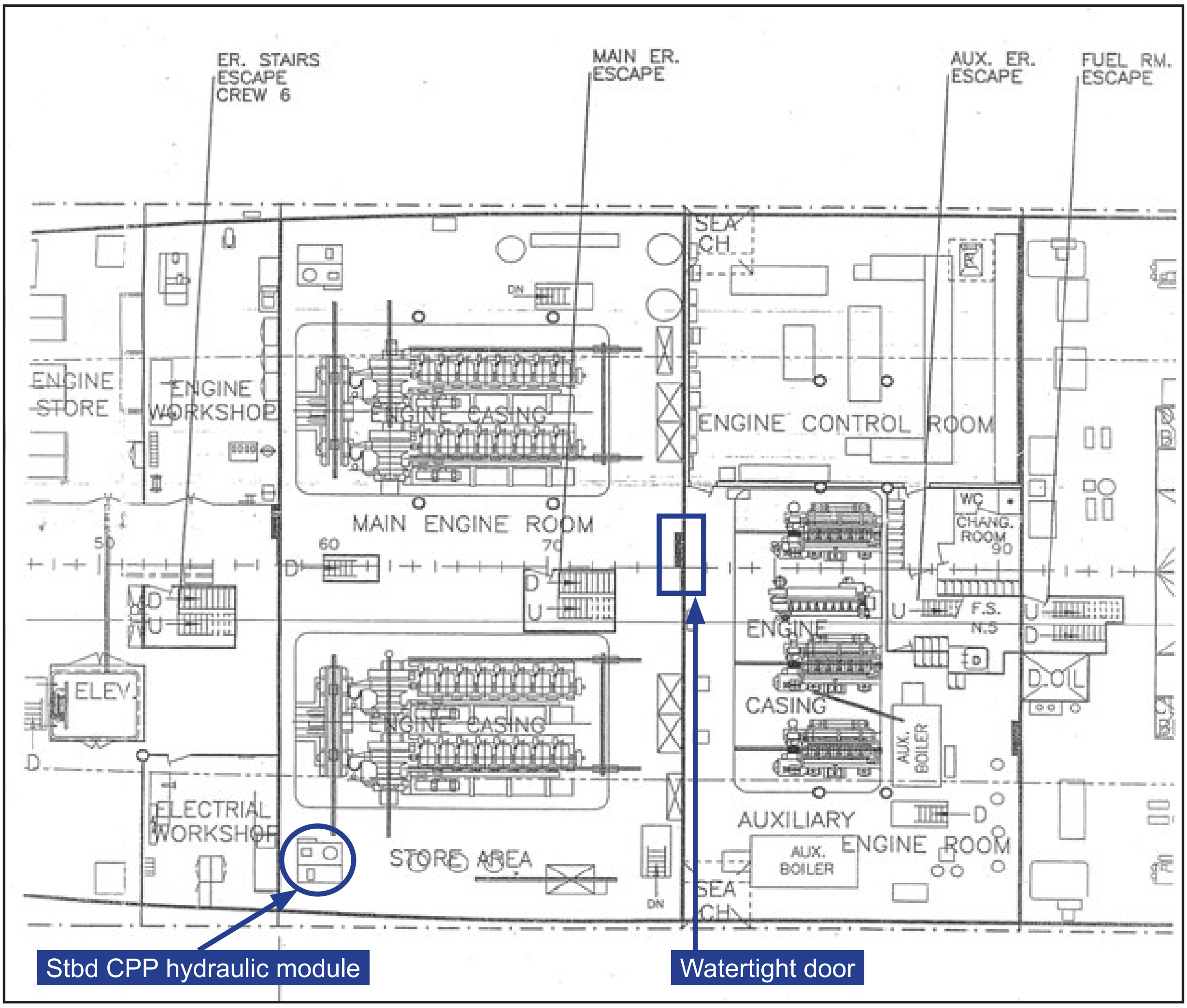

Figure 2: Main engine room and engine control room layout, deck 2

The second engineer called the bridge to establish if the port inboard main engine was required for entering Calais, to which the master decided it would not be needed. The senior third engineer returned to the ECR, confirming the hydraulic oil in the starboard CPP system was hot and there was no temperature difference across the oil cooler. The second engineer then went to the main engine room to investigate. He found the pressure analogue gauge (PG3) on the CPP system apparently indicating zero, but on closer inspection noted that the needle had been forced all the way round the dial past 20 bar and onto the stop **(Figure 3)**. The second engineer returned to the ECR and informed the bridge that he was starting the port inboard main engine as he was concerned about the starboard CPP system.

At 0740, an alarm sounded, indicating a problem with the starboard CPP system hydraulic pressure sensor. The electrical technical officer (ETO) was paged to report to the ECR to investigate the sensor. Around the same time, as the second engineer started the port inboard main engine, the starboard main engines suddenly indicated 100% load and the turbochargers temporarily increased to 16000 revolutions per minute. After informing the bridge team that the port inboard main engine was running, the second engineer called the chief engineer, who was in his cabin, and asked him to come down to the ECR.

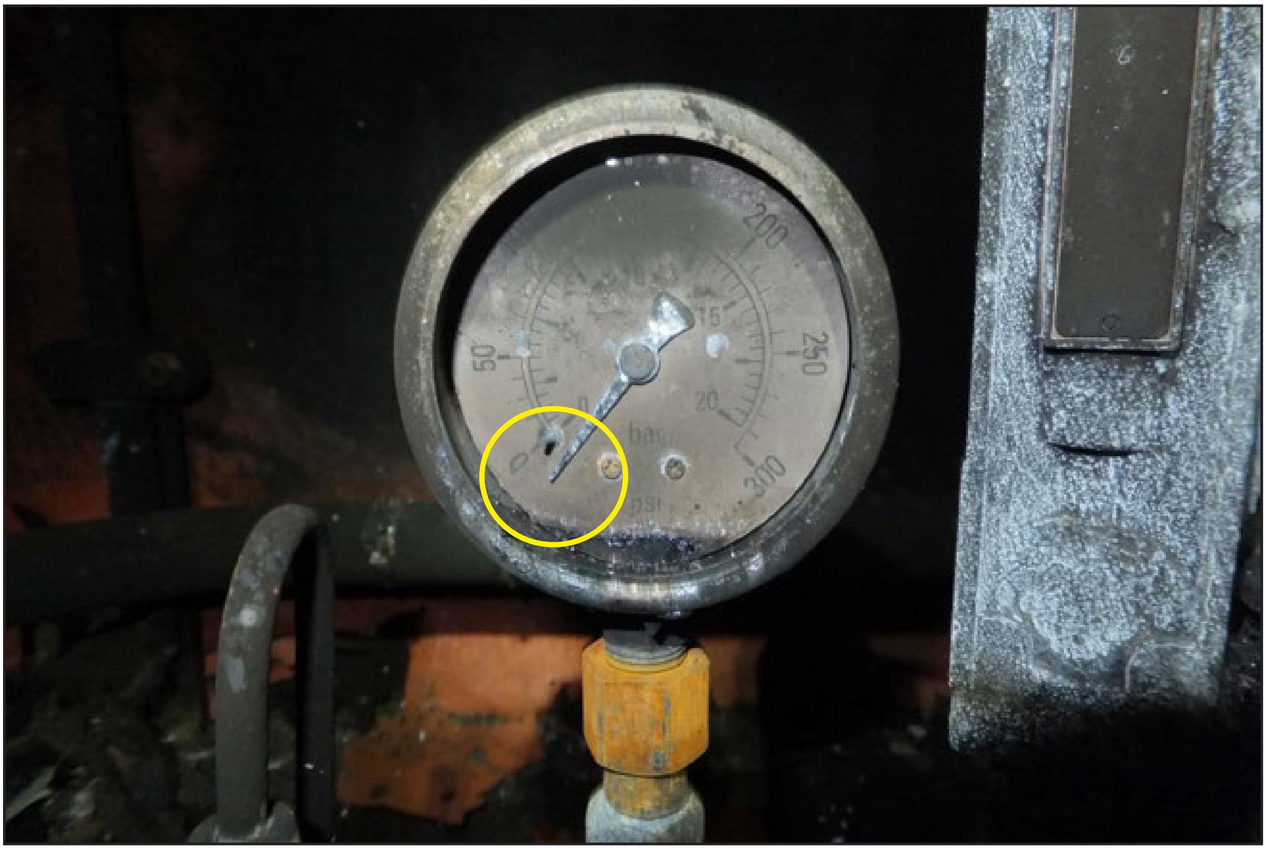

Figure 3: Starboard controllable pitch propeller system oil distribution box return line oil pressure gauge (PG3) (post-fire)

At 0743, the master arrived on the bridge in preparation for arriving at Calais. He was briefed by the OOW about the problem with the starboard CPP system and that the fourth main engine had been started. At 0750, he took the con from the OOW.

The chief engineer arrived in the ECR and took charge after receiving a handover from the second engineer. He then called the master on the bridge who attempted to reduce the pitch on both propellers to ensure he had control. The starboard propeller pitch did not change as the pitch control setting was reduced. The master switched to the emergency mode and tried again to reduce the starboard propeller pitch, but without success. Control of the starboard CPP was then passed to the chief engineer in the ECR, who also tried but was unable to reduce the pitch. The master decided to declutch the starboard main engines and stop them.

The master informed the bridge team of his intentions to berth the ship using one propeller shaft and one bow thruster, and asked for a tug to be ordered to assist if required. He was confident, given the favourable weather conditions, that he could berth the ship safely bow into berth 5. A broadcast was made to the passengers, informing them that there was a technical problem but that there was no cause for concern.

At 0755, the chief engineer declutched the starboard main engines and subsequently shut them down. By this time, the ETO was in the engine room, investigating the hydraulic pressure sensor failure.

At 0801, with *Pride of Canterbury* approximately 4 cables from the berth **(Figure 4)** the master moved from the centre console to the starboard wing console and took control of the port CPP, both rudders and one bow thruster.

In the ECR, the chief engineer noticed that the starboard hydraulic CPP system electric stand-by pump had not started automatically as was normal, so he switched the pump to manual start mode and started it to ensure that the CPP system oil would keep circulating.

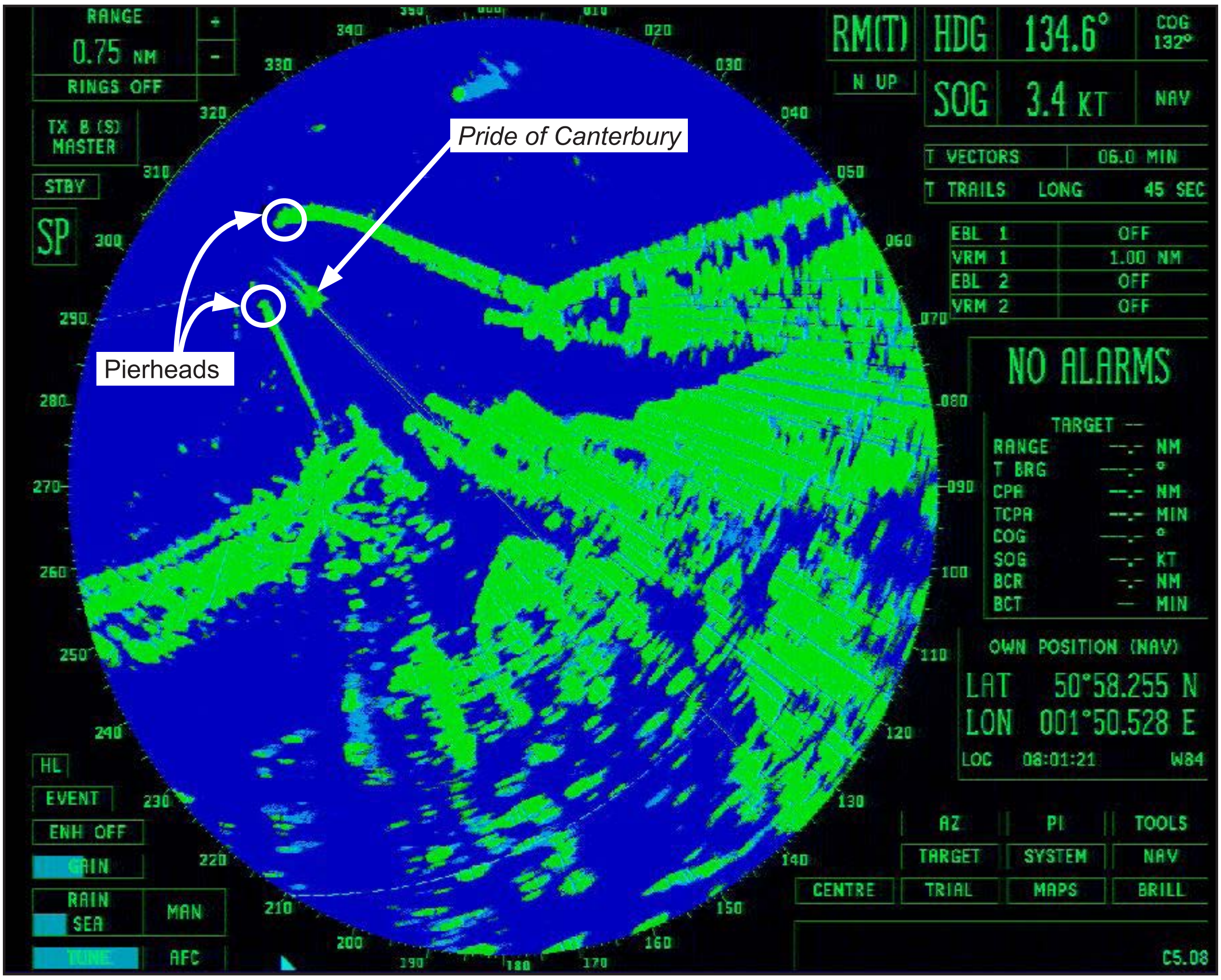

Figure 4: Radar display at 0801 on final approach to berth

The motorman who was on watch in the main engine room then saw hydraulic oil spray from a flanged pipework joint situated between the two starboard main engine turbochargers **(Figures 5** and **6)**. The hydraulic oil ignited immediately. The motorman and remaining personnel evacuated from the main engine room and raised the alarm in the ECR. At 0804, the fire alarm was automatically activated by the sensor heads situated above the starboard main engines.

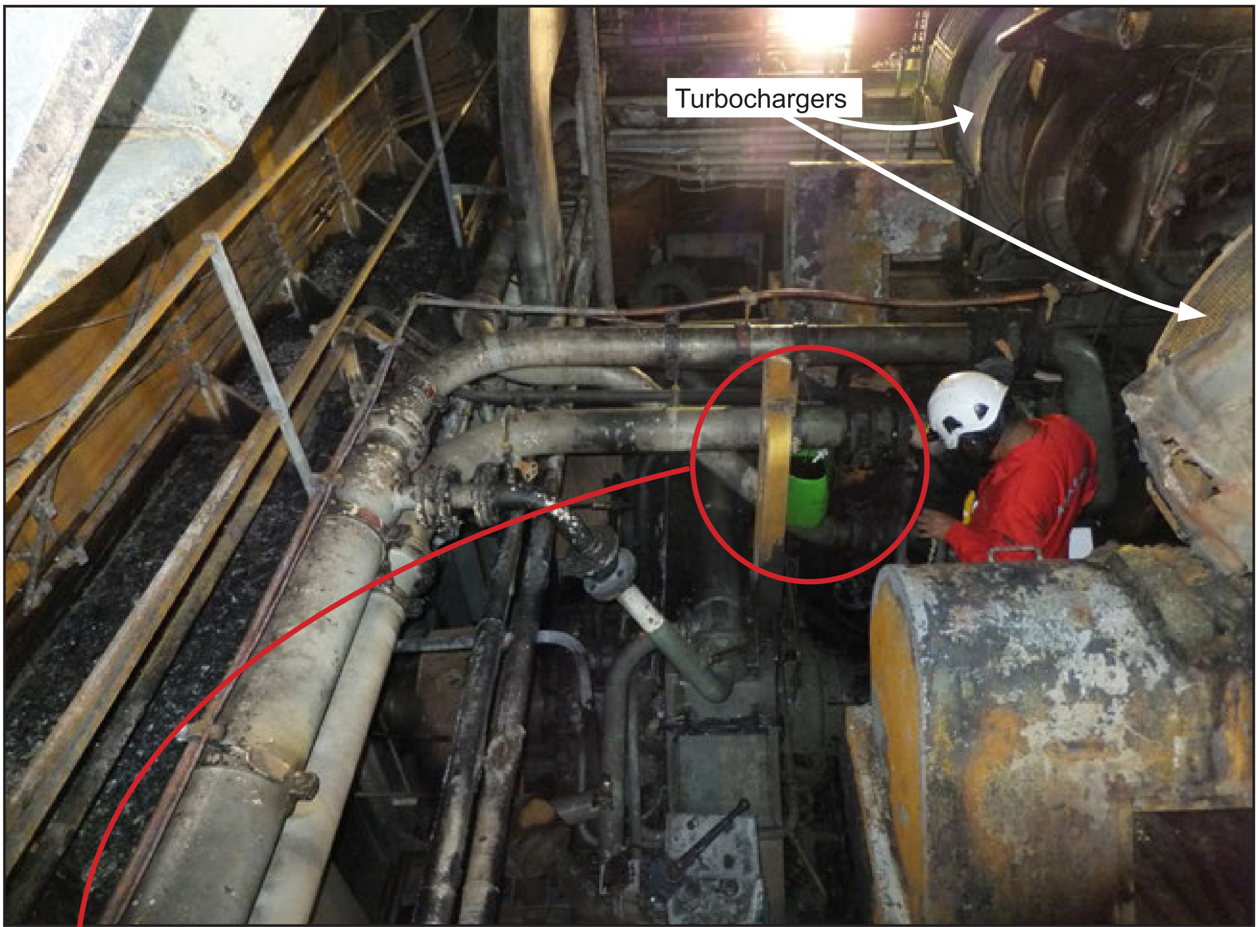

Figure 5: Area aft of starboard main engines

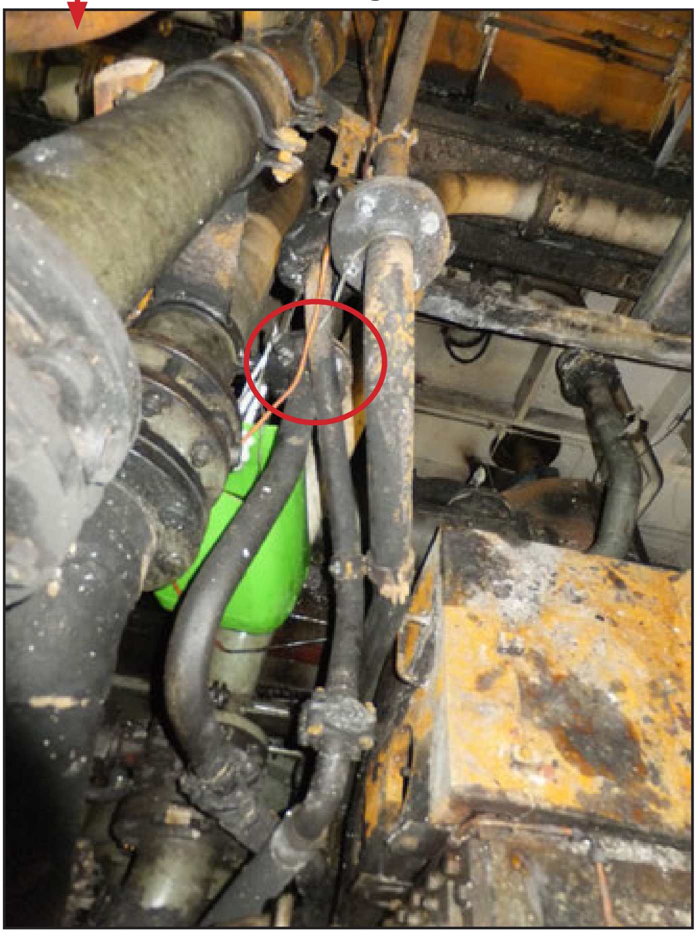

Figure 6: Failed flanged joint

1.2.2 Emergency response

The chief engineer alerted the bridge team to the fire and requested that they close the vessel's watertight doors remotely as thick smoke was preventing closure of the watertight door between the auxiliary engine room and the main engine room at its local control. From the closed circuit television (CCTV) picture in the ECR, the chief engineer was aware that *Pride of Canterbury* was close to the berth, so he activated the hi-fog fixed fire-fighting system for the starboard main engines **(Figure 7)** and ordered the associated fuel shut-off valves to be closed. He and the second engineer then reconfigured the ventilation fans, switching off the supply fans but leaving the starboard side exhaust fans running to clear the smoke.

Figure 7: Hi-fog control panel in engine control room (*Pride of Canterbury* was previously named *European Pathway*)

At 0806, the bridge team activated the general alarm, which sounded in the crew's quarters, and an announcement was made informing the passengers of the situation and to await further instruction. The port authority was also informed.

The chief engineer instructed the junior third engineer and motorman to don breathing apparatus (BA) at the fire party muster station outside the ECR **(Figure 8)**, and a fire hose was rigged in the auxiliary engine room ready for re-entering the main engine room. The chief engineer briefly spoke to the master and informed him that he would like to shut down the port main engines as soon as possible. This was acknowledged by the master. At 0810, a tug arrived and was requested to stand-by the ship's stern ready to push the ship alongside.

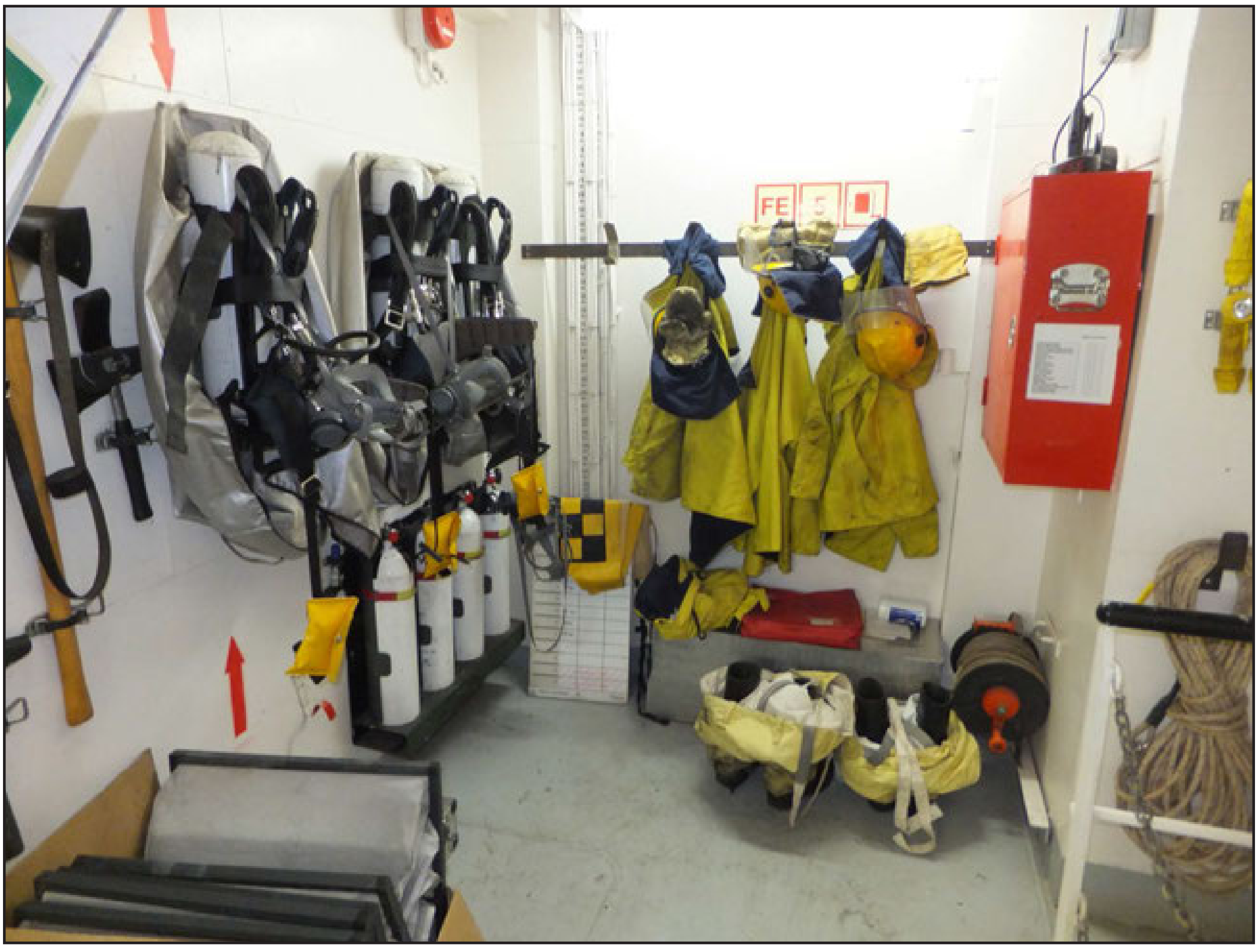

Figure 8: Fire party muster station

At 0811, the bridge team sounded the general emergency alarm throughout the ship and passengers were instructed to muster at the emergency stations. With control teams now closed up and BA teams preparing, the drenchers on vehicle deck 3 were activated to boundary cool the deck above the engine room.

At 0814, with lines ashore and the master having ordered 'finished-with-engines', the chief engineer declutched and stopped the port main engines. The tug pushed the ship alongside at the stern until all mooring lines were ashore and secured.

At 0816, with the first BA team ready to enter the engine room, the watertight door was cracked open. Some residual flame was apparent in the starboard aft area of the engine room. The door was then opened and the third engineer and motorman entered the engine room and started to direct a fire hose onto the fire. Around this time, the local fire brigade arrived on the quayside and waited for the cargo loading ramp and passenger gangway to be deployed.

At 0820, the master informed the chief engineer that he was about to order an 'in port' passenger evacuation and asked whether it was safe to disembark passengers and vehicles normally. The chief engineer responded that there were no more flames and the fire was under control. With drencher water pooling on deck 3 and no sign of steam, the master decided a normal disembarkation could take place, and announced this to the passengers.

The first BA team were relieved a short time later by a second BA team of three, as neither the junior third engineer nor the motorman had entered the space with a radio. The chief engineer had instructed that one of the second BA team should be a member of the engine room team to ensure familiarity with the locality. A further two BA teams then entered the engine room in succession to damp down any hotspots. Once on board, the local fire brigade liaised with the chief engineer and, at 0857, confirmed the fire was completely extinguished.

1.3 ENVIRONMENTAL CONDITIONS

The weather for the channel crossing and arrival in Calais was good with a light variable force 2-3 breeze, good visibility and calm sea. During the crossing, the tide was on the ebb with low water at Calais expected at 0959.

1.4 DAMAGE

External damage to *Pride of Canterbury* was limited to some smoke staining leading from two main engine room ventilator grills on the starboard side of the ship **(Figure 9)**. Internally, damage was limited to the main engine room, where the fire had been centred above the starboard gearbox **(Figure 10)**. The greatest damage was sustained in the area of the aft bulkhead, deckhead, and to equipment situated on deck 2 on the starboard aft side **(Figure 11)**. The severity of fire damage decreased as the distance from the starboard gearbox increased, with only smoke damage sustained to the port area of the engine room. Following the accident, *Pride of Canterbury* was towed to a local shipyard for repair.

Figure 9: Smoke staining on starboard side

Figure 10: Fire damage around starboard main engines, deck 2

Figure 11: Fire damage looking aft on starboard side, deck 2

1.5 MANNING

1.5.1 General

Pride of Canterbury had a 24-hour operating pattern, completing five round trips a day between Dover and Calais with what were effectively two crews, a day and a night crew, operating 12 hours on duty and 12 hours off duty. The crew duty changeover was normally arranged to coincide with the ship turnaround in port. The crew worked this routine in rotation with 1 week on duty and 1 week on leave.

1.5.2 Bridge

During the crossing of the Dover Strait the bridge was manned with an OOW, helmsman and dedicated lookout. For port arrival and departure, the master and a checklist officer joined the bridge team. At the time of the accident, there was also a trainee helmsman present on the bridge.

The master held a II/2 STCW[1] certificate of competency, which he obtained in 1985. Since then, he had worked solely on cross-Channel ferries with P&O Ferries and its predecessors as a deck officer, and had been promoted to master in 2000. He was appointed as senior master on *Pride of Canterbury* in February 2013. Prior to joining *Pride of Canterbury* he had served as master for 4 years on its sister ship *Pride of Kent.*

1.5.3 Engine room

An engine room watch normally consisted of a second engineer, a senior and junior third engineer, a senior engineer rating and a motorman. An ETO was also available to be called during the day. The ship had only one chief engineer, who worked 0600-1800 but remained available during the night if required. During the day the chief engineer covered departures from port in the ECR, while the day-second engineer covered arrivals. The night-second engineer covered both departures and arrivals. During arrivals and departures, it was standard practice to have an engineer rating stationed in the engine room.

The chief engineer, a French national, held a III/2 STCW certificate of competency. He also held a II/2 STCW certificate of competency although he had never served in the rank of master, and this additional qualification was not recognised on his UK certificate of equivalent competency. He had worked as a deck officer and an engineer on a variety of ships until 2000 when he became a chief engineer with P&O Ferries, primarily on *Pride of Canterbury* but also on *Pride of Kent*. He was appointed senior chief engineer on *Pride of Canterbury* in 2008.

The on-watch second engineer held a III/2 STCW certificate of competency. He had worked for a variety of companies but had joined P&O Ferries in 2011, and had been a senior engineer on *Pride of Canterbury* and her sister vessels ever since.

The senior third engineer held a III/2 STCW certificate of competency and had started work in the ferry trade in 1999 with Irish Ferries before joining P&O Ferries in 2006. He joined *Pride of Canterbury* as third engineer in 2008.

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[1] STCW Standards of Training, Certification and Watchkeeping for Seafarers 1978, as amended

The junior third engineer held a III/1 STCW certificate of competency, which he obtained in 2011. He was employed via an agency and had been working with P&O Ferries since April 2014 on several ships including *Pride of Canterbury*.

The motorman first went to sea as a steward in 2000 before transferring to the engineering department and completing a 6-month training scheme to obtain his engine room watch rating certificate in May 2002. He had also completed a fire prevention and fire-fighting course in September 2001. He had worked on board *Pride of Canterbury* as a motorman since May 2012.

1.6 CONTROLLABLE PITCH PROPELLER SYSTEM

1.6.1 Overview

Pride of Canterbury was propelled by two shafts fitted with CPPs, with each shaft driven by two main diesel engines via clutches and a gearbox. As well as driving one of the two shafts, each gearbox drove an alternator that powered a bow thruster, and a power take-off driving a hydraulic pump for that shaft's CPP system. The two CPP systems were independent of each other.

Figure 12 provides a simplified schematic of one of the CPP systems. The main components of the system were the propeller hub, oil distribution (OD) box **(Figure 13)**, power take-off (PTO) driven pump **(Figure 14)**, hydraulic module **(Figure 15)** and oil header tank. The hydraulic module housed the CPP system's reservoir, filters, pressure safety valves (PSV), oil cooler, stand-by pump, pressure gauges and sensors. The OD box was situated between its respective diesel engines on deck 1, while the hydraulic modules were positioned outboard on deck 2 in the engine room.

1.6.2 Hydraulic oil pressure regulation

The system oil pressure was regulated by maintaining the return line from the OD box at 8 bar utilising a pressure safety valve (PSV3) termed a back pressure valve **(Figure 16)**. A further pressure safety valve (PSV1) was fitted in the supply line to the OD box to enable pressure to be dissipated into the return line if it exceeded 145 bar. **Figure 17** shows the fire-damaged starboard hydraulic module with the relevant components highlighted. An oil cooler was situated after the back pressure valve and a non-return valve (NRV6) was positioned immediately before the return into the reservoir.

The return line from the OD box also contained a pressure switch (PRS3), which automatically started the electrically-driven stand-by pump if the pressure reduced below 6 bar, and two system pressure transducers (PT1 and PT2), which were set to alarm when the pressure dropped to 4 bar. When the shafts were not turning, engaging the automatic stand-by pump ensured that a positive pressure remained in the CPP hydraulic system, preventing potential sea water contamination at the propeller hub and ensuring circulation of the oil. The stand-by pump could also be started manually in the ECR if for some reason it failed to start automatically. The system was also provided with a temperature sensor on the OD box, which was set to alarm at 69ºC.

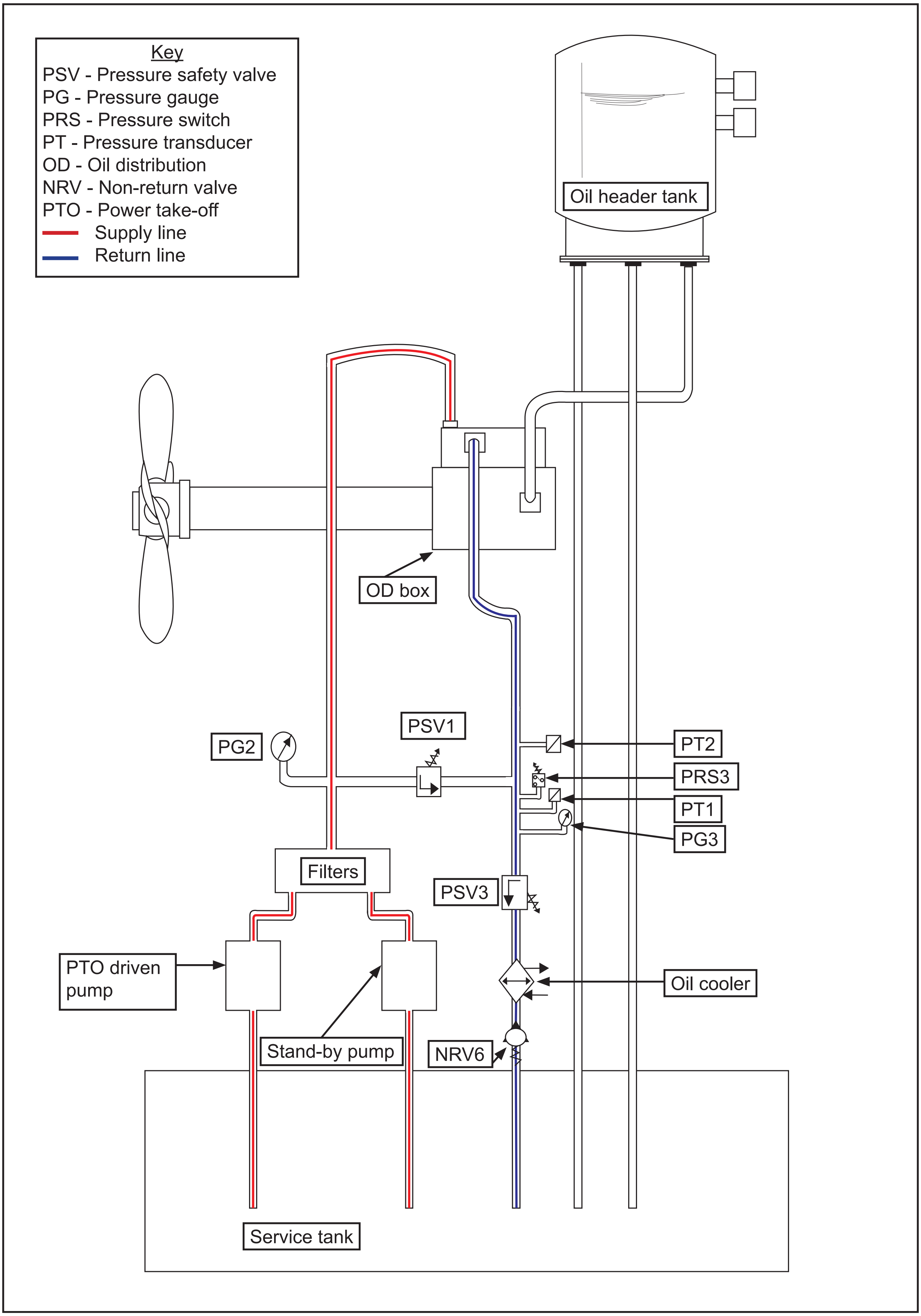

Figure 12: Controllable pitch propeller system simplified schematic

Figure 13: Oil distribution box, deck 1

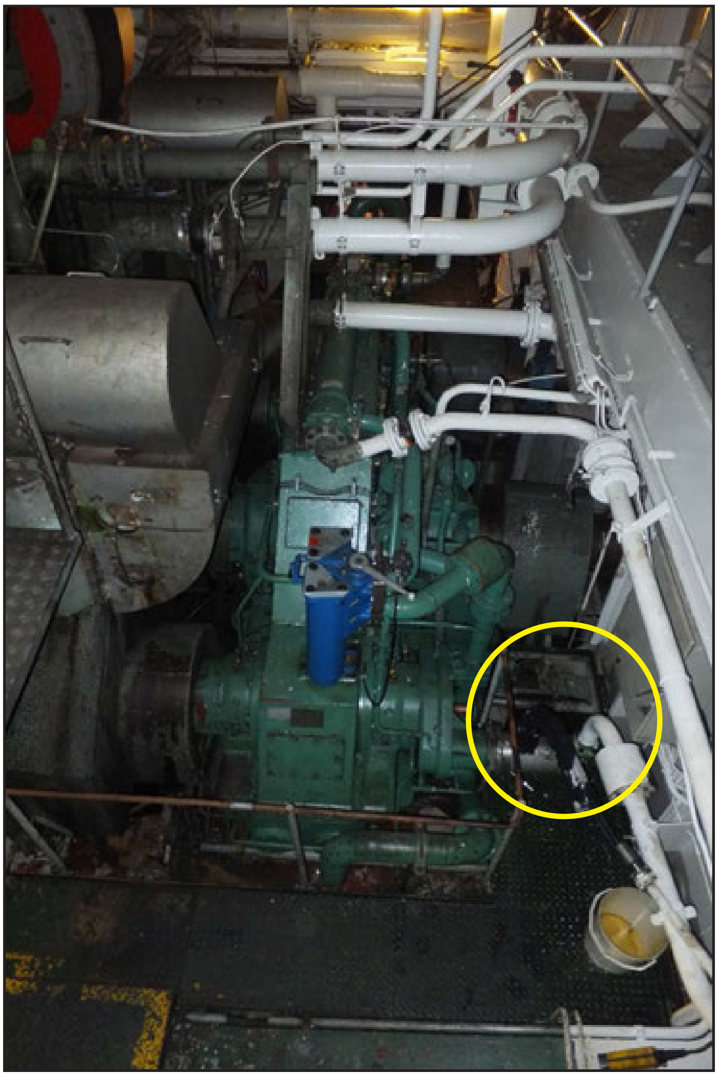

Figure 14: Power take-off controllable pitch propeller pump, deck 1

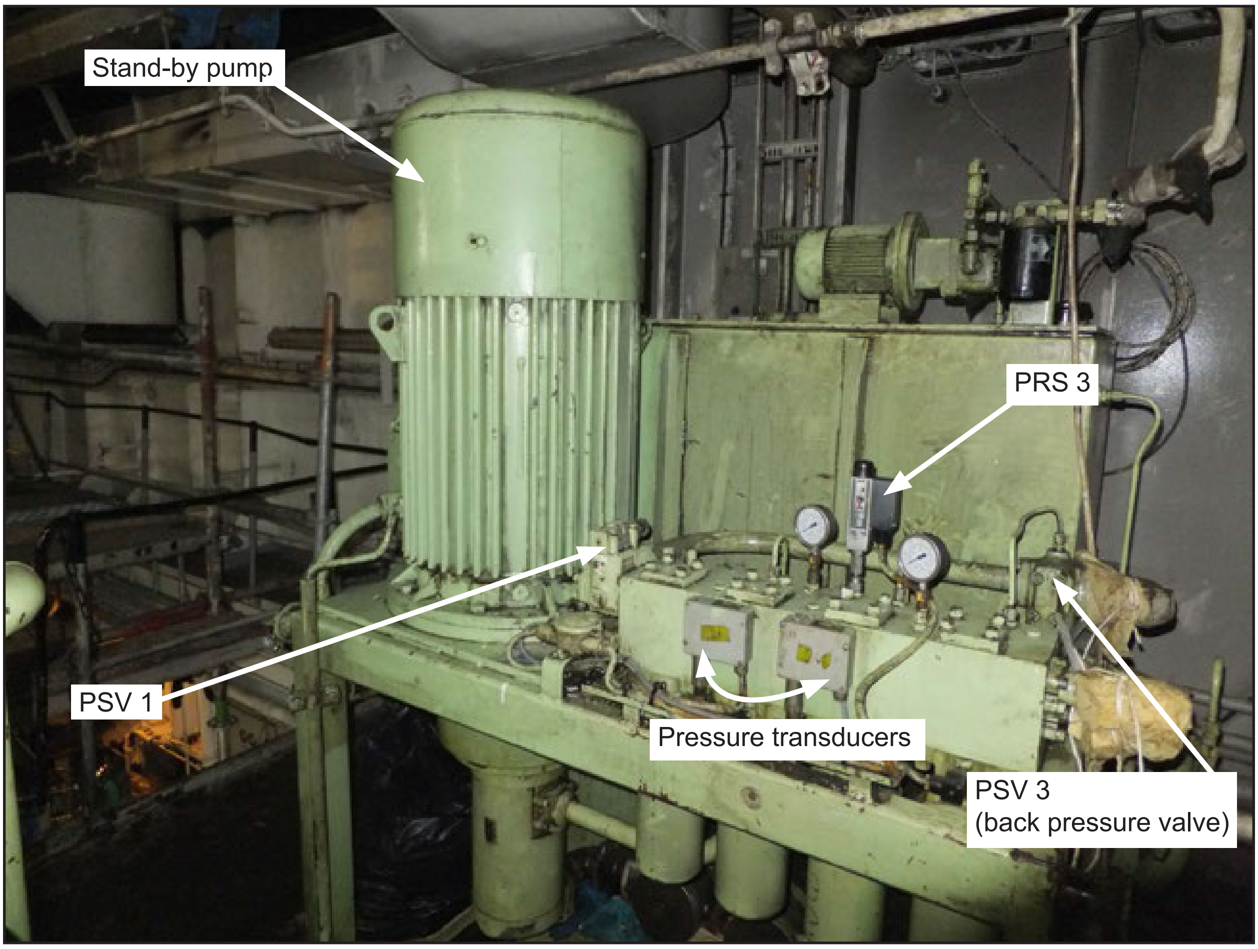

Figure 15: Controllable pitch propeller hydraulic module, deck 2

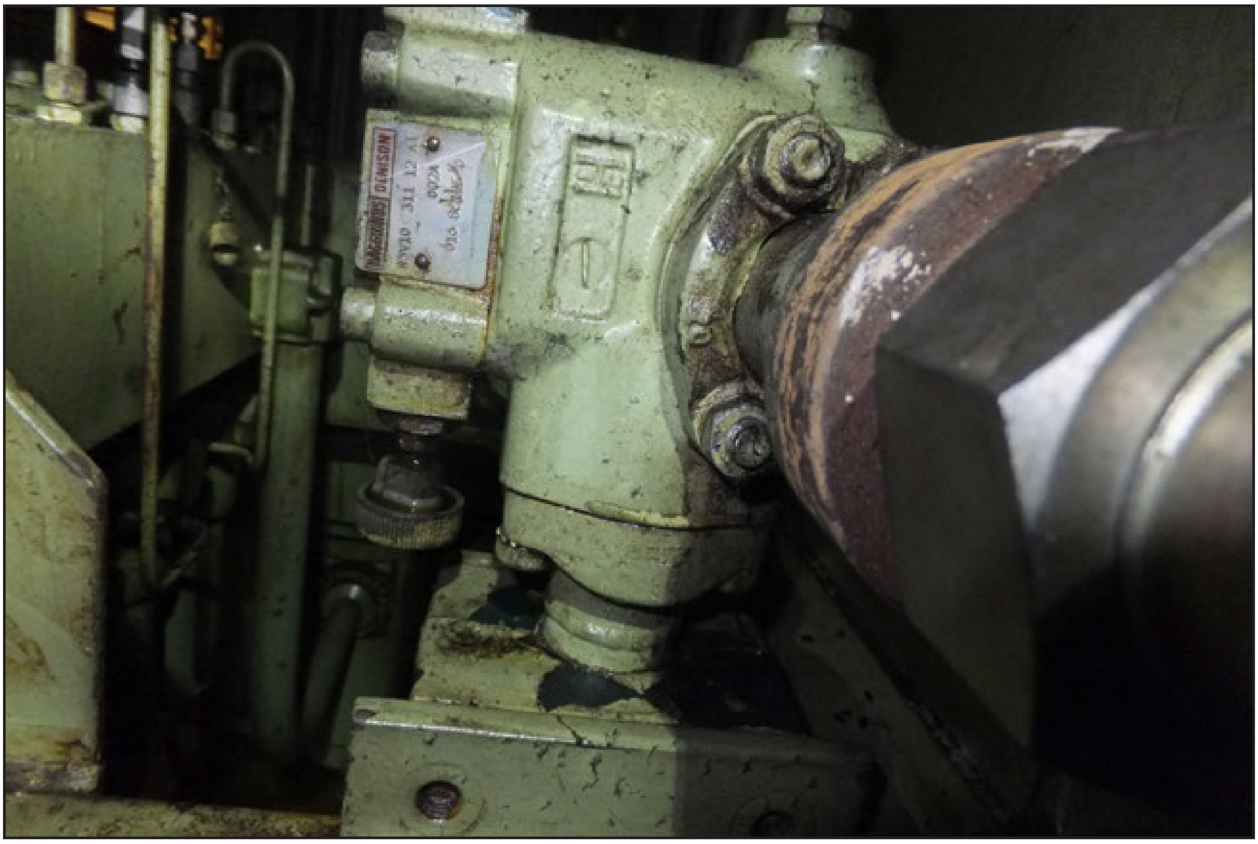

Figure 16: Back pressure valve (PSV 3)

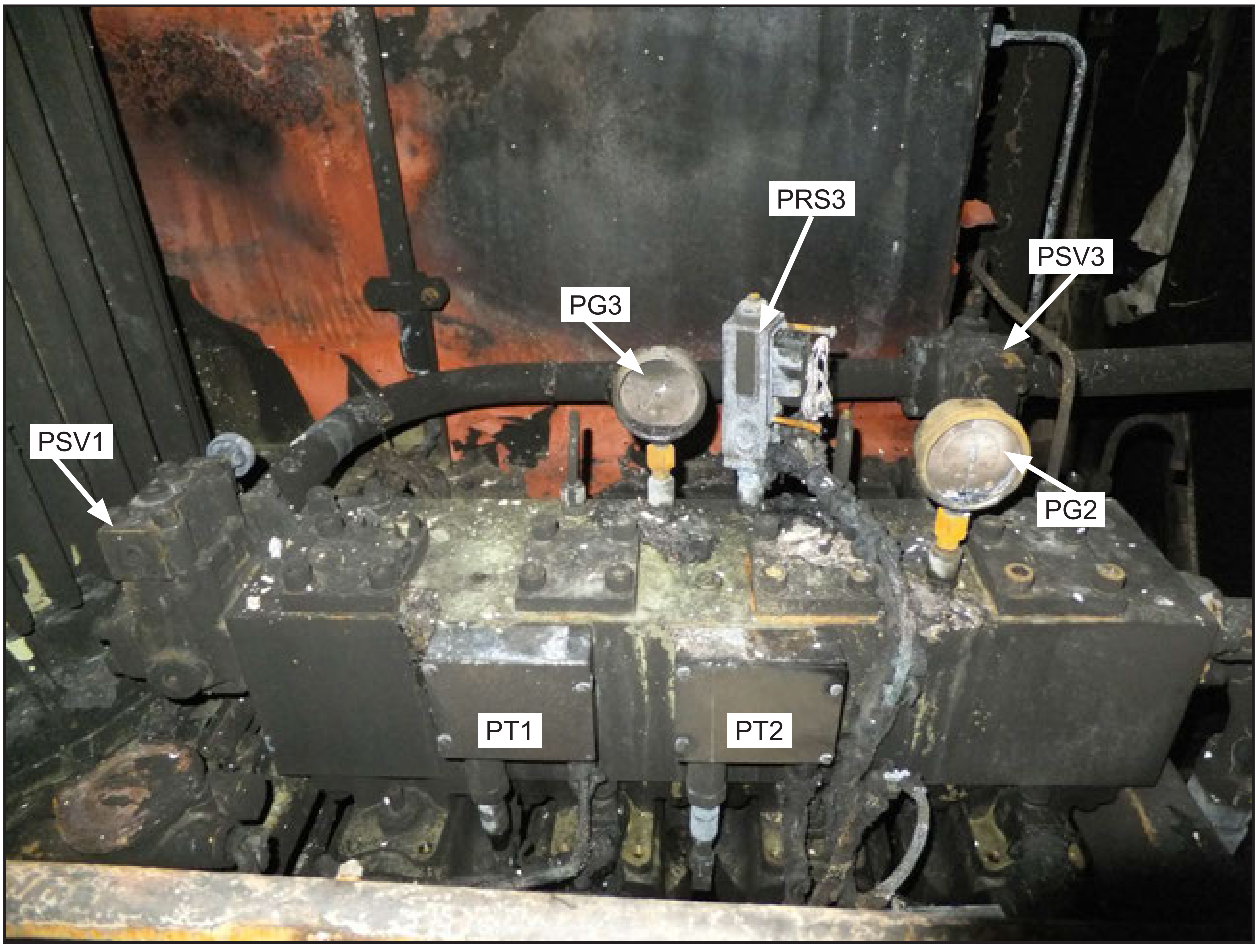

Figure 17: Fire damaged starboard controllable pitch propeller hydraulic module

1.6.3 System pipework

Instructions for pipe runs and specifications were provided on the manufacturer's system drawings. The original drawings for the system stated:

'Hydraulic units will be supplied with SAE 3000PSI flanges and weld fittings'

The flanged joints on the return line from the OD box were not to this standard. The associated drawing data sheet stipulated the supply line pipework to the OD box, satisfying DIN2391, was 42mm outside diameter with 5mm wall thickness. This would equate to a pressure rating of over 240 bar. The return line to the OD box was stipulated to be 48mm outside diameter with 3mm wall thickness. This would broadly equate to a pressure rating of approximately 150 bar.

The pipework joints on the supply line to the OD box, which experienced 100 bar in normal operation, were made using hydraulic couplings and were shielded to prevent a spray of oil in the event of leakage **(Figure 18)**. The return line from the OD box, which normally experienced up to 8 bar, employed flanged joints and, although some of these joints were shielded, not all of them were protected in this way. In particular, the return line joints positioned between the main engine turbochargers were not shielded **(Figure 19)**.

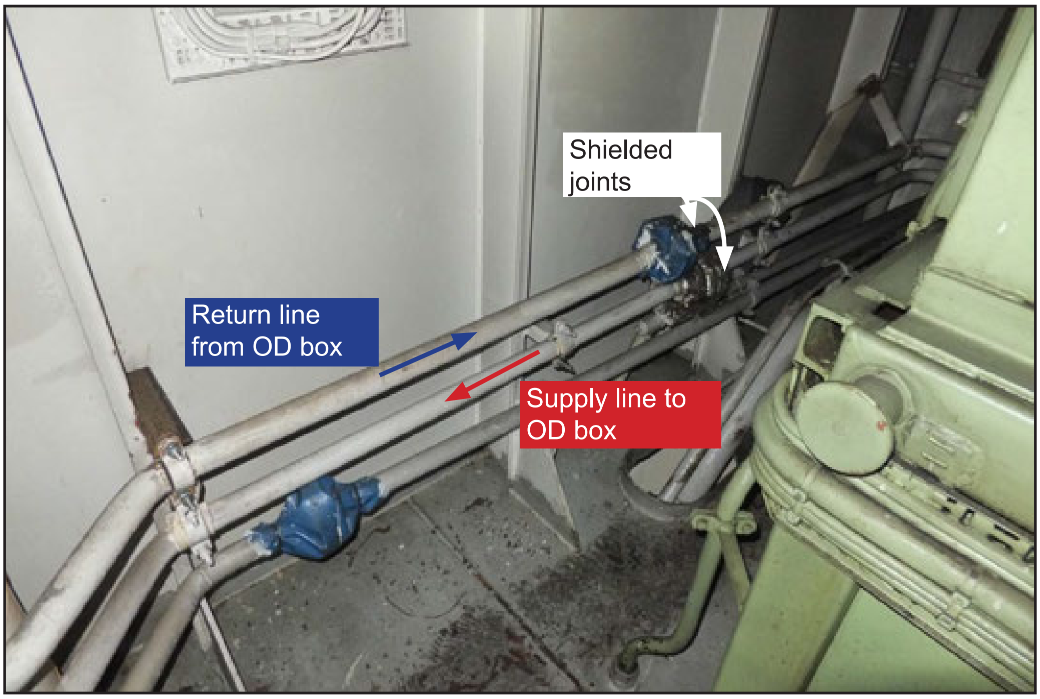

Figure 18: Shielded joints on port controllable pitch propeller system

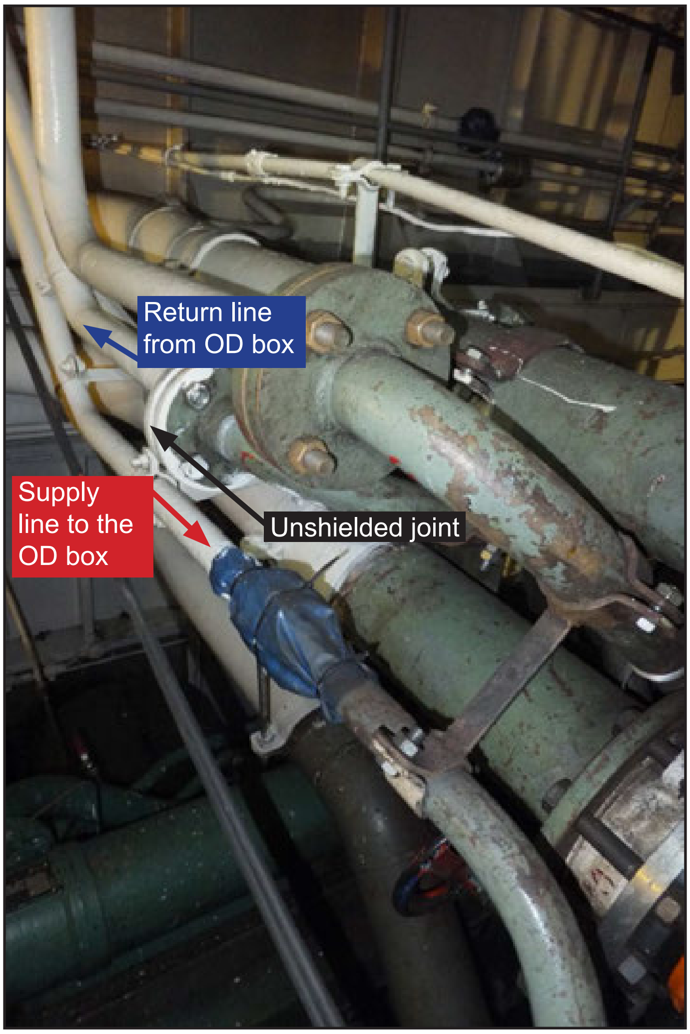

Figure 19: Unshielded joint on port controllable pitch propeller system

1.6.4 Planned maintenance

The propeller and OD box were included in the ship's planned maintenance system. This required their associated flexible hoses to be inspected every 3 months; vibration readings to be taken monthly; and CPP hydraulic oil samples to be sent for testing every 6 months. The last hydraulic oil sample from the starboard CPP system was taken in August 2014. The results of the analysis indicated the oil was normal and suitable for continued use.

1.7 MANUFACTURER'S MAINTENANCE REQUIREMENTS

The CPP system was designed and manufactured by LIPS, which became part of Wartsila in 2002. The manual for the CPP system included maintenance instructions (Annex A). It included a requirement to test the pressure safety valve (PSV1), back pressure valve (PSV3) and pressure switch (PRS3) setting annually. How this was to be conducted was not specified.

1.8 LLOYD'S REGISTER RULES AND REGULATIONS

Pride of Canterbury was constructed and was maintained to Lloyd's Register (LR) Rules and Regulations. The CPP system was approved at the plan approval stage before construction. Although some components of the system had been type-approved by recognised organisations, the CPP system as a whole was not type-approved.

LR Rules and Regulations did not include any specific testing or inspection requirements for the CPP system, apart from a set-to-work test following refits and scheduled surveys. The testing and examination of the CPP system components were expected to be conducted in accordance with the manufacturer's instructions.

LR Rules and Regulations did contain some requirements for CPP alarms and safeguards. These included:

- Hydraulic system low pressure alarm
- Hydraulic oil supply low level alarm
- Hydraulic oil high temperature alarm

1.9 SOLAS FIRE PREVENTION REQUIREMENTS

The extant International Maritime Organization (IMO) Safety of Life at Sea (SOLAS) Chapter II-2/Regulation 4 covers measures to prevent fires in engine rooms from oil and fuel leaks stating, for ships constructed on or after 1 July 2012:

> *'2.2.5.3 …As far as practicable, oil fuel lines shall be arranged far apart from hot surfaces, electrical installations or other sources of ignition and shall be screened or otherwise suitably protected to avoid oil spray or oil leakage onto the source of ignition. The number of joints in such piping systems shall be kept to a minimum.'*

Paragraphs 2.3, arrangements for lubricating oil used in pressure systems, and 2.4, arrangements for other flammable oils employed under pressure, invoke requirement 2.2.5.3, therefore applying the same requirement to these systems and, specifically, the CPP system in this case.

However, by virtue of resolutions MSC[2].31(63) and MSC.201(81), these requirements did not apply to *Pride of Canterbury* due to its date of construction.

In June 2009, the IMO published further guidance (MSC.1/Circ.1321) on guidelines for measures to prevent fires in engine rooms and cargo pump rooms to supplement the SOLAS requirements. This practical guidance included the need for spray shields to be fitted around flanged joints of oil fuel or lubricating oil systems having an internal pressure greater than 1.8 bar **(Annex B)**.

1.10 VOYAGE DATA RECORDER RECOVERY

Pride of Canterbury was fitted with a Danelec Marine voyage data recorder (VDR), which was downloaded and analysed as part of the MAIB investigation. During MAIB's analysis, it was discovered that the VDR had not been configured correctly. For example, the watertight doors indications were incorrectly assigned and propeller shaft revolutions and pitch were for the opposite shaft.

1.11 PRESSURE SAFETY VALVE TESTING

The hydraulic module was returned to the manufacturer for examination, and the back pressure and pressure safety valve were tested and examined by the valve supplier.

The back pressure valve (PSV3), when tested, although intended to release at 6-8 bar, released at much greater pressures, ranging from 20 to 77 bar. When dismantled it was found that the piston was worn, allowing it to tilt and stick sporadically. The valve supplier considered the amount of wear was normal given its 23 years of service. The pressure safety valve (PSV1) was also dismantled and found to be worn, but to a much lesser extent.

1.12 SIMILAR ACCIDENTS

1.12.1 Controllable pitch propeller system failures

In 2000, *P&OSL Aquitaine* suffered a port shaft CPP system failure while entering Calais. The port PTO pump had been damaged, unbeknown to the crew, and was unable to supply adequate pressure to the system. The port CPP locked in its last pitch achieved position, providing ahead propulsion when astern was demanded on the bridge, resulting in the ship colliding with the link span at a speed of 7 knots. The ship and berth sustained damage, and 180 passengers and 29 crew were injured.

In 2010, *Isle of Arran* collided with the linkspan in Kennacraig at a speed of over 8 knots. A mechanical failure in the starboard CPP system resulted in the pitch remaining at full ahead. There were no injuries but both the vessel and linkspan were damaged.

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[2] MSC- Maritime Safety Committee of IMO

Between 2002 and 2011, the MAIB has recorded a further six passenger ship CPP systems failures, most with little consequence.

1.12.2 Passenger ship engine room fires from oil leaks

In 2006, the cruise ship *Calypso* suffered an engine room fire when a low pressure fuel oil pipe flange failed. The lack of an effective guard allowed fuel to spray onto the adjacent turbocharger and/or exhaust piping, causing it to ignite. Extensive fire damage was sustained to the starboard main engine and uptake.

Between 2002 and 2011 the MAIB has recorded a further 36 passenger ship engine room fires caused by oil leaks, several on high-speed craft, but most resulting in minor damage.

SECTION 2 - ANALYSIS

2.1 AIM

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

2.2 CAUSE OF THE FIRE

The fire was initiated following the spray of hydraulic oil, from a ruptured pipework joint in the starboard CPP system, onto the hot exhaust uptakes of the starboard main engines. The flanged joint ruptured because the CPP system became over-pressurised as a result of the back pressure valve (PSV3) becoming jammed in the closed position.

The reason for the temporary increase in the starboard main engine load to 100% and corresponding increase in turbocharger rpm has not been determined. However, the reason is not believed to be related to the cause of the fire.

2.3 CONTROLLABLE PITCH PROPELLER SYSTEM FAILURE

2.3.1 System design

The ruptured flanged joint **(Figure 6)** was in a section of the return line from the OD box to the CPP oil service tank. The back pressure valve (PSV3) was in the same line and was critical to the operation of the CPP system as it maintained the overall system pressure. When this component failed to operate correctly, there were no means within the system to effectively relieve excess pressure. In addition, pressure safety valve (PSV1), which enabled pressure to be dissipated into the return line, was set to operate at 145 bar. This was significantly higher than the pressure at which some parts of the system were able to withstand as built.

It would be prudent for CPP systems not to have a single point of failure as was the case with *Pride of Canterbury*. The provision of an additional means of dissipating excess pressure within the system would have ensured over-pressurisation did not occur.

2.3.2 Pressure safety valve inspection and maintenance

Pressure safety valves, as the name suggests, are a vital ‘safety’ aid to prevent over-pressurisation and, as such, they need to be checked to ensure they continue to function correctly. However, in the case of *Pride of Canterbury* these valves had never been tested or inspected since the ship was constructed 23 years previously.

The LIPS CPP system manual provided some maintenance instructions, including annual testing of pressure safety valve (PSV1) and the back pressure valve (PSV3). However, how this testing was to be achieved was not specified. Testing in situ would not have been possible without modification to the system, so removal of the valves would have been necessary. With a regular 6-monthly oil sampling programme in place, as was the case on *Pride of Canterbury*, the annual removal of the valves and their refitting was deemed an unnecessary measure. However, the oil sampling programme had not identified the wear in the back pressure valve as it had, most likely, occurred gradually over a long period of time.

2.3.3 Pipework joints and shielding

Whereas the main components of *Pride of Canterbury*'s CPP system were supplied after testing by the manufacturer, the interconnecting pipework was supplied and fitted by the shipyard when the vessel was constructed. Although the manufacturer's drawings specified a particular type of joint, whether it should have been used throughout the system was not clear. The builder had employed different joint types, hydraulic couplings and flanged joints, in the supply and return lines to and from the OD box. The reason for this variation is not known, but it had not been a problem during the ship's 23-year life due to the lower pressure at which the return line normally operated. Indeed, the misconception that the return line always operated at 'low pressure' might have resulted in lower standard joints being used instead of hydraulic couplings. Considering the fact that PSV1 could lift at 145 bar, there was always the possibility the return line could experience a pressure of 145 bar.

It has not been possible to determine at what pressure the flanged joint that caused the spray of hydraulic oil failed, but had the joint been a hydraulic coupling rated to cope with the maximum system design pressure it might have held in this instance. Although hydraulic systems will often operate at different pressures within the same system, careful consideration of the pressures that could be experienced in the event of component failure should be made to minimise the possibility of a high pressure leak into a section of the system designed to operate at a lower pressure.

Coupled with maximising the security of a pipework joint is minimising the effect a leak from a failed joint could have. Although SOLAS now requires that, as far as practicable, oil lines should have the minimum of joints, be arranged as far apart from hot surfaces, and be shielded to prevent oil spray onto hot surfaces, these control measures were not required when *Pride of Canterbury* was constructed.

However, the shielding of joints, which is a requirement for ships constructed on or after 1 July 2002, and recommended for other ships in respect of pressurised flammable oil systems, was a relatively easy modification that could have been carried out retrospectively. On board *Pride of Canterbury,* all hydraulic couplings on the supply line to the OD box were shielded, but only some of the flanged joints on the return line from the OD box were protected. Critically, in the zone between the two starboard main engines where the leak occurred, there was no evidence after the fire of shielding on the flanged joints. Given the port side arrangement had no shielding for the same joints **(Figure 19)**, it is concluded unlikely that shielding was ever in place on the starboard side.

Although surveyed and inspected on a regular basis, the omission of shielding from some of the CPP pipework joints had not been acted upon. If an effective joint shield had been fitted, this simple last line of defence would have prevented a spray of oil being released onto the hot exhaust uptakes to cause the fire in this case.

2.3.4 System monitoring

The CPP system had instrumentation and sensors to allow its operation to be monitored in accordance with the requirements of LR Rules and Regulations. A temperature sensor was fitted, which fed back to the ECR and was set to alarm at 69ºC. This provided the initial indication there was something wrong with the CPP system, but alone was not sufficient to diagnose the problem.

In addition to the temperature sensor, analogue pressure gauges were included on the hydraulic module on the supply and return lines to and from the OD box (PG2 and PG3), but these were only readable at the module, located in the engine room. The pressure transducers (PT1 and PT2) that were fitted to the CPP system were set to alarm in the ECR when the pressure dropped below 4 bar, thereby warning of an impending loss of control. However, a high pressure alarm was neither fitted nor required by LR Rules and Regulations.

A high pressure alarm was a critical missing safety feature in this accident. If the chief engineer in the ECR had been made immediately aware that there was high pressure in the starboard CPP system, he could have taken steps to reduce it. Instead, his action in starting the stand-by pump, although well intended, might have increased the pressure.

Even if an alternative pressure relief mechanism was included in the CPP system, the inclusion of a high pressure alarm would be a prudent and simple means of providing a warning of impending over-pressurisation and so enable preventative action to be taken at an early stage.

2.4 FIRE-FIGHTING

The hi-fog system fitted on *Pride of Canterbury* was highly effective in fighting the resulting fire following the hydraulic oil leak. Critically, it enabled the chief engineer to keep the port main engines running, allowing the master to bring the ship alongside in a controlled and safe manner. The CCTV screen in the ECR that showed the view from the bridge enabled the chief engineer to gain an instant appreciation of the ship's position and to act accordingly.

An alternative and normally preferred option to fight the fire would have been to close down the engine room and flood it with carbon dioxide using the fixed fire-extinguishing system, but this would have resulted in the ship losing all propulsion. Given the ship's close proximity to the quay and other ferries within Calais Harbour, this alternative option was undesirable. The decision to use the hi-fog system was therefore reasonable in the circumstances.

Once alongside, the chief engineer looked through the engine room watertight door by partially opening it. Following his assessment of the situation he decided to send in the first BA team to tackle the fire using a fire hose. Again, with the ship alongside, the fixed fire-fighting system could have been used. However, the hi-fog had contained the fire, enabling the residual flames around the periphery to be tackled easily. The decision not to use the fixed fire-fighting system was therefore again reasonable.

The first BA team consisted of two duty engine room staff as the chief engineer believed they were better positioned to deal with the fire given their familiarity with the engine room. The chief engineer also instructed that each of the subsequent BA teams contained at least one member from his engine room team. While not in accordance with the duty muster list, these actions enabled a potentially quicker and more effective response than would otherwise have been the case.

While the hi-fog was able to tackle the fire in the immediate vicinity of the two main diesel engines, the fire was able to spread outside of this area. This was not helped by combustible materials, including wooden packaging, that were located near the source of the fire **(Figure 11)**. Identifying suitable storage areas for spare parts can be a problem on board ships, but having spares and their packaging in a machinery space must be avoided to minimise the amount of combustible material and so reduce the risk of fire spread.

2.5 BRIDGE EMERGENCY RESPONSE

As *Pride of Canterbury* approached Calais, the normal arrival routine had been completed, including a CPP pitch control check. Unbeknown to the crew, the build-up of pressure in the starboard CPP system had led to the pressure equalising on both sides of the propeller hub, thereby locking the propeller pitch at the last demanded setting. The benefits of completing a propeller pitch check before entering port were clear to see from this accident, as the master was quickly able to declutch the starboard main engines and prevent similar accidents to those previously, including *P&OSL Aquitaine* and *Isle of Arran.*

By the time the CPP control check was complete, *Pride of Canterbury* was in the approach channel to Calais and the master decided that, given the relatively benign weather conditions and the simple berthing manoeuvre required in Calais, it was safer to proceed with one propeller and one bow thruster rather than anchor in the fairway. He briefed the bridge team of his intentions and, as a precaution, requested tug assistance. His decision to proceed was reasonable given the weather conditions, his familiarity with the ship and the port.

Once the general alarm was raised, the ship's crew followed their onboard procedures, mustering initially at their emergency muster stations. At the same time, the passengers were informed of what was happening. The master, following communication with the chief engineer, determined the safest option was to bring the ship alongside swiftly to enable an in-port evacuation if necessary. Given the options presented to the master this was an effective way of evacuating his ship quickly and safely.

The swift and timely response of the crew can be credited to their training and to the regular emergency drills held on board *Pride of Canterbury*. While the emergency did not follow any one set procedure, the drills enabled good team working and ultimately led to a successful outcome with no injuries to passengers or crew.

2.6 VOYAGE DATA RECORDER CONFIGURATION

While not contributing to the accident, the poorly configured VDR hampered the MAIB investigation. During commissioning, it is essential that adequate checks are made of the various feeds into a VDR to ensure they are configured correctly. A VDR is an important tool in establishing what happened following an accident and, if configured incorrectly, will provide misleading and erroneous information.

SECTION 3 - CONCLUSIONS

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

1. There were no effective means for the CPP hydraulic system to relieve excess pressure in the event that the back pressure valve failed. [2.3.1]

2. The pressure safety valve (PSV1) and back pressure valve (PSV3) had never been functionally tested or inspected since the ship was constructed 23 years previously. [2.3.2]

3. Although the manufacturer's instructions specified annual testing of the pressure safety valve and back pressure valve, how it was to be achieved was not specified. [2.3.2]

4. A programme of oil sampling had not identified wear in the back pressure valve. [2.3.2]

5. Differing joint types were employed in the supply and return lines to and from the OD box, possibly as a result of the misconception that the return line would always operate at a lower pressure. Original system drawings were not clear as to what joint types should be used. Consequently the system was unable to withstand the same level of pressure throughout. [2.3.3]

6. If an effective joint shield had been fitted to the flanged joint that ruptured, this would have prevented a spray of oil being released to cause the fire. [2.3.3]

7. The lack of a high pressure alarm in the ECR prevented the chief engineer from being immediately aware that there was high pressure in the starboard CPP system. [2.3.4]

8. Lloyd's Register Rules and Regulations do not include a requirement for a high pressure alarm in CPP systems. [2.3.4]

9. While the hi-fog system was able to tackle the fire in the immediate vicinity of the two main diesel engines, the fire was able to spread outside of this area. This was not helped by combustible materials, including wooden packaging, that were located near the source of the fire. [2.4]

3.2 OTHER SAFETY ISSUES DIRECTLY CONTRIBUTING TO THE ACCIDENT

1. Although the shielding of joints in pressurised flammable oil piping systems is currently recommended for ships constructed before 1 July 2012, there is no requirement in SOLAS to do so. [2.3.3]

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

1. During commissioning, it is essential that adequate checks are made of the various feeds into a VDR to ensure they are configured correctly. [2.6]

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

SECTION 4 - ACTION TAKEN

4.1 P&O FERRIES

P&O Ferries has:

On 13 October 2014, instructed all chief engineers in the fleet to complete a target audit of machinery space fire safety and implement any necessary actions. The scope included:

- Identify all areas of increased risk with regard to oil systems adjacent to hot surfaces.
- Identify all connections, flanges that if they were to fail would cause oil to leak.
- Ensure category A machinery spaces are free of all combustible materials, e.g. pallets.

On 5 December 2014, following investigation, instructed the following actions:

For *Pride of Canterbury* and its sister ships:

- Replaced PSV1 and PSV3 on all CPP hydraulic modules.
- Implemented a maintenance programme in which at least PSV1, PSV3 and NRV6 are disabled and their function checked once every 5 years.
- Added a full flow check-valve, with an opening pressure of 10-12 bar, in the return oil circuit by-passing PSV3, the Oil Cooler and NRV6. Also, an additional alarm signal was to be fitted in the control system to give an alarm at 9-10 bar.

For all ships in its fleet:

- Checked that all CPP system flanges meet standards recommended by manufacturers.
- Checked all CPP system flanges are fitted with protective coverings.
- Examined hi-fog systems to ensure that the system provides full coverage of all high-risk machinery.

4.2 WARTSILA

Wartsila has issued a Technical Bulletin **(Annex C)** instructing operators to replace back pressure valves at least every 15 years.

SECTION 5 - RECOMMENDATIONS

Lloyd's Register is recommended to propose to IACS that:

2015/153 A unified requirement regarding controllable pitch propeller alarm and safeguards is developed, that includes a hydraulic system high pressure alarm, in addition to the low pressure, high temperature and low supply tank level alarms already required under Lloyd's Register Rules and Regulations.

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

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