

Report on the investigation of
a fire on board the RoPax ferry

Dieppe Seaways

on the approach to, and subsequently alongside,
the port of Dover, UK
on 1 May 2014



Extract from
The United Kingdom Merchant Shipping
(Accident Reporting and Investigation)
Regulations 2012 – Regulation 5:

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NOTE

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For all enquiries:

Marine Accident Investigation Branch
Spring Place
105 Commercial Road
Southampton
United Kingdom
SO15 1GH

Email: maib@dft.gsi.gov.uk
Telephone: +44 (0) 23 8039 5500
Fax: +44 (0) 23 8023 2459

Press enquiries during office hours: 020 7944 4166 / 3176

Press enquiries out of hours: 020 7944 4292

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- Annex A** - Centre Technique des Industries Mécaniques - Coil Material Analysis Report – CET0114426/01/a dated 8 September 2014
- Annex B** - SeaTec UK Limited - Vibration Analysis Report – dated 24 October 2014

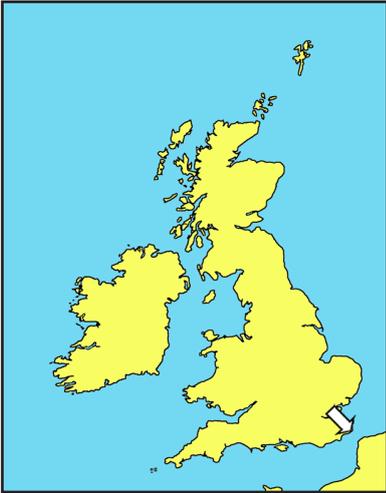
GLOSSARY OF ABBREVIATIONS AND ACRONYMS

BA	-	Breathing Apparatus
C	-	Celsius
CCTV	-	Closed Circuit Television
CETIM	-	Centre Technique des Industries Mécaniques
cm	-	centimetre
CO ₂	-	Carbon Dioxide
COBRA	-	Combined water-jet cutting and fog nozzle fire-fighting equipment
CoC	-	Certificate of Competency
DFDS A/S	-	Det Forenede Dampskibs-Selskab Aktieselskab
DNV GL	-	Det Norske Veritas Germanischer Lloyd
FCP	-	Forward Control Point
FRS	-	Fire and Rescue Service
HFO	-	Heavy Fuel Oil
KFRS	-	Kent Fire and Rescue Service
kg	-	Kilogramme
MCA	-	Maritime and Coastguard Agency
MCR	-	Machinery Control Room
MGN	-	Marine Guidance Note
MGO	-	Marine Gas Oil
MIRG	-	Marine Incident Response Group
mm	-	millimetre
OEM	-	Original Equipment Manufacturer
OIC	-	Officer in Command
OOW	-	Officer of the Watch
PPE	-	Personal Protective Equipment
PWT	-	Prozess-Wärmeträgertechnik GmbH

- RoPax - Roll on Roll off passenger ferry
- s - second
- SOLAS - International Convention for the Safety of Life at Sea 1974, as amended
- STCW - International Convention on Standards of Training, Certification and Watchkeeping for Seafarers 1978, as amended
- UTC - Universal Co-ordinated Time

TIMES: All times used in this report are UTC

SYNOPSIS



On 1 May 2014, the roll on roll off passenger ferry *Dieppe Seaways* was approaching the Eastern Ferry Terminal at the port of Dover when an uncontrolled fire broke out in the furnace of the port thermal oil heater.

Ship's staff attempted to extinguish the fire using methods based on experience from a similar incident that had occurred on the same unit in 2009. However, on this occasion the burner unit opened as a result of the fire and this allowed the fire to develop beyond the furnace; a fact not recognised by the crew.

The vessel was met by a team from Kent Fire and Rescue Service on arrival at the berth. Liaison between the team and ship's staff, and the subsequent control of fire-fighting, were incomplete and not fully co-ordinated. An initial entry into the port boiler room was attempted, which resulted in a backdraught with an accompanying fireball that caused a number of casualties and necessitated the shutdown of the compartment.

A strategy of containment, cooling and boundary monitoring was then initiated until it was deemed safe to re-enter the compartment some hours later.

The investigation has identified that a crack in the thermal oil heater coil allowed thermal oil to enter the furnace, resulting in an uncontrolled furnace fire. It is concluded that the coil failed as a result of stress caused by the weld securing the refractory insulation support plate.

Recommendations have been made to: the thermal oil heater manufacturer, Prozess-Wärmeträgertechnik GmbH, to investigate alternative methods of securing the refractory insulation plate; the ship's classification society, Det Norske Veritas Germanischer Lloyd, to provide additional guidance to its surveyors with regard to examining thermal oil heaters; Kent Fire and Rescue Service in respect of shipboard training and procedures; and, both Det Norske Veritas Germanischer Lloyd and the management company, DFDS A/S, to review the suitability of dry powder as a fixed fire-extinguishing medium for use in thermal oil heater furnaces.

SECTION 1 - FACTUAL INFORMATION

1.1 PARTICULARS OF *DIEPPE SEAWAYS* AND ACCIDENT

SHIP PARTICULARS	
Vessel's name	<i>Dieppe Seaways</i>
Flag	France
Classification society	DNV GL (since 2007)
IMO number	9211511
Type	RoPax
Registered owner	Stena Line North Sea Ltd
Manager(s)	DFDS A/S
Construction	Steel
Year of build	2002
Length overall	203.9m
Registered length	187.164m
Gross tonnage	30,551
Minimum safe manning	49
Authorised cargo	1,200 passengers, 110 lorries
VOYAGE PARTICULARS	
Port of departure	Calais, France
Port of arrival	Dover, UK
Type of voyage	Short international
Cargo information	Cars, lorries and passengers
Manning	65
MARINE CASUALTY INFORMATION	
Date and time	1 May 2014, 1231
Type of marine casualty or incident	Less Serious Marine Casualty
Location of incident	Port boiler room
Place on board	7 to 9 deck, port side
Injuries/fatalities	Serious injuries to one KFRS firefighter and two crew members
Damage/environmental impact	Equipment damage to the ship
Ship operation	On passage
Voyage segment	Mid-water/arrival
External & internal environment	Daylight, fine weather conditions
Persons on board	315 passengers, 65 crew, 6 contractors

1.2 BACKGROUND

Dieppe Seaways (**Figure 1**) operated a regular ferry service between Calais and Dover carrying passengers and vehicles. The schedule comprised five crossings per day except on Sundays, when this was reduced to four crossings to allow time for bunkering, maintenance and crew training.

1.3 NARRATIVE

1.3.1 Departure from Calais

On 1 May 2014, *Dieppe Seaways* embarked vehicles and passengers at the port of Calais in preparation for a scheduled crossing to Dover departing at 1130. During the preparations for departure, a flame failure in the port thermal oil heater caused an alarm to activate and the burner unit to automatically shut down. The alarm was investigated by the on-watch engine room rating and was reset locally at the heater control panel. The heater then functioned normally, and the ship departed on schedule from Calais.

1.3.2 The fire

At 1231, when *Dieppe Seaways* had reached a position approximately 3 nautical miles from Dover, an alarm sounded on the ship's fire detection system. The alarm source was identified as a smoke detector on deck 9 in the port boiler room (**Figure 2**). The master instructed a deck rating to proceed to the port boiler room to investigate the cause of the alarm. On arrival, the rating noted a light smoke haze in the compartment, but that there was no sign of fire and no indication where the smoke was coming from. He reported this to the master, who then instructed the bridge officer of the watch (OOW) to contact the machinery control room (MCR) and to direct the engine room OOW to investigate further.

The fourth engineer, who was the engine room OOW, sent the duty motorman to the port boiler room. He then contacted the chief engineer, second engineer and third engineer, who were taking coffee in a rest room adjacent to the MCR. They then proceeded to the port boiler room to investigate. The fourth engineer remained in the MCR. He set the closed circuit television (CCTV) monitor to show the camera view of the port thermal oil heater burner unit, and saw a pulse of smoke emanate from the jointing surfaces at the top of the furnace, which continued to pulse smoke at intervals of 2 to 3 minutes.

1.3.3 Initial fire-fighting actions

At 1236, boiler room ventilation was stopped from the bridge, and the ship's fire teams were instructed to don fire-fighting outfits. Dover Port Control was informed of the fire and the master requested priority entry to the port.

The chief engineer gave directions for the port thermal oil heater to be shut down at the local control panel, and for burner fuel and air supplies to be isolated. He then instructed the second engineer and engineer cadet to open the thermal oil supply by-pass valve, and to close the port thermal oil heater coil inlet and outlet valves. The valves were situated outside the port boiler room on deck 7. The chief engineer then advised the master that there was an uncontrolled fire in the port thermal oil heater furnace, which had probably been caused by a coil failure that had allowed thermal oil to pass into the furnace.

Image courtesy of Fotoflite



Figure 1: Dieppe Seaways

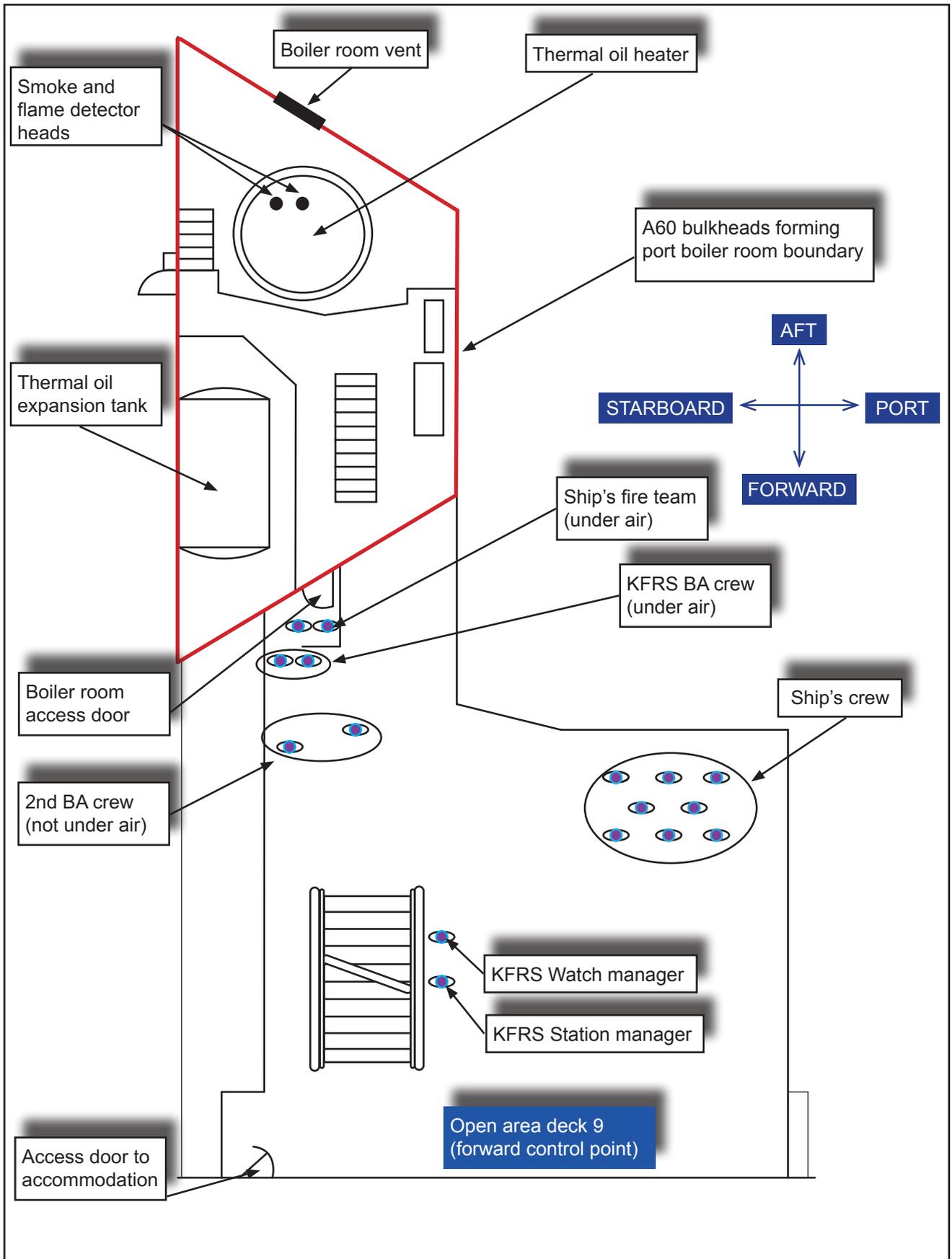


Figure 2: Diagram showing location of port boiler room and port thermal oil heater

At 1240, the master again contacted Dover Port Control and requested that the local fire and rescue service (FRS) meet the ship on its arrival alongside. He then made a public address announcement to passengers and crew informing them that the ship's crew were dealing with a minor incident. Following this announcement, the master informed the management company, DFDS A/S, of the situation.

The smoke in the port boiler room was now considered too dense for personnel to safely remain in the space. Consequently, the engineering team exited the compartment, but remained outside on deck 9 adjacent to the port boiler room. The entrance door was left open to allow the smoke to vent. Meanwhile, the fourth engineer witnessed on the CCTV monitor more frequent and larger volumes of smoke emanating from the jointing surfaces at the top of the furnace. He then saw the burner unit lift and remain open, allowing heat and smoke from the furnace to continuously enter the port boiler room. This was also noticed by the chief engineer, who re-entered the compartment and closed the burner unit. However, owing to the density of the smoke he was unable to remain in the space for long and it is uncertain whether or not he properly secured the burner unit latching mechanism (**Figures 3a** and **3b**). Shortly after the chief engineer had exited the compartment, the fourth engineer again witnessed the burner unit lift and remain open. Soon after this, the CCTV images from inside the port boiler room were lost due to a build-up of smoke in the compartment.

The chief engineer became concerned that the thermal oil pressure in the heater coil would rise to an unacceptable level due to thermal expansion as a result of the heat of the fire. In the absence of a pressure gauge outside the boiler room to monitor the pressure, he instructed the second engineer to open the heater coil outlet valve for 30 seconds every 2 to 3 minutes. At approximately 1257, he sent the engine room fire team into the port boiler room to read the local pressure gauge. The team returned and reported a pressure of 9 bar¹ on the gauge, and that the compartment was heavily smoke-logged but that there was no sign of flames. At around this time, the port boiler room entrance door was closed. Approximately 10 minutes later, the chief engineer sent the engine room fire team back into the port boiler room to recheck the heater coil pressure and to attempt to manually operate the heater coil pressure relief valve. By this time, conditions had deteriorated within the compartment, and they were unable to complete either task.

At 1308, a 15 kilogramme (kg) dry powder fixed fire-extinguishing system for the port thermal oil heater furnace was activated on the chief engineer's instruction.

At 1321, *Dieppe Seaways* berthed alongside in Dover. The master requested that the FRS remain on the jetty until all passengers had disembarked.

Ship's staff attempted to monitor the boundary temperatures around the port boiler room using a thermal imaging device. The furnace temperature was also monitored using the remote exhaust temperature readout located on deck 7 adjacent to the coil isolating valves and fixed fire-extinguishing control point.

1.3.4 Backdraught

At 1330, the first of the Kent Fire and Rescue Service (KFRS) firefighters, a watch manager, arrived on board and was escorted to deck 9 where he liaised with the chief engineer.

¹ System pressure relief valve was set to operate at 10 bar.



Figure 3a: Photograph showing burner unit latching mechanism (open)



Figure 3b: Photograph showing burner unit latching mechanism (closed)

The Forward Control Point (FCP) for the incident was established outside on deck 9, adjacent to the port boiler room (**Figure 4**). The KFRS watch manager assumed the role of Officer in Command (OIC) for KFRS². It appeared to him that the chief engineer was controlling the fire-fighting effort with support from both the chief officer and second engineer. Actions that had already been carried out were discussed, and the KFRS watch manager was taken to the starboard boiler room to gain an appreciation of the layout of the port boiler room (the two spaces had a similar layout) and of the hazards within that space. From this discussion, the KFRS watch manager understood that the fire was restricted to the port thermal oil heater furnace.



Figure 4: Photograph of forward control point location on deck 9

Monitoring of the port thermal oil heater furnace exhaust temperature showed that between 1325 and 1341 it had risen from 280°C to 340°C.

At about 1350, the master ordered the chief engineer to drain the thermal oil expansion tanks in both boiler rooms to remove the potential for the thermal oil in the tanks to fuel the fire. At this point, the ventilation shutdown was extended to the main fire zone. Dense smoke was seen emitting from the port boiler room natural exhaust vent, the fire flap for which had been remotely operated but still allowed some smoke to pass.

² The FRS Incident Command Structure (ICS) ensures that an officer with suitable training and competence is on site to exercise authority over fire service resources at an incident. The level of command will change to meet the requirements of an escalating situation.

During this period, a KFRS station manager had arrived on board. He had been involved in the inspection of the starboard boiler room and, once briefed by the KFRS watch manager, had taken control as the OIC. He reviewed and confirmed the watch manager's decision to make an entry of the port boiler room using a combined team of two ship's crew supported by two KFRS firefighters. The plan was for the ship's crew to open the entrance door, which was secured shut and needed to be unlocked by means of a mechanical keypad. They would then enter the port boiler room, backed up by the two KFRS firefighters carrying a charged fire hose and a portable dry powder extinguisher. The ship's crew would operate the heater coil pressure relief valve, and the KFRS firefighters would inject dry powder directly into the furnace. Once the entry on deck 9 had been successfully completed, the deck fire team, under the direction of the chief officer, would open the lower compartment door on deck 7 to aid ventilation of the compartment.

At this point, the watch manager was controlling the KFRS firefighters (under the authority of the OIC), with the chief engineer directing the ship's crew. The master was aware of and had approved the entry, but he was content that direct control of the incident was being managed locally from the FCP. At 1415, a KFRS group manager arrived on the jetty and assumed the role of OIC, taking overall responsibility for KFRS fire-fighting actions. The station manager reverted to the on-scene operations commander located at the FCP. The group manager had been briefed about the actions already completed, and approved the entry plan. It remained the understanding of the KFRS firefighters that the fire was restricted to the port thermal oil heater furnace.

As the KFRS command handover was taking place, the two ship's crew took position by the port boiler room entrance door while the two KFRS firefighters continued their preparations; they successfully tested the charged fire hose but the ship-supplied portable dry powder extinguisher would not shut off after activation. The watch manager called for some KFRS portable dry powder extinguishers to be provided, and was in the process of removing their anti-tamper seals when the port boiler room entrance door was opened by the ship's crew.

The opening of the port boiler room access door resulted in an unexpected fireball, which swept across deck 9 with considerable force, knocking a number of personnel to the deck. The boiler room door was then closed and all personnel in the vicinity entered the accommodation on deck 9. First-aid treatment for burns was administered on board the ship while ambulances, including an air ambulance, were called to the jetty. All injured personnel were initially treated on board, and those in need of further medical support were then transferred to local hospitals.

At 1420, all ship's crew who were not involved in fire-fighting were mustered and accounted for. The master then called 'Code Red', which indicated to the crew that there was a fire that required them to proceed to emergency stations. At the same time, the fourth engineer manually operated the hi-fog fixed fire-extinguishing system covering the port thermal oil heater burner unit, and the ship's crew commenced boundary cooling on decks 7 to 9.

1.3.5 Containment and subsequent fire-fighting actions

Immediately after the backdraught, an experienced Marine Incident Response Group (MIRG) KFRS station manager deployed to the bridge to liaise directly with the master. The priority became to contain the fire within the port boiler room

through boundary cooling and temperature monitoring, while continuing with attempts to extinguish the fire using the compartment's fixed fire-extinguishing systems. The compartment boundaries were 'Class A-60 divisions'³. This structural fire protection made it very difficult to accurately establish the internal compartment temperatures⁴. However, coupled with the boundary cooling, it successfully prevented the fire from spreading.

Following further discussions between ship's crew and KFRS firefighters, it was decided to inject foam directly into the port thermal oil heater furnace using the dry powder fixed fire-extinguishing system pipework. This took more than 3 hours to achieve due to delays in planning and approval, a KFRS firefighter shift change, and blockages in the pipework caused by residual dry powder. KFRS also deployed its combined water-jet cutting and fog nozzle fire-fighting equipment (COBRA) to assist in cooling the port boiler room.

The COBRA was operated in conjunction with the ship's hi-fog fixed fire-extinguishing system for approximately 1½ hours. The KFRS OIC then proposed making a re-entry of the port boiler room. Boundary temperatures had been monitored throughout the containment phase and, at 2115, the master concurred with the KFRS OIC that it was safe to conduct a further entry of the space.

KFRS firefighters entered the port boiler room. On their return they reported that the area was clear of smoke and that the hi-fog fixed fire-extinguishing system was still in operation. Shortly after this, they made another entry and reported the same findings. The hi-fog fixed fire-extinguishing system was then stopped and KFRS deemed the space to be safe for personnel dressed in fire-fighting suits to enter. A section of furnace insulation was removed to facilitate external temperature monitoring of the furnace. Some 2 hours later, a rise in furnace temperature was noted that initially raised concerns about possible re-ignition. On further investigation, the rise in temperature was deemed to be the result of an incorrect temperature reading by the boundary monitor.

At 0051, more than 12 hours after the initial smoke detector had operated, the fire was confirmed as being extinguished. Temperature monitoring of the furnace then continued throughout the night.

1.4 CONSEQUENCES OF THE FIRE

As a consequence of the fire, six ship's crew and four KFRS firefighters suffered burn injuries, three of which were serious. All of the injuries resulted from the backdraught. The injured personnel had all been located in the vicinity of the FCP on deck 9.

There was mechanical damage throughout the port boiler room. This included fire-damaged electrical cables on lighting and monitoring circuits, significant damage to the heater control panel and the burner unit (**Figures 5a** and **5b**), and numerous melted light fittings. There was significant smoke damage within the space that resulted in the need to replace much of the A-60 insulation in the upper areas of the compartment.

³ Regulation 3 of SOLAS Chapter II-2 Part A requires the temperature on the unexposed side of a 'Class A division' to rise no higher than 140°C above the original compartment temperature within 60 minutes.

⁴ Some vessels have dedicated monitoring points with small sections of insulation (typically 100mm X 100mm) removed to facilitate accurate temperature measurement.



Figure 5a: Fire damage to thermal heater control panel

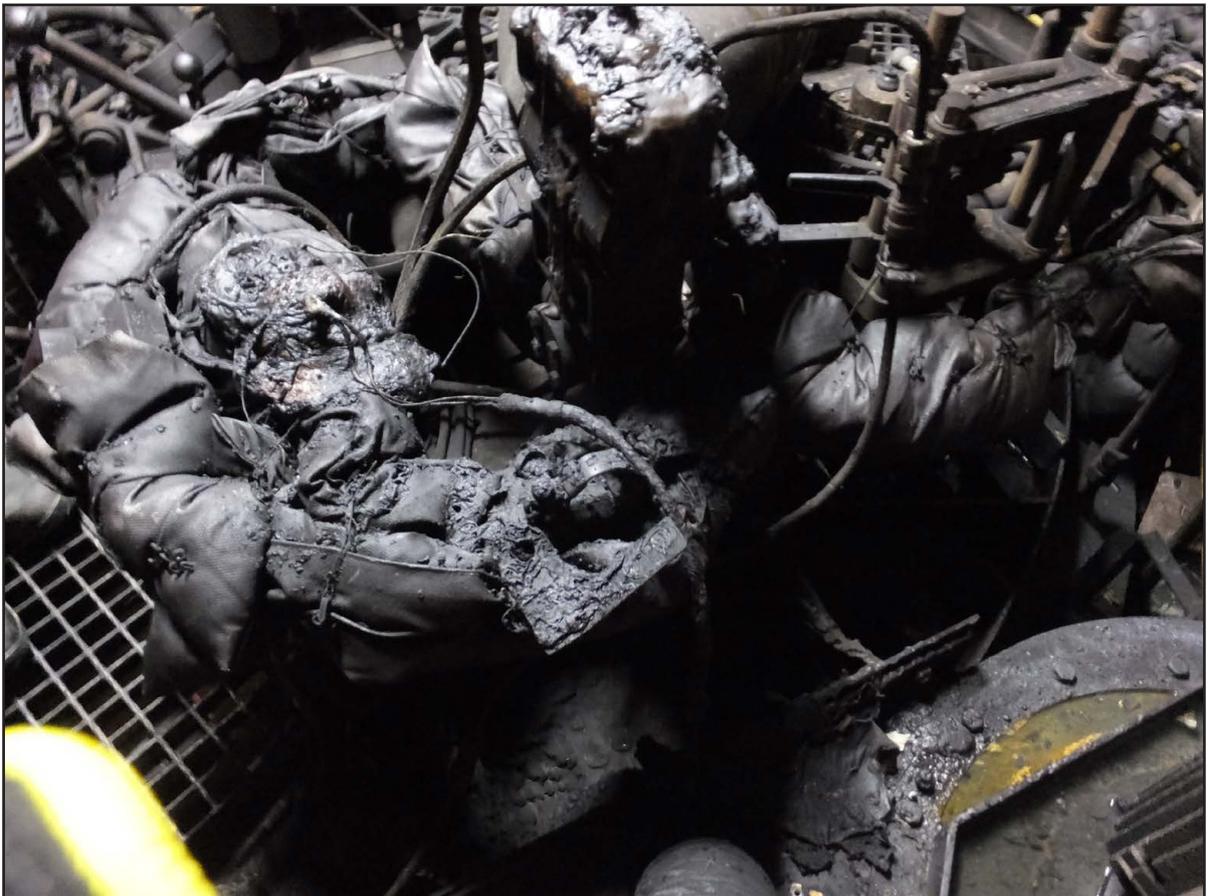


Figure 5b: Fire damage to burner unit

The port thermal heater coil was found to have failed at the top of the furnace, resulting in fire damage to the refractory insulation and its supporting structure within the furnace.

1.5 THERMAL OIL HEATING SYSTEM

Dieppe Seaways was one of a class of four ships built with the same type of thermal oil heating system installation. A further two ships were also built with similar systems; however, their installations differed considerably.

Dieppe Seaways utilised heavy fuel oil (HFO) as its normal fuel source for both main propulsion plant and auxiliary generators, changing to marine gas oil (MGO) when the ship was expected to remain in port for extended periods. The HFO was heated to operating temperature through the use of the thermal oil heating system.

The thermal oil heating system on *Dieppe Seaways* was manufactured by Prozess-Wärmeträgertechnik GmbH (PWT) and comprised four exhaust gas economisers and two oil-fired heaters with a common thermal oil circulation system. The thermal oil had an open cup flash point of 222°C, a fire point of 249°C and a spontaneous ignition temperature of 420°C.

In normal operation, the economisers provided indirect heat to the thermal oil, with the oil-fired heaters in automatic mode set to activate if reduced engine loading caused the exhaust gas temperature to drop below a pre-determined level. *Dieppe Seaways'* short sea trading pattern resulted in the oil-fired boilers operating intermittently during each of the ship's port visits.

The oil-fired thermal heaters were PWT DW III thermal transfer heaters. These were fitted with a roof mounted burner unit that could be operated using either HFO or MGO (**Figure 6**).

The units were originally supplied with a fire cement type refractory protecting the roof of the furnace and the uppermost section of the thermal oil coil (**Figure 7**). At some point in the vessel's history, the coil refractory had been replaced with a ceramic matting type of insulation with the refractory being retained in way of the furnace roof. This is likely to have been carried out as a result of damage to the original refractory.

The burner unit comprised a rotary cup nozzle assembly with a linking orifice to a forced draught fan. There was an integral electric motor driving the rotary cup. The unit was located on top of the heater and was hinged to allow access to the nozzle assembly for maintenance. The burner unit securing device consisted of a moving pawl and locking lever (**Figures 3a and 3b**).

The securing device was found to have significant wear, with excess play in the bushes and on the nose of the clip.

Fuel from a storage tank was pumped to the inlet of the burner unit fuel pump. This pump then boosted the fuel pressure and circulated it to the burner unit, returning through the regulating valve to the suction side of the pump.

Combustion air was ducted from the forced draught fan to the side of the burner unit and flowed, via a modulating damper, around the rotary cup and into the furnace.

In the days preceding the fire, there had been several flame failures on the port thermal oil heater that had been remedied by resetting the unit at the local control panel within the port boiler room on deck 9.

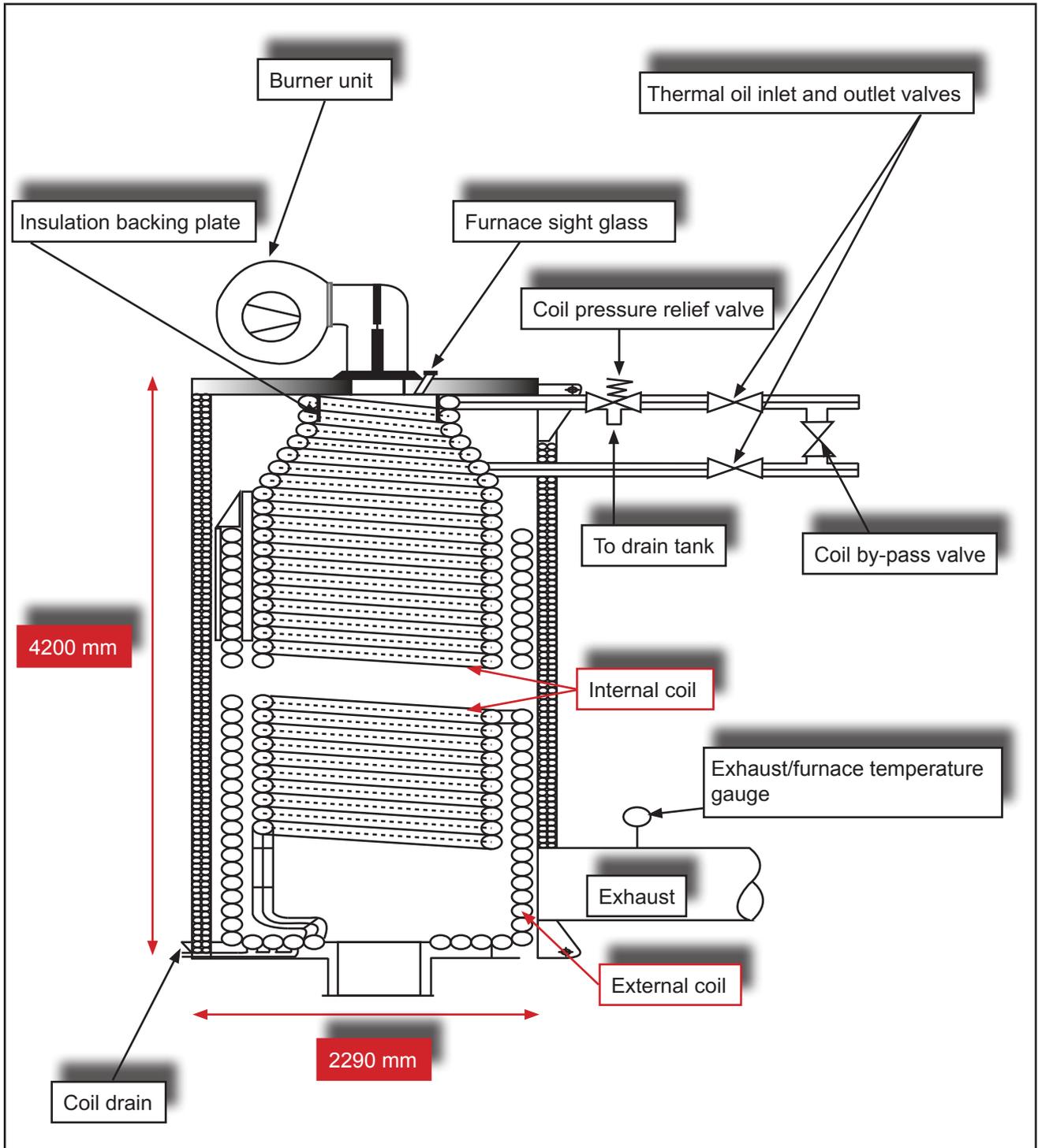


Figure 6: Diagram of the port thermal oil heater

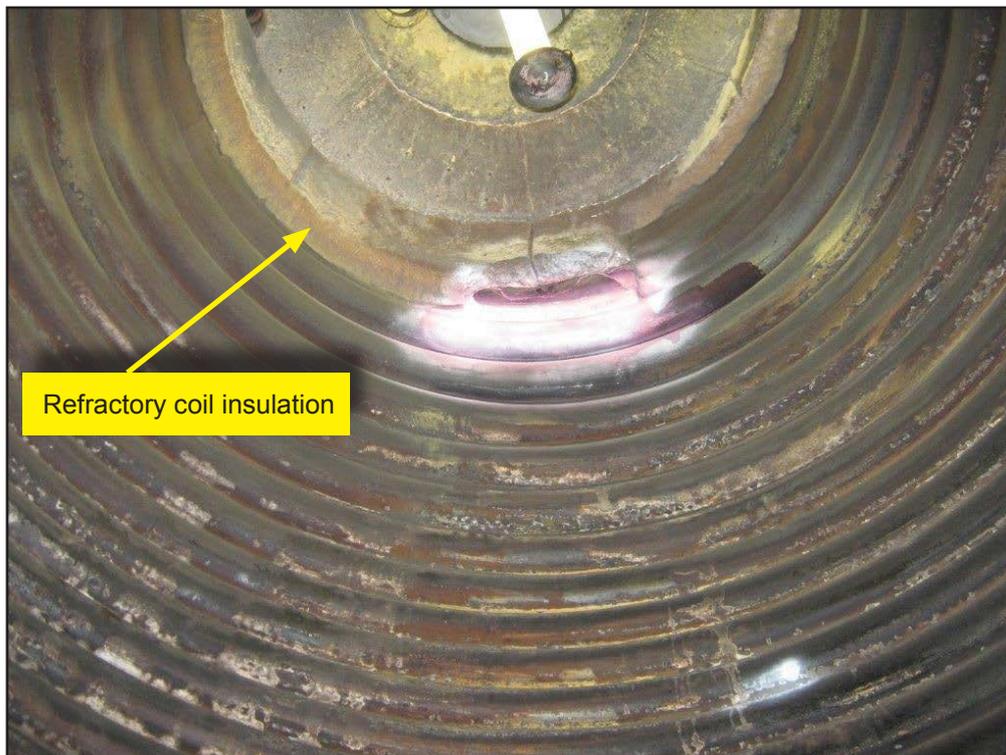


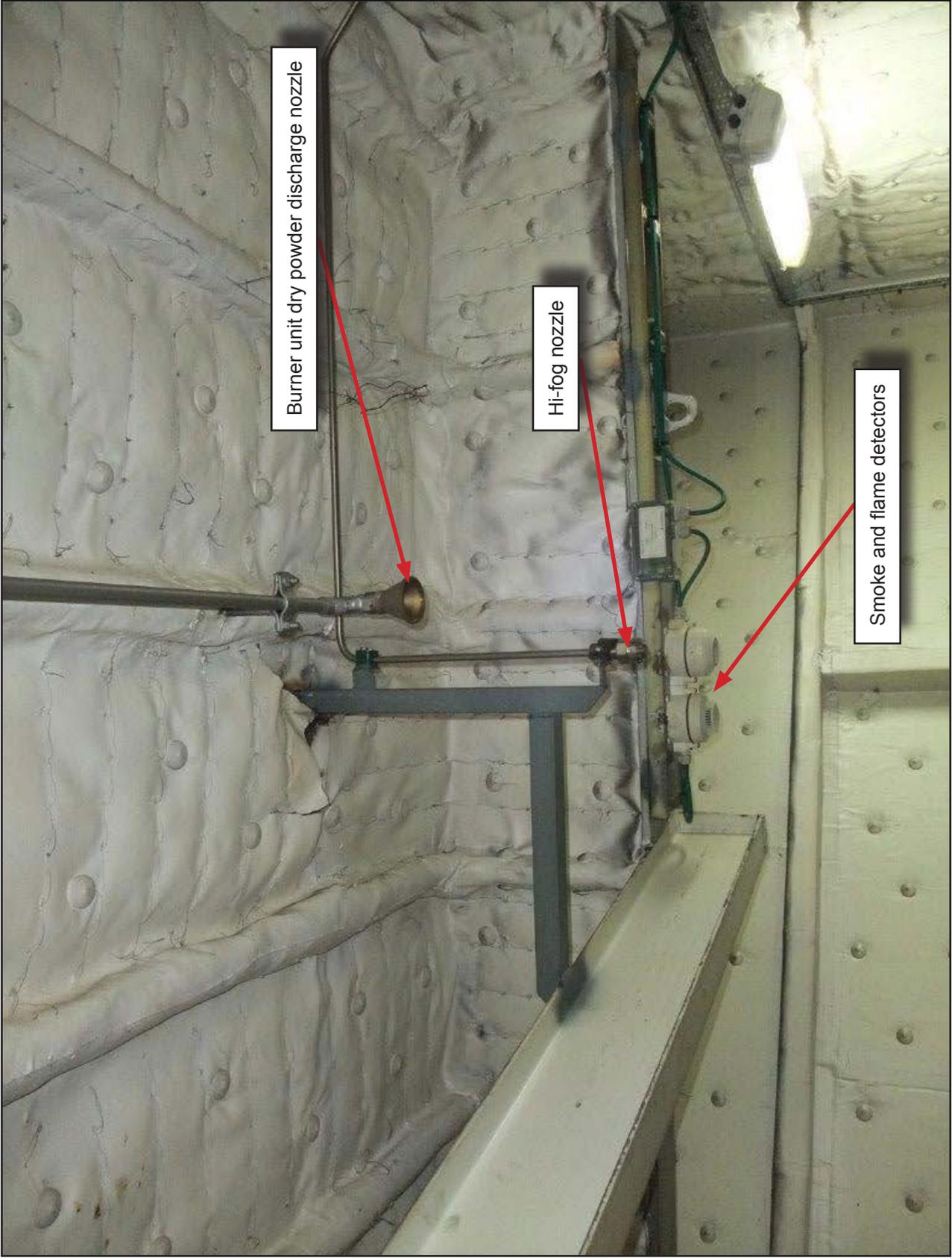
Figure 7: Photograph of internal view of a similar thermal oil heater furnace roof showing original refractory

1.6 FIXED FIRE-EXTINGUISHING SYSTEMS

The port boiler room was fitted with three fixed fire-extinguishing systems (**Figure 8**):

- A CO₂ system was designed to provide fire-extinguishing capability for the whole compartment. It was a manually operated system actuated from a control station adjacent to the boiler room on deck 7.
- A dry powder system was designed to extinguish fires on the top of the heater. This consisted of a 15kg stored pressure extinguisher located at the same control station as the CO₂ system (**Figure 9**). The extinguisher was connected by a fixed steel pipe to a discharge nozzle located above the burner unit.
- An automatic hi-fog water-mist system was designed to spray high pressure freshwater through a discharge nozzle located above the burner unit. The control station for this system was located in the MCR. The system was activated through a combination of smoke and flame detectors. The detectors were located adjacent to the discharge nozzle above the burner unit (**Figure 8**). A smoke detector raised an initial alarm and the system was subsequently activated if the flame detector registered a flame. The system could be overridden at the control station and manually activated.

Following a previous coil failure and fire, the thermal oil heaters had been fitted with a furnace fixed fire-extinguishing system. This comprised a 15kg dry powder extinguisher (**Figure 9**) coupled by permanent steel pipework to an inlet in the top of the furnace. This system had been installed during the ship's previous ownership.



Burner unit dry powder discharge nozzle

Hi-fog nozzle

Smoke and flame detectors

Figure 8: Photograph of boiler room fixed fire-extinguishing systems



Figure 9: Photograph of fixed fire-extinguishing system control position

It was not approved by PWT and did not form part of the ship's mandated fire-extinguishing systems. It was a manually operated system with the extinguisher located at the fire control station on deck 7.

The thermal oil heaters were supplied from the original equipment manufacturer (OEM) with a connection on top of the furnace that could be used for a fire-extinguishing medium. This facility had never been used by PWT.

1.7 SURVEY AND REGULATION

Dieppe Seaways was classed with Det Norske Veritas Germanischer Lloyd (DNV GL) and subject to a regular survey regime. An intermediate survey had been completed on 27 February 2014, which had included a survey of both port and starboard thermal oil heaters. The furnace had been opened and cleaned in preparation for the survey.

DNV GL Rules for Classification of Ships gives survey requirements for ships in operation at Part 7 Chapter 1 Section 5 Miscellaneous Class Surveys G. Thermal Oil Heater Survey.

G. 203 Hydraulic pressure testing (to be witnessed by a DNV GL surveyor) states:

'For coils in thermal oil installations heated by oil or gas burner(s) or by exhaust, which are not accessible for visual external inspection, survey may be performed by hydraulic pressure testing 1.5 times the calculated working pressure.'

The test pressure shall be maintained for a period of at least 30 minutes.'

The Det Norske Veritas survey report for the Main Class Intermediate/Bottom Survey dated 27 February 2014 states that survey of the thermal oil heater, oil-fired port was complete. No note of existing repairs was made during the survey.

The survey report records:

'Thermal oil heater was opened for inspection. Furnance, heating coils and complete burner, extinguishing system were inspected and found in order. Upon inspection completion complete system was operationally tested satisfactorily including safety devices. Emergency shutdown satisfactorily tested from deck no. 9. Safety valve opening pressure recorded 10 bar. Set pressure [bar]: 10' [sic]

There were no class memoranda⁵ relating to the thermal oil heaters at the time of the survey.

The port boiler room fire protection and extinguishing arrangements complied with the requirements of SOLAS Chapter II-2 - Construction – Fire Protection, Fire Detection and Fire Extinction.

⁵ Information of assistance to the surveyor and owners may be recorded as 'memoranda'. Memoranda may include notes concerning materials and other constructional information. A memorandum may also define a condition which, though deviating from the technical standard, does not affect the class (e.g. minor deficiencies, which do not affect the operational safety of the machinery). Memoranda could define recurring survey requirements, including annual survey of specified items such as the thermal heater coils.

1.8 **DIEPPE SEAWAYS' SENIOR STAFF**

Dieppe Seaways' master held an STCW⁶ II/2 (master – unlimited) Certificate of Competency (CoC). He had 12 years' experience of ferry operations before joining *SeaFrance Molière* (later named *Dieppe Seaways*) as chief officer during its conversion for operation on the Dover/Calais route. He had been the master on *Dieppe Seaways* for approximately 1 year.

The chief officer held an STCW II/2 (master – unlimited) CoC. He had 8 years' experience of ferry operations and was promoted to chief officer in 2011. He joined DFDS A/S in 2013 and was a regular member of the crew of *Dieppe Seaways*.

The chief engineer held an STCW III/2 (chief engineer officer - unlimited) CoC and had 20 years' experience at sea of which 10 years had been spent on ferries. He had sailed on *Dieppe Seaways* in the capacity of second and chief engineer since 2008 when it had operated as *SeaFrance Molière*. In 2009, he had been second engineer on the vessel when a similar furnace fire in the port thermal oil heater had occurred.

1.9 **SHIP EXERCISE AND TRAINING PROGRAMME**

The vessel's exercise and training programme was designed to ensure that all crew members received the necessary training. The programme comprised vessel familiarisation, periodic musters and specific exercises. The training exercises covered fires, collision, flooding and evacuation. Exercises were generally conducted on Sundays while the ship was berthed in Calais.

In common with many passenger vessels, incidents were initially dealt with by dedicated teams of trained ship's personnel. Incidents were only escalated to involve the rest of the crew and passengers if they developed beyond the control of the dedicated teams. In this eventuality, the ship's master would make a general announcement alerting all other personnel. In the case of a fire, this would result in a 'Code Red'. When a 'Code Red' was called all personnel were required to muster at their dedicated emergency station and, from there, they were directed by the ship's command team to carry out specific tasks.

At the time of the accident, there was no standard operating procedure for dealing with a fire on the thermal oil heating system installation. However, the ship's Emergency Response Manual contained a decision support system checklist that was used to support the fire-fighting effort.

1.10 **KFRS ORGANISATION**

A KFRS group manager was the OIC at time of the backdraught. He was an experienced fire officer who had been in the FRS for 21 years and had had a direct operational or training role throughout his career. He had a marine background, held a BTEC level 4 qualification in marine fire-fighting, and was a qualified incident commander.

A KFRS station manager was located at the FCP at the time of the backdraught. He had worked for KFRS for 24 years in both operational and training roles.

⁶ International Convention on Standards of Training, Certification and Watchkeeping for Seafarers 1978, as amended

A KFRS watch manager was the first firefighter to board the vessel. He took control of the KFRS efforts leading up to the initial entry to the port boiler room. At the time of the backdraught he was at the FCP preparing portable dry powder extinguishers for the KFRS firefighters to take into the space. He was an experienced firefighter with 20 years' service.

Another KFRS station manager arrived on board *Dieppe Seaways* immediately after the backdraught, and deployed to the bridge to liaise directly with the master. He was an experienced MIRC firefighter and a marine training project officer who had been with KFRS for 23 years.

KFRS is the lead agency in the MIRC EU organisation, and conducts two maritime exercises per year. Since the accident, KFRS conducted a four-nation exercise in June 2014.

1.11 BACKDRAUGHT

The FRS operational guidance (GRA5.8 – flashover, backdraught and fire gas ignitions⁷) examines the hazards, risks and controls that relate to FRS staff and others who could be exposed to the phenomena of flashover, backdraught or fire gas ignition. GRA5.8 includes:

'Backdraught

A backdraught is where limited ventilation can lead to a fire in a compartment producing fire gases containing significant proportions of partial combustion products and unburnt pyrolysis products. If these accumulate, the admission of air when an opening is made to the compartment can lead to a sudden deflagration. This deflagration moving through the compartment and out of the opening is a backdraught.'

The GRA provides two scenarios to explain the phenomenon:

'Scenario 1

If the fire is still burning within a compartment when the door is opened, especially if the combustion gases are not escaping, the incoming air will mix with the gases and create an explosive mixture. If the gases within the compartment are hot enough, they will auto-ignite and flame will spread back into the compartment along with the fresh air. This would result in rapid fire growth, but not necessarily in a backdraught. Alternatively, if the gases are not sufficiently hot they will only be ignited once sufficient oxygen has reached the gases surrounding the fire. The flame will then travel across the compartment towards, and out of the doorway, driven by the expanding gases behind it.

Scenario 2

A more dangerous situation can occur if the fire in the compartment has almost died out. Once the door is opened air flows in and an explosive mixture may be created. There is the potential for ignition of these gases not to occur

⁷ General Risk Assessment, published in August 2009 by The Stationary Office with the permission of the Department for Communities and Local Government, and the Chief Fire and Rescue Adviser (CFRA)

immediately. Once the firefighters enter the room however, and start to disturb the contents (e.g. turning over), an ignition source may be exposed and result in total flame engulfment. This is defined as a 'delayed backdraught'.

GRA5.8 also gives the following guidance:

'Incident command and control

The National Incident Command System should be adopted on arrival at the incident.

Where a high risk of backdraught is identified, consideration should be given to the initial adoption of defensive firefighting tactics.

Detailed guidance on operational tactics is published in the Fire and Rescue Service Manual, Volume 2, Fire Service Operations – Incident Command, 3rd Edition 2008⁸.

Ventilation of the premises should be conducted in a controlled and considered manner with due account taken of wind conditions. Effective communications are essential for this to be achieved.

Ventilation points and exposed risks should be covered by water sprays to reduce the risk of external fire spread.

Suitable communications will be needed to ensure that the Incident Commander and sector commanders are able to communicate at all times.

The area outside the building on fire should be controlled (Inner Cordon Management) to reduce the number of persons at risk to the minimum necessary should a backdraught occur. This may include the tactical positioning of breathing apparatus entry control boards and fire appliances.

Recognition of the signs of backdraught...'

External signs of backdraught
<i>Fire in a compartment with limited ventilation:</i>
<i>Fire has been burning for some time</i>
<i>Fire gases being pushed out under pressure from gaps</i>
<i>Windows blackened with no visible sign of flame</i>
<i>Fire gases pulsing out from gaps</i>

STCW Manila 2010⁹ Chapter VI Section B-VI/1 Guidance regarding mandatory requirements for safety familiarization and basic training and instruction for all seafarers details the fire-fighting training requirements for seafarers.

⁸ Fire and Rescue Service Manual, Volume 2, Fire Service Operations – Incident Command, 3rd Edition, published in August 2008 by The Stationary Office with the permission of the Department for Communities and Local Government on behalf of the controller of Her Majesty's Stationary Office

⁹ International Convention on Standards of Training, Certification and Watchkeeping for Seafarers 1978, including 2010 Manila amendments.

The standard entry technique relies on an assessment of conditions within the compartment. STCW training requirements include teaching that covers the risk of re-ignition. However, the initial entry into a space will always carry a significant degree of risk, which can be mitigated if an accurate assessment of internal conditions is available. The current technique taught at accredited training establishments is to use the door for protection and open it 10cm for a period of 10s. This constitutes prudent entry but will not prevent the rapid development of a backdraught if the necessary conditions exist.

GRA 5.8 details training requirements and states that standard Personal Protective Equipment (PPE), in itself, will not afford adequate protection against the effects of either flashover or backdraught. It is therefore imperative that all possible controls are put in place to give adequate protection to personnel involved in the entry. The requirement for this is further emphasised in the Fire and Rescue Service Manual, Volume 2, Fire Service Operations – Incident Command, which states:

‘Incident Risk Management – the principal consideration of Incident Commanders is the safety of our personnel. Therefore, prior to deciding upon tactics an assessment of risk must be performed. The Incident Commander must identify the hazards, assess the risks, and implement all reasonable control measures before committing crews into a risk area’.

1.12 TECHNICAL INVESTIGATIONS

An analysis of the failed coil sections from both the port and starboard thermal oil heaters was undertaken by Centre Technique des Industries Mécaniques’ (CETIM) metallic materials and surfaces laboratory on behalf of DFDS A/S (**Annex A**). The following is an extract from the report’s conclusions:

‘Leaks from the upper spirals of the port and starboard boiler coils of the ship SEAWAYS DIEPPE, occurred in the spring of 2014 after five years of service from a previous repair in 2009 (following a first identical failure after seven years of service), likely result from a process of progressive fatigue cracking.

‘These cracks originate in the tube-deflector weld root which are presumed to have an almost inevitable insufficient melt. This causes a notch effect with strong acute stresses on the tube walls adjacent to the weld; these cracks then spread longitudinally and underlying the welds and perpendicular to the tube walls until they open right through.

‘The state of tensile stress affecting the tube walls examined and giving rise to circumferential fissures, is the sum of a number of permanent stresses arising from the welding and subsequently from the temperature and pressure, among which are those which are believed to be due to the difference in nature of the metals of the tubing and the welding: in fact, the welds were made with a filler made of austenitic stainless steel which is not appropriate to be used with tubes of unalloyed steel. A key contributor to the ongoing cracking process has been mechanical vibration.’ [sic]

A vibration and thermal analysis of the thermal oil heater was undertaken by SeaTec UK Limited on behalf of the MAIB (**Annex B**). Vibration measurements were taken on the external surfaces of the starboard heater, which was in service, and on the

coil surface inside the port heater furnace, which was out of commission undergoing repair. A thermal survey was carried out on the starboard heater to identify any potential hot spots. The following are extracts from the report's findings:

'The vibrations reading were taken on various areas under different conditions. All readings were well within the allowable limits...

'Thermal image did show areas of hot spot indicating inadequate insulation; however it is within the allowable SOLAS recommendation...' [sic]

1.13 PREVIOUS SIMILAR INCIDENTS

Since build, *Dieppe Seaways* has experienced three known furnace fires as a result of coil failures. However, during the investigation and the repair of the port and starboard units following this incident, and a subsequent fire in the starboard unit in June 2014, evidence of additional previous coil repairs was noted, indicating other apparently unrecorded incidents.

Dieppe Seaways suffered a fire in the furnace of the port thermal oil heater in 2009. At the time of the incident, the vessel was being operated as *SeaFrance Molière*. The fire was contained within the heater furnace. Despite this earlier incident, a specific procedure for dealing with a furnace fire had not been developed.

Approximately 1 month after the fire in the port thermal oil heater, a very similar incident occurred in the furnace of *Dieppe Seaways'* starboard thermal oil heater. On that occasion, ship's staff were able to contain the fire within the furnace, putting into place lessons learnt from the fire in the port thermal oil heater.

Information was requested from the other companies operating *Dieppe Seaways'* sister ships.

One of the sister vessels had suffered two similar fires, one in each oil-fired thermal oil heater; both resulted in significant damage.

At the time of this incident, another sister vessel had one heater out of commission due to cracking in the coil. This was awaiting classification society approval for a repair proposal, which appeared similar to the weld repairs found on the failed coil of *Dieppe Seaways'* port thermal oil heater.

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 OVERVIEW

The fire in *Dieppe Seaways*' port thermal oil heater started because a fracture developed in the coil carrying the oil through the furnace, and this allowed thermal oil to enter the furnace and ignite. The nature of the fire was such that it created a succession of small explosions, some of which were powerful enough to cause the burner unit to hinge open. The aperture in the heater furnace caused by the opening of the burner unit then allowed the fire to migrate to the boiler room.

2.3 COIL FAILURE

A number of possible explanations for the port thermal oil heater coil failure emerged during the course of the investigation. These included: fracture due to stress, vibration, direct mechanical damage and material flaw. Material flaw was largely ruled out owing to the high number of previous failures as it was considered highly unlikely that a number of material batches over several years would suffer the same flaw. Similarly, no evidence of direct mechanical damage was detected.

The analysis of the coil sections carried out by CETIM on behalf of DFDS A/S confirms that the failure of the port thermal oil heater coil was the result of a fracture along the circumferential weld securing the refractory insulation support plate at the top of the furnace (**Figure 10**). The welds were assessed as having an insufficient melt that caused a notch effect with acute stresses on the tube walls adjacent to the weld. The report also noted that an inappropriate filler material had been used for the welding.

The vibration analysis carried out by SeaTec UK Limited on behalf of the MAIB confirms that under the ship's normal trading pattern, vibration on and around the thermal oil heaters was not excessive. Therefore, vibration was unlikely to have been a significant contributing factor to the coil failure.

The thermal analysis carried out on the starboard thermal oil heater indicates that there were no significant insulation issues. However, it was noted that the type of furnace refractory insulation in both thermal oil heaters on *Dieppe Seaways* had been changed from fire cement to ceramic matting. Previous vibration damage to the fire cement refractory insulation as a result of normal operation cannot be ruled out. The heater coil internal oil film operating temperature in this area was approximately 400°C and, with a flame temperature of approximately 1200°C, any previous loss of refractory insulation could have exacerbated thermally induced stress of the heater coil. However, vibration is unlikely to have affected the replacement ceramic matting.

With the damaged section cut out of the coil, some evidence of light contamination of the internal coil walls was noted (**Figure 11**). However, the level of contamination is unlikely to have contributed to additional thermal stress.

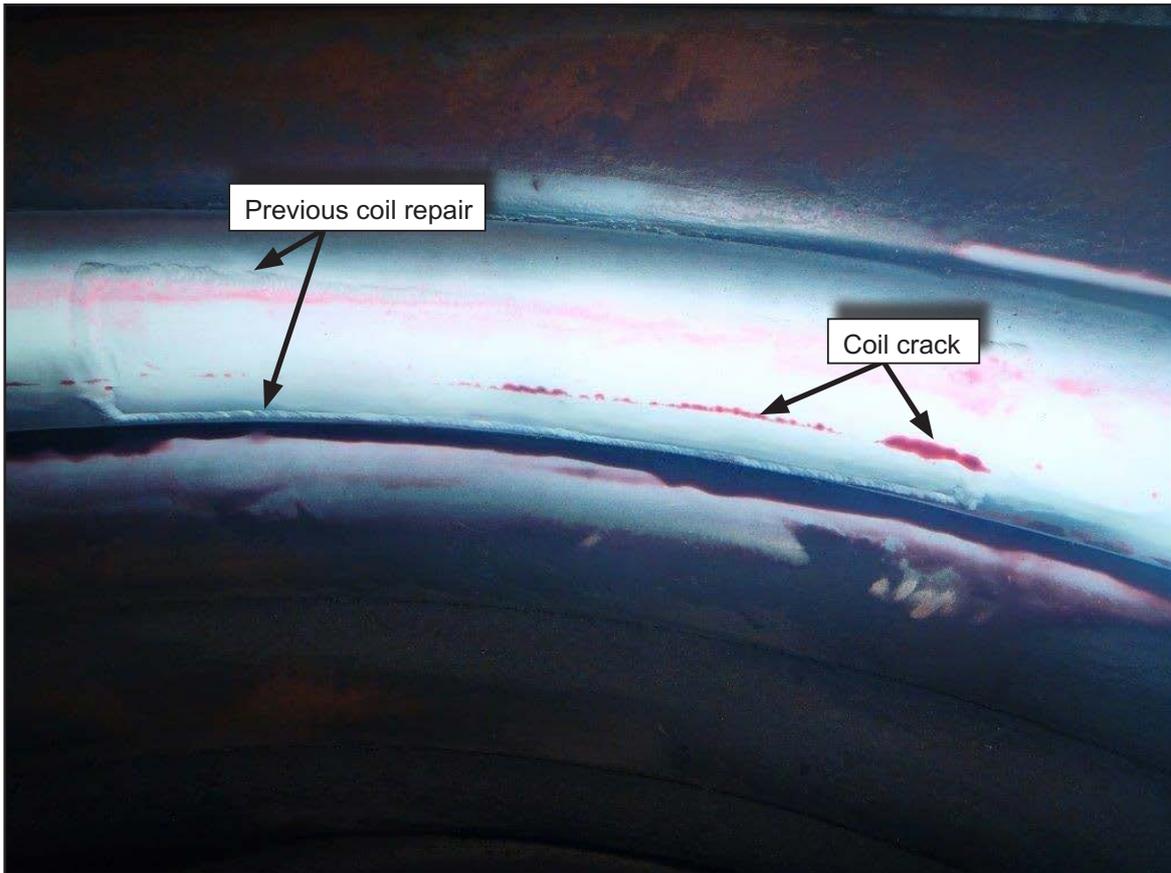


Figure 10: Photograph of port thermal oil heater coil fracture



Figure 11: Photograph of internal surface of damaged section of port thermal oil heater coil

It is concluded that the port thermal oil heater coil failed as a result of stress caused by the weld securing the refractory insulation support plate. This was as a result of stresses introduced through insufficient melting of the weld and an inappropriate filler material for the welding. This might have been exacerbated through thermally induced stress resulting from previous damage to the refractory insulation (**Figure 12**).

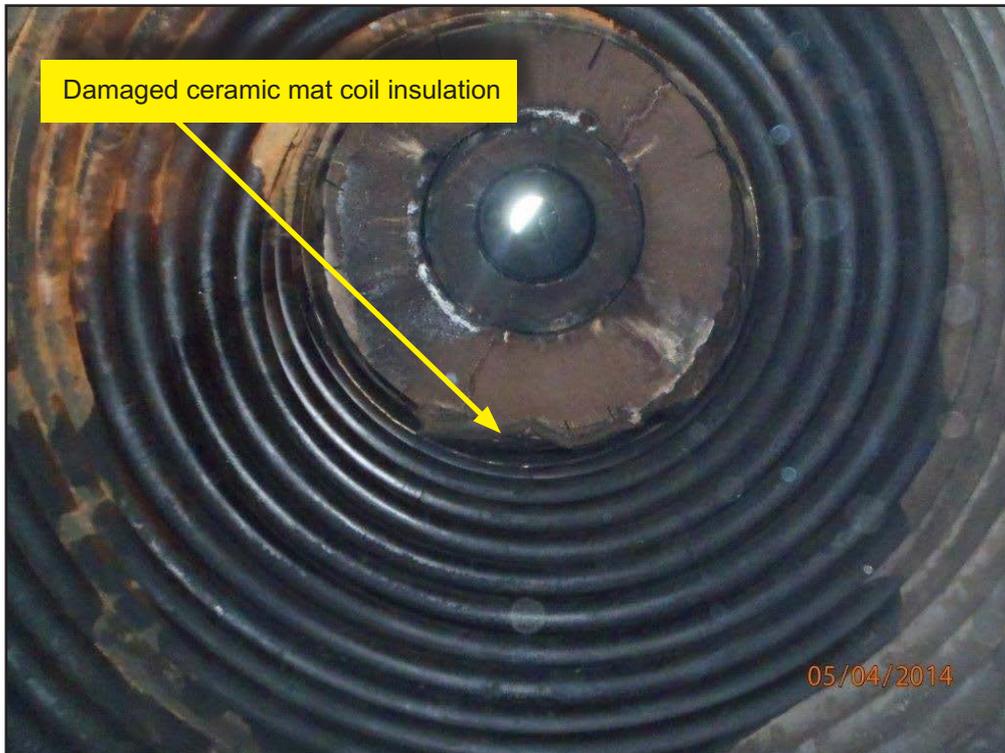


Figure 12: Photograph of internal view of port thermal oil heater furnace roof showing burner unit aperture and damaged insulation

2.4 COIL SURVEY AND INSPECTION

The port thermal oil heater was opened and visually inspected during the Main Class Intermediate/Bottom Survey on 27 February 2014 and found to be in good order, some 2 months before the fire.

However, the section of coil that failed was particularly difficult to visually inspect due to the refractory insulation located in its vicinity. Furthermore, parts of the external coil (**Figure 6**) were inaccessible for visual examination.

DNV GL survey rules for coils in thermal oil installations heated by oil or gas burners or by exhaust, which are not accessible for visual external inspection, state that survey may be performed by hydraulic pressure testing 1.5 times the calculated working pressure and that the testing must be witnessed by a DNV GL surveyor.

In view of the coil access limitations, hydraulic pressure testing during the 27 February survey would have been a prudent option to complement a visual inspection and functional test.

Detailed maintenance records had not been transferred between vessel managers during the vessel's changes of ownership. Consequently there were no records relating to the previous weld repairs to the thermal oil coil or, whether these repairs

had been undertaken with the approval of the classification society. Notwithstanding the number of earlier coil failures in thermal oil heaters, particularly on *Dieppe Seaways*, the problem was not well documented.

The lack of detailed maintenance records, and no evidence of previous classification society approval for repairs, might have prevented the classification society from issuing either specific class memoranda to *Dieppe Seaways* or generic advice to its surveyors. Such information could have prompted surveyors to pay particular attention to visually inspecting the upper coils of PWT DW III thermal oil heaters and for them to require hydraulic pressure testing where the coils were inaccessible for visual examination.

2.5 FIRE SPREAD INTO THE PORT BOILER ROOM

The fire spread from the furnace to *Dieppe Seaways*' port boiler room through the aperture caused by the burner unit lifting (**Figure 13**). The available evidence indicates that the burner unit opened as a result of pressure within the furnace caused by a number of explosions.

Post-fire examination found that the burner unit could not be readily opened with the latch secured. It is considered that direct forced opening (due to the explosions within the furnace) would probably have caused some damage to the latching mechanism. Other than noticeable wear in the pawl bearing and clip nose, there was no evidence that any damage to the latching mechanism occurred as a result of the fire or explosions. Therefore, it is probable that the burner unit opened as a result of not being properly latched following previous maintenance or inspection, and also probable that the chief engineer did not close it effectively when he entered the boiler room once the fire had started.

2.6 FIRE DEVELOPMENT AND BACKDRAUGHT

The fracture in the coil in the port thermal oil heater allowed thermal oil into the furnace, which ignited and resulted in an uncontrolled fire within the furnace. The fire had a ready source of fuel from the thermal oil within the system. Temperatures within the furnace are estimated to have reached 1200°C. Therefore, fuel and a source of ignition remained available until cooling was applied through the use of the hi-fog fixed fire-extinguishing system covering the burner unit, and the injection of foam directly into the furnace using the dry powder fixed fire-extinguishing pipework.

Although the heater had been shut down and the burner fuel and air isolated, a fuel source remained available through the thermal oil in the system. The pressure in the thermal oil coil caused by thermal expansion is likely to have forced the thermal oil through the crack in the coil, forming an atomised and therefore more readily ignitable fuel source. The inability to operate the coil pressure relief valve might have exacerbated this situation. Therefore, with fuel and heat sufficient for ignition, the fire became dependent on oxygen. An oxygen source existed through the heater exhaust. However, the main source was probably from the opening created at the top of the furnace after the burner unit had lifted. The observed pulses of smoke emanating from the jointing surfaces at the top of the furnace were consistent with the fire diminishing due to oxygen starvation and then suddenly re-igniting when the air/fuel ratio was again sufficient to support combustion.

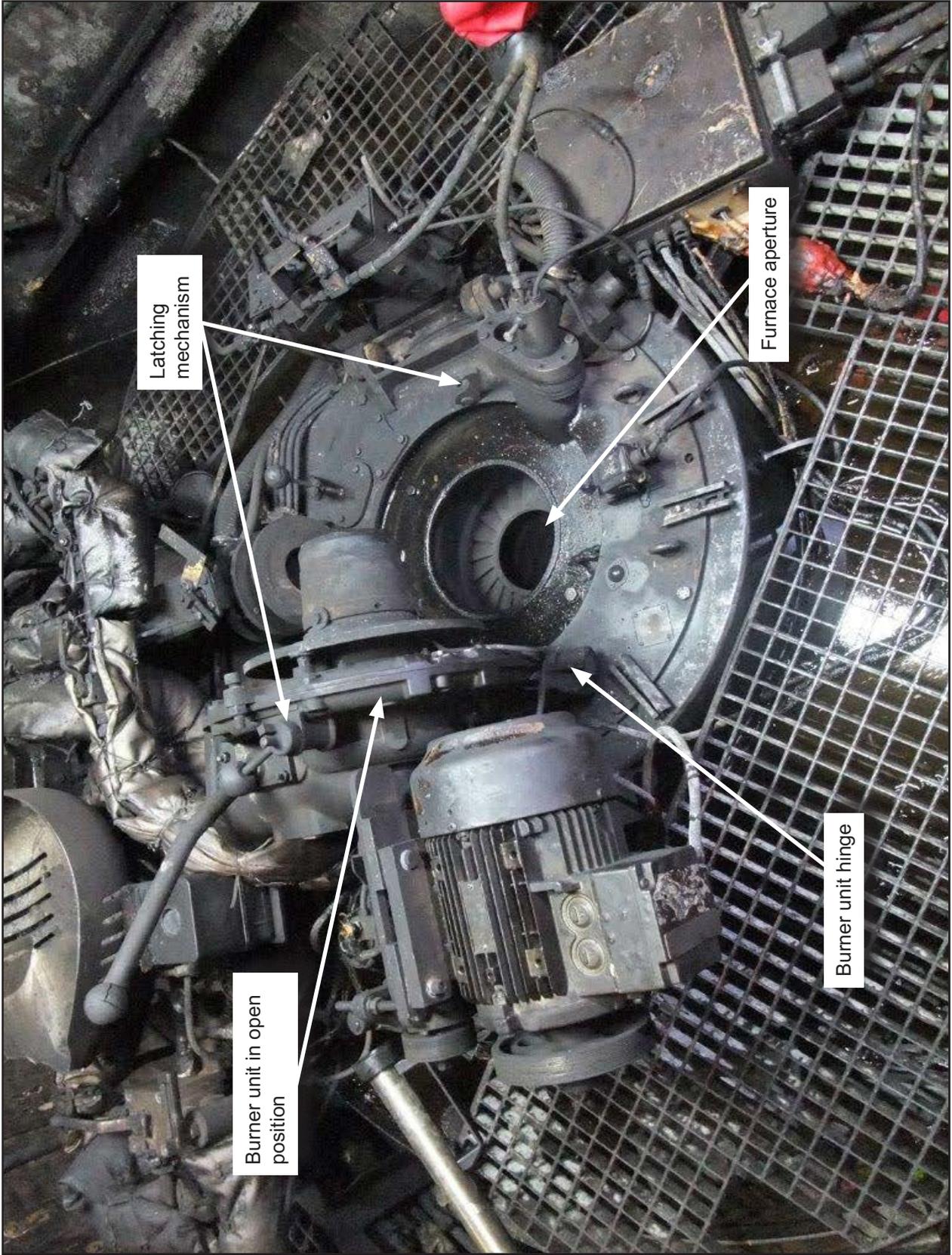


Figure 13: Photograph of port thermal oil heater burner unit in open position

While the fire continued to burn within the furnace, smoke and fire gases escaped through the burner unit aperture and amassed at the top of the port boiler room. Heat from the fire then melted fittings, forming unburnt pyrolysis products and adding to the combustible mixture within the compartment. The accumulation of this mixture, combined with a fire that had become dependent on oxygen, resulted in a backdraught when the port boiler room entrance door was opened and air was allowed to enter the space.

2.7 FIRE-FIGHTING

2.7.1 Ship's staff actions

The crew's initial response to the port thermal oil heater fire on *Dieppe Seaways* was timely and appropriate. This included the initial investigations following the fire alarm, actions taken by bridge and engine room personnel, external communications with Dover Port Control, and the request for the local FRS to attend. Following the initial actions, information to passengers and the mode of disembarkation once the vessel was alongside were well considered.

The initial understanding was that the fire was confined to the port thermal oil heater. The chief engineer took control of the fire-fighting effort using his experience from a previous incident to guide his actions. In 2009, a fire had occurred in the furnace of the port thermal oil heater. In that case, the fire had been contained within the furnace and dealt with entirely by the ship's engineering staff.

There were a number of indications that the fire in the port thermal oil heater had spread into the boiler room, including; that the burner unit had re-opened, the rise in temperature as measured at the furnace exhaust, and smoke issuing from the compartment vents. Despite these signs, the chief engineer remained focused on fighting a fire within the port thermal oil heater without full recognition of its potential to spread to the port boiler room. It is apparent that he was drawing on his previous experience without being fully aware or appreciating the significance of the different situation with which he was now faced. The focus on his previous experience appears to have unduly influenced his evaluation of the information that was available to him.

The chief engineer directed the engine room fire-fighting team to manually operate the coil pressure relief valve. However, adverse conditions within the compartment prevented this action from being achieved. Although attempts were made to reduce the thermal oil pressure by opening the coil outlet valve, remote operating positions for the coil pressure relief valve would have allowed the oil pressure to be reduced without risk of supplementing the fuel supply.

The lack of a comprehensive command review involving all of the key ship's staff compromised the fire-fighting strategy. If the ship's command team (master, chief engineer, chief officer and fire team leaders) had assimilated and reviewed the available information, it would have been possible to develop a more appropriate fire-fighting strategy that recognised that the fire might have, or had the potential to, spread to the whole compartment. Such information included the burner unit having opened for a second time, the excessive smoke both within the boiler room and from the boiler room vent, and continuing explosions in the thermal oil heater furnace.

Furthermore, the absence of a standard operating procedure for dealing with a fire on the thermal oil heating system installation meant that such a scenario had not been exercised as part of the training programme on board *Dieppe Seaways*.

That the potential for the fire to spread to the port boiler room was not recognised, resulted in an inappropriate entry procedure, an unnecessary delay in the available fixed fire-extinguishing systems being activated, and a delayed start to boundary cooling.

2.7.2 KFRS fire-fighting actions

On arrival on board *Dieppe Seaways*, it was reasonable that the KFRS watch manager took the initial information provided by ship's staff at face value. This caused him to understand that the fire was restricted to the port thermal oil heater furnace. However, given that there was then sufficient time to develop an entry plan for the port boiler room through careful investigation of the starboard boiler room, a thorough situational risk assessment should have been carried out in accordance with the instructions provided in the Fire and Rescue Service Manual.

Had this happened, the implications of smoke coming from the boiler room vent, the open burner unit and the furnace temperature rise should have become apparent. The boiler room construction (A-60 insulation, which masked the internal compartment temperature) should also have been recognised. Furthermore, the initial observations of smoke intermittently pulsing from the furnace joints should have indicated the nature of the fire. This, in turn, should have highlighted the risk of backdraught conditions developing within the compartment and have resulted in a revised entry plan, taking into account the guidance provided in GRA5.8.

In approving the entry plan without a comprehensive review of the situation, the incoming OICs (station manager and then group manager) did not allow themselves sufficient time to use their greater experience in reviewing and risk assessing the situation more fully.

A comprehensive review of the situation involving both the FRS and ship's command teams should have been carried out. This would have allowed all available information to be assessed prior to developing the fire-fighting plan which, in turn, would have allowed an entry plan appropriate to the actual situation to be developed and agreed.

2.7.3 Combined command and control

A factor that ultimately resulted in serious injuries to one KFRS firefighter and two crew members was the lack of FCP cordon control. Only personnel in full fire-fighting clothing should have been allowed in the vicinity of the entry point.

There was no formal acceptance of responsibility for the fire-fighting effort by either the ship's staff or the KFRS firefighters; each organisation felt that the other had a sufficient measure of control. This was most damaging when the joint entry was made as there were effectively three individuals independently controlling events crucial to the entry:

- The KFRS watch manager, located at the FCP directing two KFRS firefighters and in the process of preparing portable dry powder extinguishers for use.

- The chief engineer, located at the FCP directing the engine room fire team.
- The chief officer, directing the deck fire team who were on deck 7 preparing to open the lower boiler room door to aid ventilation of the space.

Furthermore, authorisation for the entry had been given separately by the ship's master and the KFRS OIC, located on the ship's bridge and on the jetty respectively, without any direct liaison between them.

The Fire Service Manual Volume 2 Fire Service Operations – Marine Incidents¹⁰ gives guidance on responsibilities (chapter 3 para 3.2) and states that when a ship is at sea or in port, it is the master who is responsible for the safety of the ship and its crew. Therefore, direct liaison between the FRS OIC and the ship's master is vital.

Prior to the entry commencing, the master and the KFRS OIC should have liaised and confirmed the entry plan and protocols. This was essential, particularly given that a joint team was to effect the entry. There should have been clear instruction to ship's and KFRS personnel, indicating who was controlling the entry and where personnel should be located when the compartment door was opened.

Although KFRS routinely engages in maritime exercises, the lack of combined command and control in this case suggests that more specific shipboard fire-fighting training may be beneficial.

2.7.4 Post-backdraught events

Following the backdraught, events became better controlled. The area around deck 9 was cleared, with access controlled from the bridge. The master took direct control of events with a MIRG-trained KFRS officer on the bridge giving advice on fire-fighting issues. Although no formal handover took place, it is apparent that with the master in direct control he was able to delegate fire-fighting operations to KFRS, who then used its expertise to stabilise the situation through the use of containment, fixed fire-extinguishing systems (including COBRA) and boundary monitoring.

2.8 FIXED FIRE-EXTINGUISHING SYSTEMS

The boiler room had three separate fixed fire-extinguishing systems, all designed to provide fire-fighting medium into the compartment for dealing with a fire external to the heater. This was entirely consistent with targeting the high risk areas within the space, particularly the burner unit, which had both fuel and ignition sources in the same vicinity.

The failure of the hi-fog system to operate automatically can be explained by the location and development of the fire. The system was designed to react to a fire on the burner unit, which is the high risk area of the compartment. In the case of this uncontrolled furnace fire, the smoke detector operated as designed and raised an alarm. However, even with the burner unit open, the flame flicker sensor could not

¹⁰ Fire and Rescue Service Manual, Volume 2, Operations – Marine Incidents, published in 1999 by The Stationary Office with the permission of the Home Office on behalf of the controller of Her Majesty's Stationary Office

detect a fire within the furnace and therefore did not activate the system. The heat from the open burner aperture then destroyed both smoke and flame sensors, thus disabling the automatic function.

Manual use of the hi-fog was not considered until after the backdraught had occurred as the fire was felt to be contained within the furnace; consequently, there was no imperative to use an extinguishing medium within the compartment.

While dry powder, when correctly applied and at the correct application rate, can ensure an initial quick knock-down of a fire, it has poor post-fire security. The fire-extinguishing action of dry powder can produce good results on running fuel fires but only when used in conjunction with water or foam sprays. Dry powder will only remain effective while it is present in the atmosphere above the fuel. Furthermore, it has no cooling effect, resulting in a high risk of rapid fire re-ignition. As a fixed system it is also vulnerable to the powder compacting inside an extinguisher body, a problem which is exacerbated on ships as vibration can cause the powder to compress under its own weight.

The failure of the retro-fitted furnace dry powder fixed fire-extinguishing system to extinguish the fire inside the thermal oil heater furnace demonstrates the unsuitability of dry powder as a fire-extinguishing medium for this purpose.

SECTION 3 - CONCLUSIONS

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

1. The coil in the port thermal oil heater on board *Dieppe Seaways* failed as a result of stress caused by the weld securing the refractory insulation support plate to the coil. [2.3]
2. The section of coil that failed was particularly difficult to inspect visually due to the refractory insulation in the vicinity. In such circumstances it would have been more appropriate to pressure test the coil, as recommended in DNV GL Rules for Classification of Ships, during the intermediate survey earlier in the year. [2.4]
3. The lack of detailed maintenance records and no evidence that classification society approval had previously been given for repairs to the port thermal oil heater might have prevented DNV GL from issuing pertinent advice to its surveyors. [2.4]
4. Adverse conditions within the port boiler room prevented manual operation of the coil pressure relief valve. Remote operating positions for the coil pressure relief valve would have allowed the oil pressure to be reduced without risk of supplementing the fuel supply to the fire. [2.6, 2.7.1]
5. The chief engineer's previous experience of a thermal oil heater fire appears to have unduly influenced his evaluation of information that was available to him. A comprehensive review involving all of the key ship's staff might have identified that the fire had, or had the potential to, spread to the port boiler room. [2.7.1]
6. The absence of a standard operating procedure for dealing with a fire on the thermal oil heating system installation meant that such a scenario had not been exercised as part of the training programme on board *Dieppe Seaways*. [2.7.1]
7. Had a thorough situational risk assessment been conducted by KFRS, the risk of backdraught conditions should have been identified and have resulted in a revised entry plan. [2.7.2]
8. The serious injuries resulted from a lack of FCP cordon control. Although KFRS routinely engages in maritime exercises, the lack of combined command and control in this case suggests that more specific shipboard fire-fighting training may be beneficial. [2.7.3]
9. The failure of the retro-fitted furnace dry powder fixed fire-extinguishing system to extinguish the fire inside the port thermal oil heater furnace demonstrates the unsuitability of dry powder as a fire-extinguishing medium for this purpose. [2.8]

3.2 OTHER SAFETY ISSUES RELATING TO THE ACCIDENT¹¹

1. It is probable that the burner unit of the port thermal oil heater opened as a result of not being properly latched down following previous maintenance or inspection. This allowed smoke and fire gases to amass at the top of the port boiler room, resulting in a backdraught when the port boiler room entrance door was opened. [2.5, 2.6]

¹¹ 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.

2. The port boiler room's A-60 structural fire protection masked the internal compartment temperature and prevented an accurate assessment of conditions within the compartment. [2.7.2]

SECTION 4 - ACTION TAKEN

Kent Fire and Rescue Service has:

Conducted an internal investigation which recommended additional emphasis on cordon control during leadership training for incident commanders.

DFDS A/S has:

Developed a standard operating procedure to be followed in the event of a thermal oil heater furnace fire.

Issued a Fleet Safety Alert that highlights this incident and recommends that all applicable staff:

- Re-familiar themselves with incident reaction procedures relating to shutdowns and fire suppression systems.
- Use fire drills to identify safe compartment entry procedures highlighting the dangers of backdraught and flashover.
- Reinforce to all personnel that the master has overriding responsibility for command and control of any incident on board.

Dieppe Seaways ship's staff have:

Made temporary arrangements to allow remote operation of the thermal oil heater coil pressure relief valve.

Dover Harbour Board has:

Carried out an internal investigation.

SECTION 5 - RECOMMENDATIONS

Prozess-Wärmeträgertechnik GmbH is recommended to:

2015/148 Investigate alternative methods of securing the refractory insulation support plate on PWT DW III thermal oil heaters.

Det Norske Veritas Germanischer Lloyd is recommended to:

2015/149 Provide guidance to its surveyors on:

- Previous incidents involving PWT DW III thermal oil heaters; and
- Appropriate and effective methods for examining welded connections on thermal oil heater coils, to reinforce its existing recommendation for hydraulic pressure testing where coils are not accessible for visual external inspection.

Kent Fire and Rescue Service is recommended to:

2015/150 With regard to shipboard fire-fighting:

- Emphasise to its firefighters the available guidance provided in GRA5.8 and the Fire and Rescue Manual with regard to backdraught conditions with particular emphasis on the need to conduct a thorough situational risk assessment before developing an entry plan.
- Issue guidance to FRS OIC on the need to liaise effectively with the ship's master, recognising that the ship's master is responsible for the safety of the ship and its crew.
- Provide more specific shipboard fire-fighting training to exercise combined command and control, and enhance risk perception in respect of ship construction and associated hazards.

Det Norske Veritas Germanischer Lloyd and **DFDS A/S** are recommended to:

2015/151 Review the suitability of dry powder as a fixed fire-extinguishing medium for use in thermal oil heater furnaces.

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

