Report on the investigation of the electrical blackout

and subsequent grounding of the ro-ro cargo ship

Moondance

in Warrenpoint Harbour, Northern Ireland

29 June 2008

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London
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In this investigation, the MAIB has taken the lead role pursuant to the IMO Code for the Investigation of Marine Casualties and Incidents (Resolution A.849(20)) with the full cooperation and assistance of the Bahamas Maritime Authority (the Flag State). The Flag State's contribution to this investigation is acknowledged and gratefully appreciated.

Extract from

The United Kingdom Merchant Shipping

(Accident Reporting and Investigation)

Regulations 2005 – Regulation 5:

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

NOTE

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

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GLOSSARY OF ABBREVIATIONS AND ACRONYMS

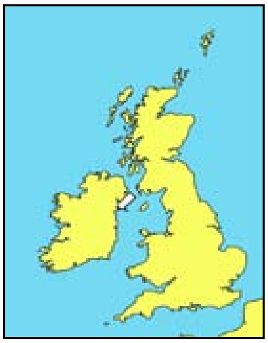
AB	-	Able bodied seaman
CPP	-	controllable pitch propeller
dc	-	direct current
DPA	-	Designated Person Ashore
ECR	-	Engine Control Room
EOOW	-	Engineer Officer of the Watch
ETA	-	estimated time of arrival
GMDSS	-	Global Maritime Distress and Safety System
Hz	-	Hertz
IMO	-	International Maritime Organization
ISM Code	-	International Safety Management Code
kW	-	kilowatt
LOF	-	Lloyd’s Open Form
m	-	metre
MCA	-	Maritime and Coastguard Agency
MIN	-	Marine Information Note
OT	-	Oil Transfer
PEC	-	Pilotage Exemption Certificate
PMSC	-	Port Marine Safety Code
PMSCSG	-	Port Marine Safety Code Steering Group
rpm	-	revolutions per minute
SAR	-	Search and Rescue
SMS	-	Safety Management System
SQM	-	Safety, Quality and Marine

SOLAS	-	International Convention for the Safety of Life at Sea
Touch drills	-	A method of conducting drills, especially those related to machinery breakdowns which entail touching the system valves/starters to simulate actions that would be taken in the event of a real failure
UTC	-	Universal Time Co-ordinated
v	-	volt
VHF	-	Very High Frequency

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

Photograph courtesy of Seatruck Ltd

Moondance



SYNOPSIS

At approximately 1811 on 29 June 2008, the ro-ro cargo ship *Moondance* was shifting from a lay-by berth to the ferry linkspan in Warrenpoint Harbour, Northern Ireland. At 1813 she grounded on the south-western bank of Carlingford Lough following an electrical blackout. There were no injuries, but the vessel suffered severe distortion of the port and starboard rudder stocks.

At 1808, just before *Moondance* left the quay, the port generator high fresh water temperature alarm sounded. The second engineer was working under pressure and unsupervised during the critical time of preparing to leave the berth. He was unable to determine the cause of the alarm and did not alert the chief engineer or master to the problem. Soon after leaving the quay, with the vessel proceeding astern, the starboard generator also alarmed, and at 1811 a total blackout occurred. The controllable pitch propellers (CPP) defaulted to the full astern position and *Moondance* continued her sternway until she grounded.

The chief engineer and his team arrived at the Engine Control Room (ECR), and the main engines were immediately shut down without approval from the bridge and without knowledge of the navigational situation. The situation in the ECR was chaotic. The chief engineer had difficulty establishing his authority because the Polish engineers discussed fault finding options, in Polish, without consulting him. The problems were exacerbated because there was no lighting; the emergency generator had failed to start automatically because it had been left in hand control. This was due to a long-standing defect that the chief engineer was unaware of. It was not until 15 minutes later that the emergency generator was started and the generators were cooled down sufficiently to enable them to be re-started.

Communications between the bridge and engine room were poor, which resulted in the main engines being started without approval from the bridge. However, they were shut down soon afterwards on the orders of the master, which were relayed, in person, by the chief officer. At 1945 the master ordered the starboard engine to be started and, with tug assistance, *Moondance* berthed alongside at 2022.

The investigation concluded that the generator high freshwater temperature was due to the isolating valve for the sea water cooling system, supplying the generators, being left shut or being only partially opened during the system reconfiguration for departure. Many of the routines on board were lax. The move from the lay-by berth to the linkspan was considered by senior staff on board *Moondance* to be a routine operation. Complacency led to insufficient manning levels on the bridge and in the engine room, which contributed to the accident.

Recommendations have been made to the Flag State and the management company, which include:

- Conducting an urgent review of the company's Safety Management System.
- Providing guidance to suitably trained internal auditors on assessing crew knowledge, departmental management and inter-departmental communications.
- Undertaking a review of risk assessment procedures on board the company's vessels.

SECTION 1 - FACTUAL INFORMATION

1.1 PARTICULARS OF *MOONDANCE* AND ACCIDENT

Vessel details

Registered owner	:	Seatruck Navigation Limited
Manager	:	Seatruck Ferries Shipholding Limited
Flag and IMO number	:	Bahamas – IMO Number 7800112
Port of Registry	:	Nassau
Type	:	ro-ro cargo ship – maximum 12 passengers
Built	:	1977 by Rickmers Verft at Bremerhaven, Germany
Construction	:	Steel
Length overall	:	116.3m
Breadth	:	17.40m
Depth	:	12.2m
Gross tonnage	:	5881
Engine type and power	:	2 x MaK 8M453AK, 4 stroke, 8 cylinder in-line diesel engines developing total 4413kW
Propulsion	:	Reduction gearboxes driving 2 Escher Wyss 4-bladed controllable pitch propellers. Single 441kW fixed pitch, reversible motor Jastram BU80F bow thruster
Service speed	:	15.5 knots

Accident details

Time and date	:	Approximately 1813 on 29 June 2008
Location of incident	:	54º 05.90'N 6º 15.596'W – Warrenpoint Harbour, Northern Ireland
Persons on board	:	18
Injuries/fatalities	:	None
Damage	:	Damage to port and starboard rudders and rudder stocks

1.2 BACKGROUND

1.2.1 General

The Bahamas registered and Det Norske Veritas classified ro-ro cargo ship *Moondance* had been owned by Seatruck Navigation Limited since 1997. The vessel was one of six managed by Seatruck Ferries Shipholding Limited (referred to throughout this report as Seatruck Ferries) based at Heysham in Lancashire.

1.2.2 Operation

Moondance operated on the Heysham to Warrenpoint route and was certified to carry up to 12 passengers. Trade was predominantly centred on transporting self drive trucks and freight trailers. The cargo was loaded from the stern ramp and carried on numbers 1 and 2 decks. Although the lower hold deck was designed for carrying cars, it was no longer used for cargo-carrying purposes. The general arrangement of *Moondance* is at **Figure 1**.

The trading pattern typically involved sailing from Heysham at 0800 and arriving at Warrenpoint between 1600 and 1700. Following off-loading and re-loading cargo, the vessel sailed at about 2000, arriving at Heysham at 0500 to continue the pattern. The company operated a three-ship schedule on the route, which allowed all vessels periods of lay-over, both in Heysham and in Warrenpoint.

Three of the eighteen crew on board were British: the master, chief officer and chief engineer. The remainder were Polish nationals. The working language on board *Moondance* was English.

Moondance was not fitted with either a voyage data recorder or a machinery data logging system.

1.3 NARRATIVE

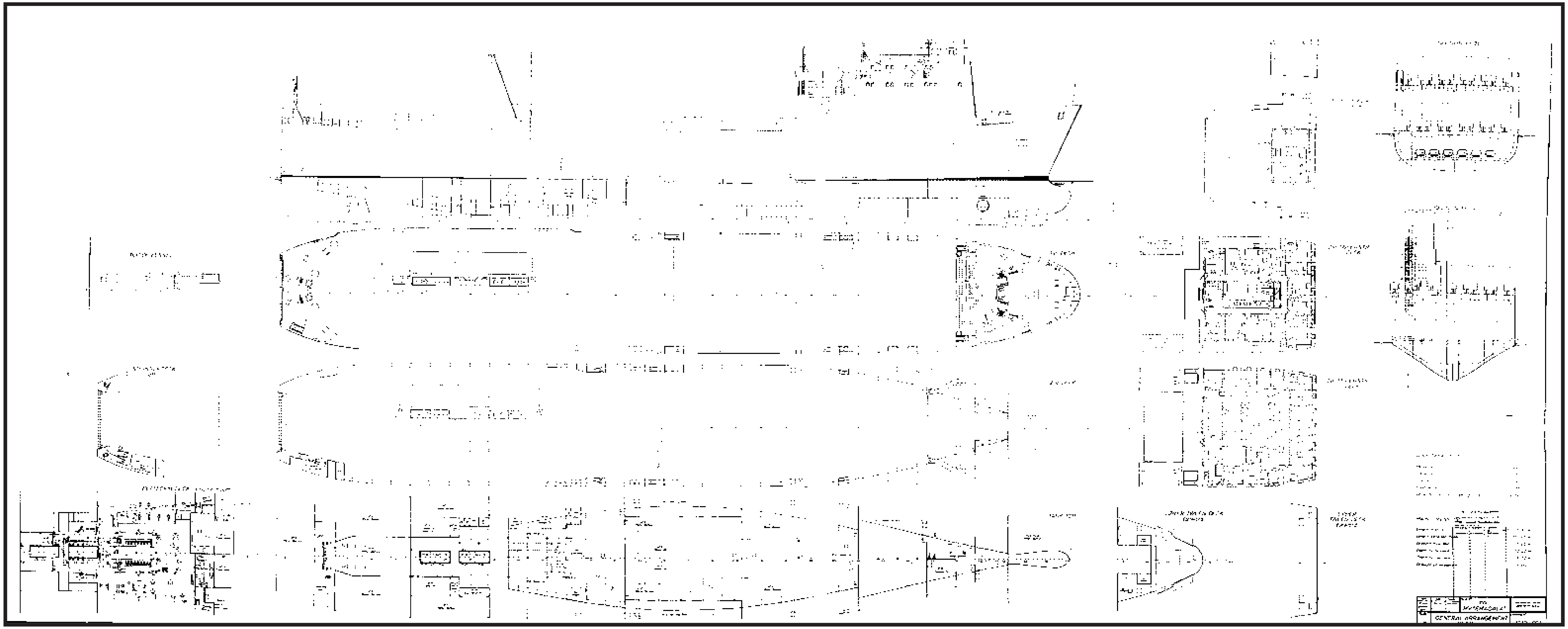
1.3.1 Layover at Warrenpoint 27-29 June 2008

Moondance arrived at the ro-ro ferry linkspan in Warrenpoint Harbour at 1800 on Friday 27 June 2008. After off-loading her cargo, she moved to number 6 lay-by berth, which was nearby.

After securing alongside the berth at 2048, the master informed the chief officer and chief engineer that *Moondance* was scheduled to return to the linkspan, in accordance with normal practice, at about 1800 on Sunday 29 June. This would provide sufficient time to load the cargo and sail to Heysham at 2000. Although the issue of readiness was not specifically discussed during their conversation, the chief engineer understood the schedule implied that “standby engines” would be required from about 1745 on 29 June.

The main engines were shut down and cooled, and it is believed that the port electrical generator was left running. It is not possible to be specific on this point because of the paucity of the manual machinery recordings. On completion, the second and third engineers assumed their harbour lay-over watch routines.

Figure 1



Moondance - general arrangement

On 28 June the engine room team carried out the 250-hour maintenance schedule of the port main engine, and also overhauled No 6 cylinder liner. Sometime during the day, the starboard generator was started and the port generator stopped. On 29 June the generators were swapped over once again. There were only two sets of readings taken during the day and there was no record of when the generator changes were made. Copies of the Watch Periodic Machinery Log for 27, 28 and 29 June 2008 are at **Annex A**. Those records that do exist show the operating parameters to be steady, and there were no comments made in the "Remarks" section of the log to indicate there were any problems during this period.

For both the deck and engineering departments, 29 June was a quiet rest day. Some of the crew went ashore to church, but most remained on board. The second engineer assumed the "on call" engine room watch at 0600. Between 0800 and 1200 he checked the running machinery, including the generator, and found the pressures and temperatures to be normal. The chief engineer also visited the engine room during the morning and found nothing to alarm him. A short time later the master confirmed to the chief engineer that *Moondance* would shift to the linkspan at about 1800. The chief engineer in turn instructed the third engineer to prepare main engines at 1730 in readiness for the move.

At 1200 the second engineer handed the engine room watch over to the third engineer, after which he had lunch and retired to his cabin to watch television and to read. After conducting routine checks around the engine room, the third engineer also returned to his cabin and switched on his engine room remote alarm system. He returned to the engine room at 1600 for further checks and to prepare the main engines for the second engineer who was due to take over the watch at 1800.

At about 1500 the master re-confirmed with the chief officer that *Moondance* was scheduled to move to the linkspan at about 1800.

In the meantime, the chief engineer went ashore and visited *Clipper Point,* which was berthed nearby. The vessel was a recent addition to the Seatruck Ferries fleet, and she also shared the Heysham to Warrenpoint route. The purpose of his visit was to view the modern engine room and discuss the performance of the vessel with the master and chief engineer, who were old acquaintances. The chief engineer returned to *Moondance* at 1645 and went straight to his cabin to continue working on his end of month report.

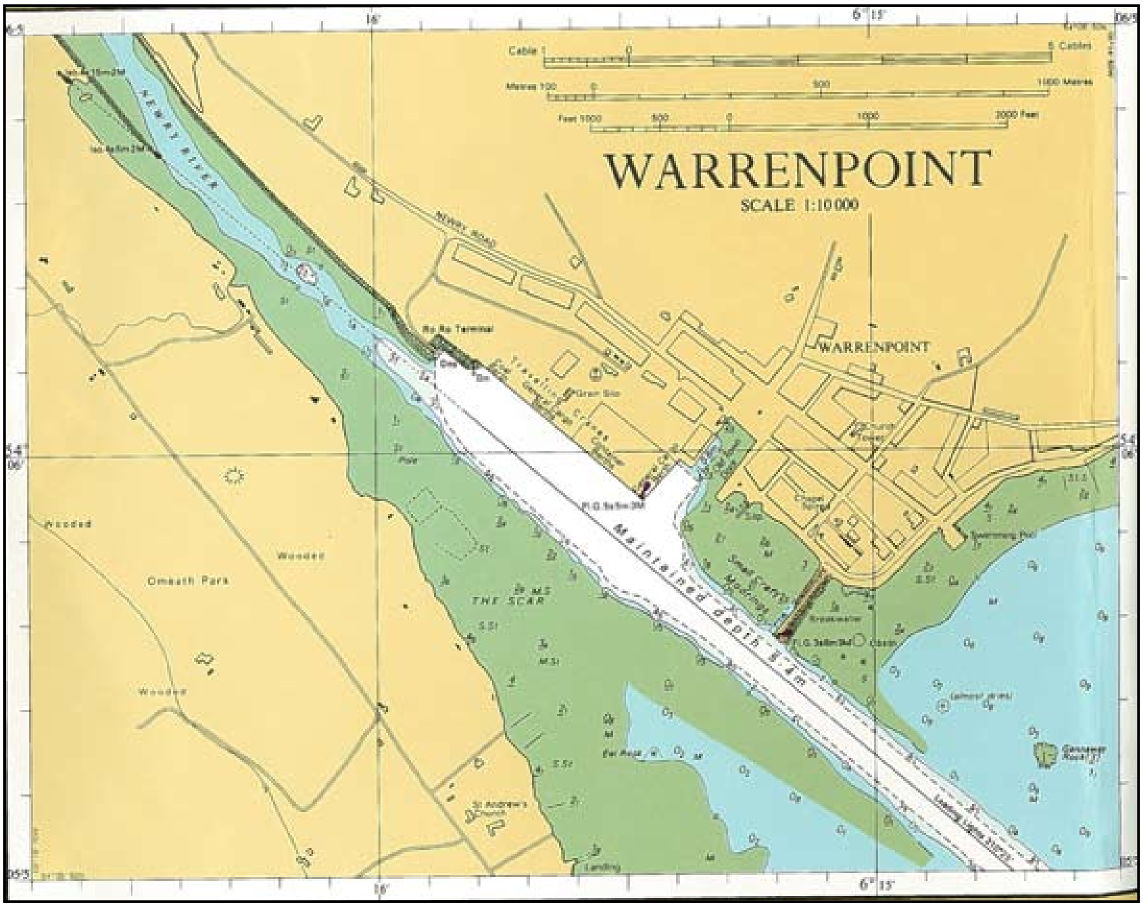
1.3.2 Preparations for the move to the linkspan – 29 June

At approximately 1740, the master went to the bridge in readiness for the move. He was alone, and in accordance with his custom and practice he did not intend for anyone to accompany him on the bridge for the move. He checked the recorded draughts, which were 3.9m forward and 4.4m aft. He then carried out steering gear and controllable pitch propeller (CPP) checks from the bridge and port bridge wing, where he intended to position himself for the departure. The port bridge wing control panel is shown at **Figure 2**. A short time later, the chief officer went to the bridge to discuss the departure plan with the master. The master explained that he intended to spring *Moondance* off the jetty, and then move the vessel astern parallel to the jetty until the stern just passed the jetty knuckle. At that point he intended to use the bow thruster set to starboard, on maximum power setting, to assist in making a 90º turn, to run stern first, alongside the container berths up to the linkspan. The layout of Warrenpoint Harbour is at **Figure 3**.

Figure 2

Port bridge wing control panel

Figure 3



Layout of Warrenpoint Harbour

At 1750 the bosun and chief officer went to the forward and after mooring stations respectively. Each was accompanied by two ABs and, on arrival, satisfactory VHF radio checks were carried out with the master.

The engine room records show that the Port Departure Procedures, as detailed in form MD 32-07 **(Annex B)**, were completed at 1730. At 1740 the third engineer started both main engines to warm them through. He also started the starboard generator. Both generators were running in parallel, connected to the switchboard, and all parameters were normal. At this point the generators' sea water cooling supply was still being supplied from the harbour service pump. At 1745 the third engineer reported to the chief engineer, by telephone, that it was approximately 15 minutes to "stand-by" main engines. The chief engineer advised that, because the move was to the linkspan, he would remain in his cabin, working on the end of month report, but that he should be advised immediately of any problems.

1.3.3 Departure

At approximately 1750 the second engineer arrived in the Engine Control Room (ECR) to take over the watch. The third engineer advised that the main engines were running at 600 rpm and were still warming through with the fresh water cooling jacket temperatures at 55ºC[1]. After handing over the watch, the third engineer returned to his cabin and switched on his remote engine room alarm panel.

At 1754 the master rang "stand-by" engines on the telegraph. The second engineer connected the port shaft generator to the switchboard to supply electrical power to the single bow thruster. The master, who was by now at the control position on the port bridge wing, started the bow thruster and ordered the forward mooring party to single up to one forward spring. He also ordered the two after back springs to be let go. At 1805 the second engineer went into the engine room from the ECR to start one of the main sea water service pumps. He noted that the discharge pressure was normal, at about 2.1 bar. He then stopped the generator sea water cooling harbour service pump and believes he opened the valve which supplied generator sea water cooling from the main service pump system before returning to the ECR.

At 1807, the chief officer reported to the master that *Clipper Point* had left the linkspan and had just passed astern of *Moondance*. The master ordered the remaining forward and after mooring lines to be let go. The helm was set hard to starboard, the starboard propeller at dead slow ahead and the port propeller at ¾ astern. *Moondance* left the jetty and made steady sternway towards the knuckle of the quay.

1.3.4 Engine room events leading up to, and immediately after the blackout

At approximately 1808, just before *Moondance* slipped from the berth, the second engineer was in the engine room when he heard an alarm. He returned to the ECR and saw that the port generator high fresh water temperature alarm was sounding and the red alarm light was illuminated on the ECR alarm panel **(Figure 4)**. The second engineer cancelled the alarm and went into the engine room to investigate the cause. As he approached the port generator another alarm sounded, but he did not, at this point, return to the ECR to check what the fault was, nor did he alert the chief engineer or the master to the overheating problem.

The second engineer felt the port generator fresh water cooler outlet pipe and found it to be hot. He also noted that the fresh water cooling thermometer was reading above 90ºC. Unable to determine the cause of the overheating, the second engineer returned to the ECR, where he was confronted with numerous red lights and audible alarms, including those for the starboard generator. He cancelled the alarms, but once again he did not alert the chief engineer to the problems. Believing there must have been an interruption in the sea water cooling of the generator fresh water system, the second engineer re-started the harbour service pump to supply the necessary cooling water to the generators. As he was about to leave the ECR to check the positions of the generator sea

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[1] When the main engine fresh water cooling jacket temperatures reached 60ºC the procedure on board *Moondance* was for one of the main sea water service pumps to be started to cool down the main engine fresh water system.

Figure 4

Engine Control Room alarm panel

water system valves, the third engineer contacted him by dial telephone to find out the cause of the alarms he had heard from his cabin alarm panel. Almost immediately afterwards, at about 1811, a total blackout occurred as the port and starboard generators tripped on high fresh water temperature.

It was not until the cabin lights went out, and the ventilation fans stopped, that the chief engineer was aware of problems in the engine room. He picked up his torch and ran from his cabin towards the engine room. He was followed by the third engineer and slightly later by the electrician, motorman and fitter.

On arrival at the ECR they found that both main engines were still running and that the second engineer was trying to connect the starboard shaft generator to the switchboard to restore electrical supplies. This was unsuccessful because of difficulties in controlling the generator’s voltage. The second engineer was extremely nervous and told the third engineer, in Polish, that the vessel had suffered a blackout but that he was not sure of the cause. There were no discussions at this point with the chief engineer.

The third engineer went into the engine room to investigate the cause of the generator high temperature, but he was hampered as there was no lighting because the emergency generator had failed to start automatically. On his way he put both of the main engine fuel racks to the “no fuel” position to stop the engines. At the same time, the chief engineer operated both main engine emergency stops from the ECR. As the main shafts slowed down, the port shaft generator supply breaker opened, disconnecting it from the switchboard and with it power was lost to the bow thruster. Notably, the third engineer did not inform the chief engineer what he had done in deciding, unilaterally, to stop the engines, neither did the chief engineer inform the master of his intention to stop main engines.

1.3.5 Actions taken by deck officers following blackout

As *Moondance* slipped from her berth, the master was on the port bridge wing looking aft **(Figure 5)**. Very soon after slipping, at about 1811, the bosun reported to the master, by VHF radio, that power had been lost to the forward winch. This was co-incident with alarms sounding on the bridge indicating loss of electrical supplies to the VHF radio, fire alarm panel and steering gear. At the same time, one of the ABs told the chief officer that power had been lost to the after winch. Before this could be reported, the master, now aware that there had been an electrical failure, attempted to contact the ECR by the dial telephone. Because there was no response due to the electrical failure, the master then tried to make contact using the sound powered telephone. This also went unanswered, so he instructed the chief officer to telephone the ECR to find out what the problem was. The master did not consider the option of stopping main engines using the bridge engine emergency stops.

When the chief officer made his way to the starboard after access to No 2 deck to use the telephone adjacent to the Emergency Generator Room access, he noticed the chief engineer standing on the mid-stair platform and then descending the ladder to the engine room. When the chief officer passed the access to the emergency generator compartment he noted that the generator was not running and that No 2 deck was in darkness.

The second officer was in his cabin when he heard the alarms from the bridge. He immediately made his way there to mute the alarms and to assist the master. At 1812 the master noticed that the main engines had been stopped and that the port and starboard propeller pitch indicators, on the port bridge wing and on the bridge indicated full astern pitch. Recognising the immediate risk of grounding, the master ordered the bosun to let go both anchors, which he duly did. However, *Moondance* continued to make sternway and, at 1813, she grounded on the south-western bank of Carlingford Lough, with the ship’s head at 055º (T). The incident was recorded on the Warrenpoint Harbour video monitoring system. The grounding position is shown on the chartlet at **Figure 6**.

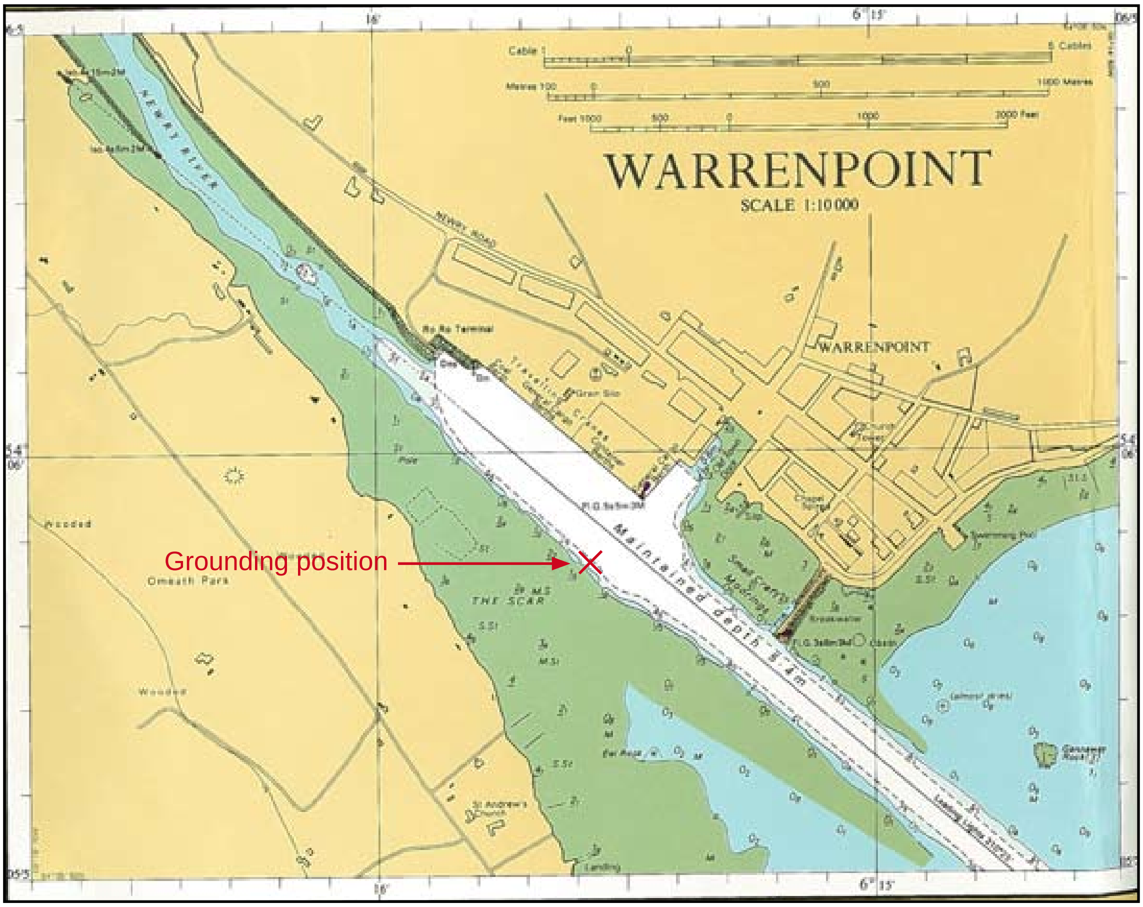
The chief officer could not make telephone contact with the chief engineer, so he made his way to the ECR. At about this time he heard the master state on the VHF radio that the vessel was aground. Once at the ECR it was clear to the

Figure 5

After view from the port bridge wing

Reproduced from Admiralty Chart BA 2800 by permission of
the Controller of HMSO and the UK Hydrographic Office

Figure 6



Chartlet of Warrenpoint Harbour, showing grounding position chief officer that the engine room team were pre-occupied in trying to identify the cause of the blackout. He advised the chief engineer that the vessel was aground, although the chief engineer could not later recall this, before returning to the bridge.

By this time the master had referred to Emergency Checklist No 8 **(Annex C)** covering grounding and stranding, which was held in the Bridge Emergency File. He contacted Seatruck Ferries and Warrenpoint Harbour Authority to advise them of the situation and to request tug assistance. The master then instructed the second officer to carry out tank soundings every 20 minutes, and for the chief officer to check the integrity of the steering gear compartment. A short time later, the second officer confirmed that the soundings were unchanged from those taken before the grounding and so the master concluded that the hull had not been breached. At about 1825 the chief officer reported to the master that there was no water ingress into the steering gear compartment, but there were obvious signs of oil leakage from the steering motors. However, the oil had been contained in the compartment.

The master and chief officer then discussed the possibility of starting the main engines. Although the chief engineer was not consulted, because the sound powered telephone was not being answered, it was decided that it would be inappropriate at this point to start them because the extent of grounding, and the condition of the rudders and propellers, were unknown. The master sent the chief officer back to the ECR at 1835 to instruct the chief engineer not to start main engines, and to verify whether the main engines could be made available if required. On returning to the ECR, the chief officer advised the chief engineer that the dial telephone was ‘off the hook’ and that he should contact the master to discuss the situation. This he apparently did, but neither could later recall the content of this discussion. The chief officer then returned to the bridge.

1.3.6 Actions taken to recover engine room systems

After the main engines had been stopped, the situation in the engine room became chaotic. The chief engineer had great difficulty in establishing his authority, and his control of the situation deteriorated as the Polish engineers discussed fault finding options, in Polish, without recourse to him. Fault finding was also severely hampered by the lack of lighting because the emergency generator had still not been started.

Attempts to restart the generators were unsuccessful because the fresh water cooling temperatures were still above the shut down threshold. Cool fresh water was run down from the boiler header tank to the port generator fresh water header tank in an attempt to bring down the fresh water temperature. Again this proved unsuccessful. The motorman then suggested flushing the port generator fresh water cooler with sea water supplied from the emergency fire pump which was driven off the emergency generator.

At about 1825 the third engineer went to the emergency generator compartment and found the generator's control panel was set to the "manual start" position instead of the normal "automatic" stand-by position **(Figure 7)**. He started the generator in "manual mode", clutched in the emergency fire pump and confirmed that it was pumping correctly **(Figure 8)**. He then went to the steering gear compartment and confirmed that the rudder stocks were damaged and that the hydraulic oil header tank had lost its oil charge. He then returned to the engine room and reported his findings to the chief engineer. By now there was limited lighting being supplied from the emergency generator, and the situation in the engine room became calmer.

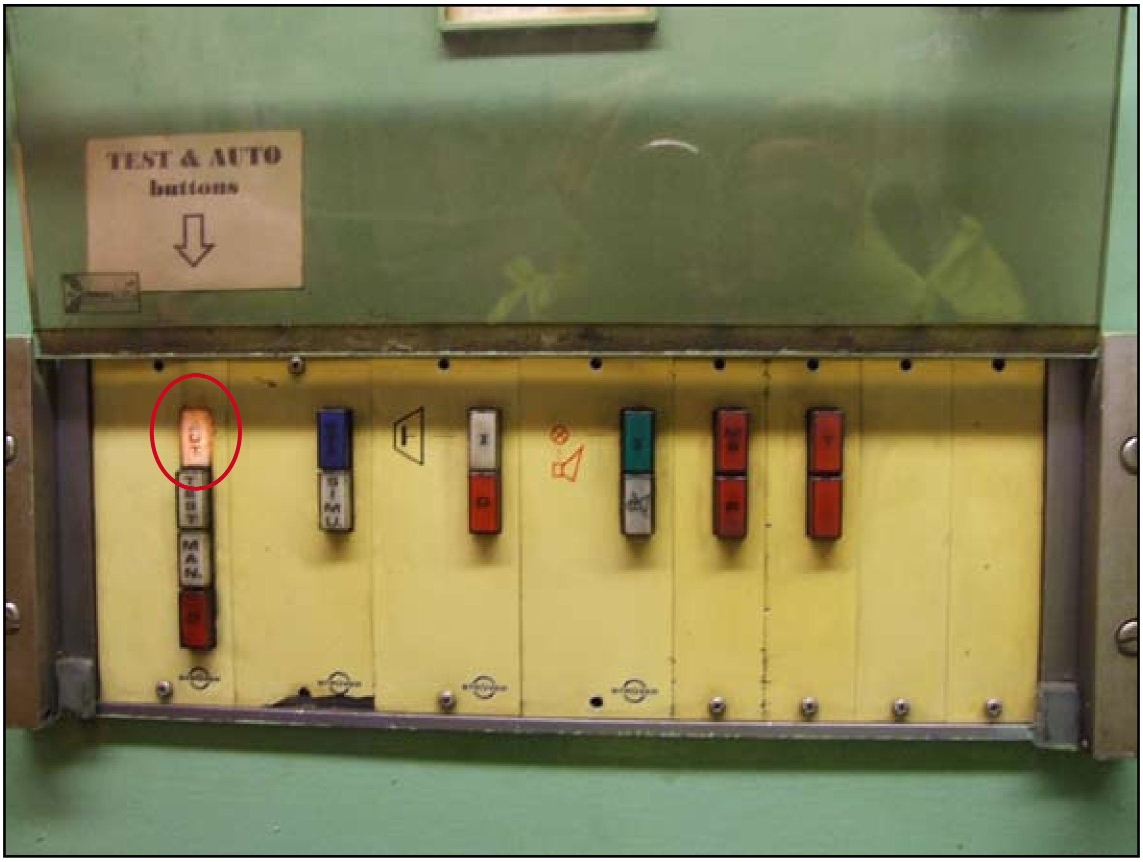
The port generator "on engine " sea water strainer was checked to be clear of debris before sea water was supplied from an engine room hydrant to the inlet side of the port generator fresh water cooler **(Figure 9)**. This quickly brought the fresh water temperature down, and the port generator was able to be started and connected to the switchboard. With electrical power now available, the generator sea water cooling harbour service pump was started to provide cooling water to the generators. From this point on recovery was rapid. The starboard generator was started and connected to the switchboard. This enabled the port generator to be shut down so that the motorman and fitter could disconnect the emergency sea water cooling arrangement and reinstate the normal cooling water supplies. The main engine fresh water cooling pumps and fuel pumps were started, as were the CPP hydraulic pumps. After the systems were re-instated the chief engineer released the third engineer back to his cabin. In the meantime, the electrician started the ventilation fans and other electrical systems before returning to the ECR.

Although the content of the discussions between the chief engineer and the master, which occurred at about 1835, could not be recalled, the chief engineer nevertheless instructed the second engineer to prepare the main engines for starting before he went to the electrician's workshop, next to the ECR, to compose himself and try to rationalise the cause of the generator overheating.

At 1839 the second engineer started the port engine, without prior approval from either the bridge or the chief engineer. The chief engineer quickly returned to the ECR on hearing the engine start, and noted that the engine revolutions were fluctuating and the engine was clearly "labouring", probably because of the excessive propeller pitch and because the propeller blades were partially imbedded in the mud. Concerned about the situation, he operated the port engine ECR emergency stop.

Both the chief and second engineers noted that the port and starboard ECR CPP control levers were set at zero and were selected for bridge control. The ECR port propeller pitch indicator was showing 15^o astern, and the starboard pitch indicator was showing about 6^o astern **(Figure 10)**. No attempt was made to ascertain the true propeller pitch position by reading the mechanical indicator on the CPP oil transfer boxes.

Figure 7

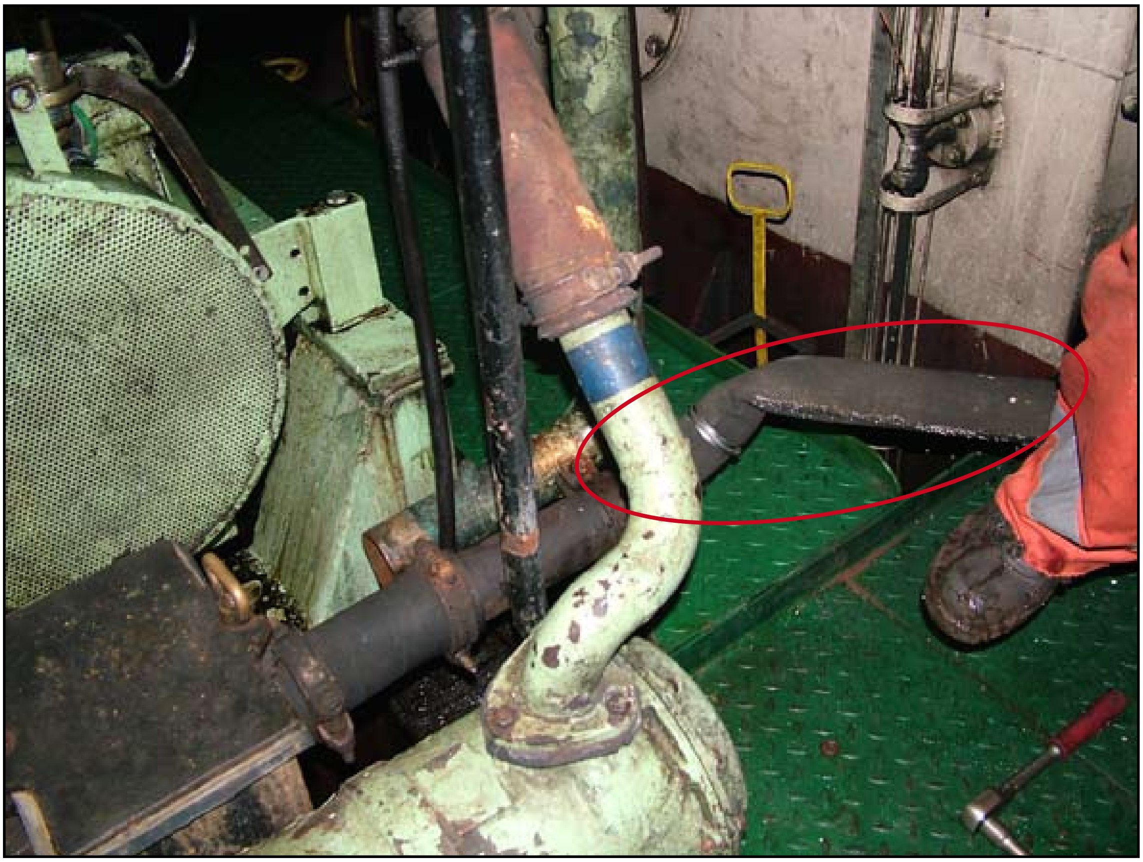


Emergency generator control panel shown in "auto" start position

Figure 8

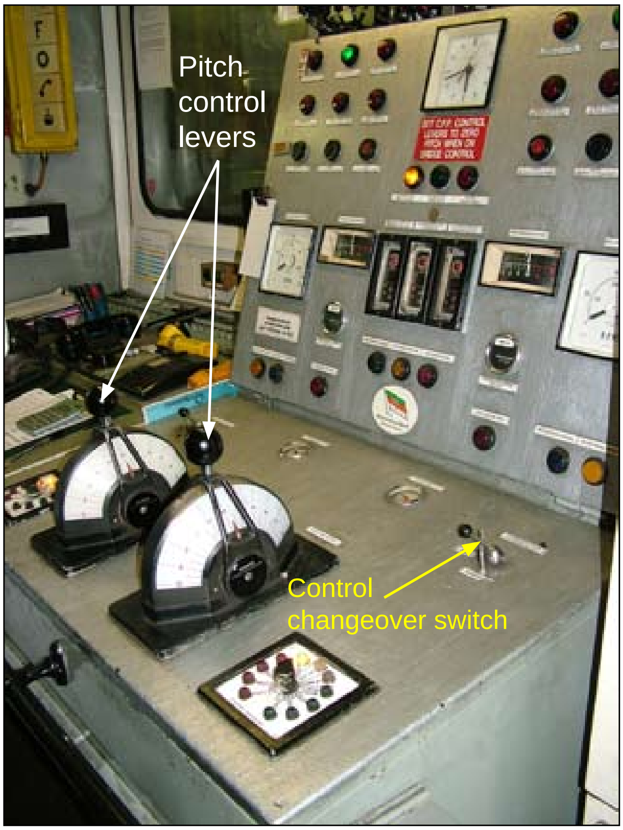
Emergency fire pump arrangement

Figure 9



Port generator emergency cooling arrangement

Figure 10



Position of Engine Control Room controllable pitch propeller levers, control changeover switch and instrumentation

Soon after this, the chief engineer instructed the electrician to align the ECR CPP indicators as there had been a history of indicator mismatch between the mechanical feedback system at the CPP oil transfer box and the ECR indicators. The electrician switched the ECR/bridge CPP control selector switch to the ECR position and the CPPs returned to zero pitch as selected on the ECR pitch control levers. The electrician then aligned the CPP indicators to the zero position, after which the CPP control selector switch was switched back to bridge control. The master and chief officer also noted that the bridge CPP indicators had moved towards the zero position.

At 1847 the second engineer started the starboard engine as instructed by the chief engineer, but this was without approval from the bridge. The engine ran for a very short time before stalling. The engine was re-started at 1902 and *Moondance* was seen to move forward by about ⅓ of a ship's length on the Warrenpoint Harbour video recording system. The master noticed the wash from the starboard propeller, and instead of operating the bridge main engine emergency stop he sent the chief officer to the ECR to order the chief engineer to stop the engine immediately because the vessel was aground. He also instructed the chief officer to inform the chief engineer that the engines were not to be started again unless specifically requested by the master. On receiving this message, the chief engineer stopped the starboard engine using the ECR emergency stop.

At 1915, as the second engineer reverted the starboard engine to the "stand-by" state, the chief engineer went to the steering gear compartment to assess the rudder damage.

1.3.7 Return to the lay-by berth

At 1930 the second officer reported that the tank soundings were unchanged[2]. At this time, the master discussed the options for recovery to the lay-by berth with Seatruck Ferries' Designated Person Ashore (DPA) and superintendent. He also discussed his concerns that, at the time of the blackout, the port and starboard propeller pitches were seen to go to the full astern position.

The DPA advised that two tugs, *Mourne Valley* and *Mourne Shore,* were making their way towards *Moondance* with an ETA of 2000, and that they had been offered Lloyd's Open Form (LOF) arrangements. To minimize the company's exposure to the terms of LOF the DPA, master and superintendent agreed that it would be safe to start the starboard engine as the tugs approached the vessel. This was based on the knowledge that the tide was flooding and the starboard engine had been started with no apparent ill effects. However, the chief engineer was not party to these discussions. At 1945 the master ordered the starboard engine to be started. The engine started without mishap, the parameters were normal and there was no vibration to indicate propulsion system damage.

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2 Tank soundings were continued until 2300, and checked again on 30 June 2008, but with no change in the levels

At 1958 *Mourne Valley* arrived and was made fast at the starboard quarter. After the anchors were aweigh *Mourne Shore* was made fast alongside, and at 2003 *Moondance* was under tow. She was secured alongside the lay-by berth at 2022.

Once alongside, the chief and second engineers went to the steering compartment, refilled the hydraulic oil header tank and attempted to move the rudders using the hand pump, but this was unsuccessful and the rudders remained set hard to starboard.

At about 2120 the chief engineer instructed the second engineer to remove the starboard main service pump strainer and check that it was clear of debris in case this was the cause of the generator overheating. Soon afterwards, the chief engineer discussed the situation with his superintendent, and he was asked if the engine room team had taken control of the CPP and put the control levers astern, which would explain why the master saw the bridge pitch indicators go to the full astern position. The chief engineer vehemently denied this.

Following advice from the superintendent and a DNV class surveyor, the chief and second engineers disconnected the steering gear tiller, blanked the system run downs, and attempted to individually pressurise each of the rudders' operating gear. This was unsuccessful, and all further attempts to move the rudders were abandoned.

1.3.8 Main service pump strainer

The motorman and fitter removed the port main service pump strainer and recovered a large amount of mussels and some small pieces of plastic. They informed the second engineer of their findings and put the debris in the engine room rubbish bin.

During the morning of 30 June the chief engineer asked what had been found in the strainer. He was presented with the contents of the rubbish bin, which included mussels and a large piece of plastic **(Figure 11)**, which he was told was recovered from the strainer.

The chief engineer showed the plastic sheeting to the master and suggested that this was the cause of the sea water cooling supply interruption to the generators. Following discussions with the superintendent, the chief engineer was advised to reconstruct the blockage in the strainer and photograph the evidence **(Figures 12 and 13)**. During the reconstruction, none of those present, who had originally cleared out the strainer, advised the chief engineer that the plastic sheet had not come from the strainer.

Figure 11

Plastic sheeting reported to have come from the main service pump strainer

Figure 12

Reconstruction of purported blocked main service pump strainer - top view

Figure 13

Reconstruction of purported blocked main service pump strainer - side view

1.3.9 Repairs

Moondance was taken in tow on 6 July, arriving at Brocklebank Dock Liverpool on 8 July. The vessel was dry docked in Cammel Laird's dry dock in Birkenhead on 10 July for survey and repairs.

The survey identified no evidence of hull damage. The propellers were also undamaged, but the starboard rudder stock was bent by about 10º **(Figure 14)** and the port rudder stock by about 5º **(Figure 15)**.

1.4 ENVIRONMENTAL CONDITIONS

At the time of the grounding visibility was good, with sunset at 2059. The wind was force 4 from the west. It was half flood tide at 25% of the spring range. High water was at 2057 with a height of 4.4m.

1.5 BRIDGE AND ENGINE ROOM COMMUNICATION FACILITIES

The bridge/engine room communication facilities were extremely limited. The bridge and ECR were both fitted with a single, mains-powered, dial telephone and a single sound powered telephone. There was no communications equipment fitted on either of the bridge wings. If bridge wing control was selected and the master was alone, it was necessary for him to leave the controlling position and go into the wheelhouse to communicate with the ECR.

There was an abundant supply of hand-held VHF radios with which the master could communicate with personnel on deck.

Figure 14

Starboard rudder stock distortion

Figure 15

Port rudder stock distortion

1.6 MAIN PROPULSION MACHINERY FIT

Moondance was fitted with two MaK 8M453AK, 4 stroke, 8 cylinder in-line diesel engines developing a total 4413kW. Each engine drove a 4-bladed Escher Wyss controllable pitch propeller through a reduction gearbox.

The main engines could operate on both intermediate fuel oil and diesel oil. They were supported by electrically driven fresh and sea water cooling pumps and lubricating oil and fuel pumps. The engines could be stopped in an emergency from the ECR, and also from the bridge.

A single 441kW, fixed pitch, reversible motor, Jastram BU80F bow thruster was also fitted. The unit had three power levels and was controllable from the bridge and from each bridge wing.

There was no machinery data logger facility fitted to *Moondance.* System and equipment parameters were manually recorded in the Engine Room Log.

1.7 CONTROLLABLE PITCH PROPELLER SYSTEM

1.7.1 General description

The CPP hydraulic oil system comprised two independent screw hydraulic oil pumps, each of which served the port and starboard systems. In an emergency these could be cross-connected. Each pump supplied oil under pressure to the CPP control valve and pitch actuator. The controlling CPP levers sent a pneumatic signal to the pitch setter, which adjusted the control valve to direct hydraulic operating oil to the oil transfer box and then to either the ahead or astern oil transfer tubes fitted inside the length of the propeller shaft. The oil acted upon pistons in the propeller hub to alter the propeller pitch. As the blades were adjusted, the movement was transmitted back to the control valve and movement continued until the achieved pitch matched that which had been demanded from the selected controlling position. A schematic representation of the CPP system is at **Figure 16**.

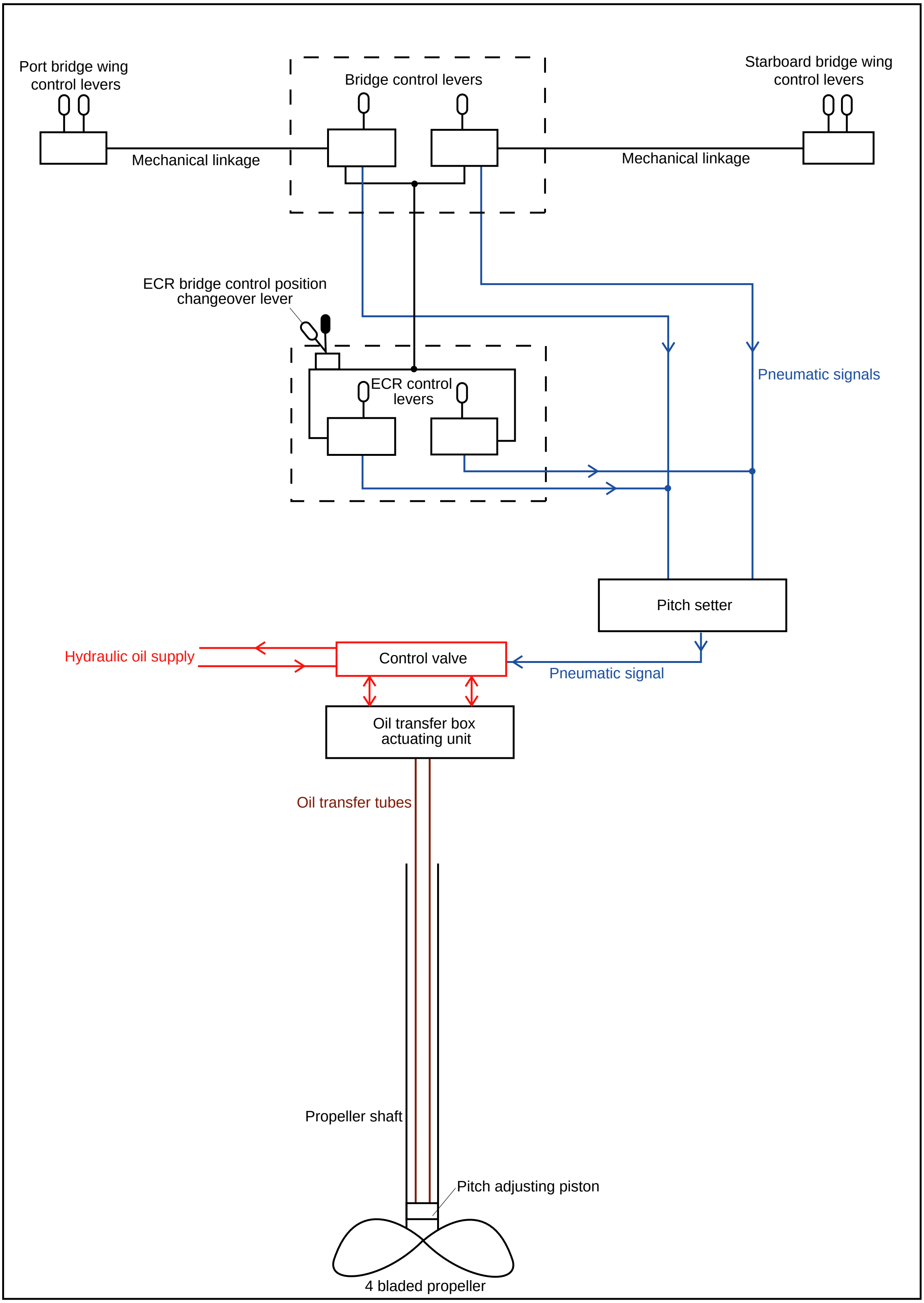
The propeller pitch range was 32º ahead and 23º astern.

1.7.2 Control

The manual CPP control levers were engraved with ten equal divisions for both ahead and astern positions. Control levers were fitted in the ECR, on the bridge **(Figure 17)** and at the port and starboard bridge wings. The bridge wing units merely operated the bridge slave unit via a chain link arrangement. The ECR was considered to be the master control position, and it was only from the ECR that control could be switched between the ECR and the bridge. An indicator light on the bridge identified which station had control.

Pitch could also be altered by hand in an emergency by manually operating the oil transfer (OT) box controls **(Figure 18)**. The procedure for doing so was promulgated in Form MD28-07 Local/Emergency Operation of Pitch Control **(Annex D)**.

Figure 16



Schematic of the CPP system

Figure 17

Bridge CPP control levers

Figure 18

Local pitch control arrangements

1.7.3 Pitch indications

Port and starboard CPP pitch indicators were fitted on the bridge, each of the bridge wings, in the ECR and on each of the OT boxes.

The OT box indicators provided a direct mechanical read off of pitch and were considered to be the datum readings. The pitch position was converted to an electrical signal by a transmitter that used the 24v control circuits to provide the indications at all other positions. In the case of a 'blackout' occurring, the pitch indicators defaulted to the bottom of the gauge, below the full astern indicated position.

1.7.4 CPP default position in the event of an hydraulic oil failure

In the event of a CPP hydraulic oil failure the pitch would default to the full astern position if the shaft was rotating.

Designed internal leakage of the CPP control valve allowed the propeller pitch to move astern under the influence of the hydrodynamic forces to which the rotating propeller was subjected. This remained true regardless of the demanded CPP position prior to failure. If the shaft stopped rotating before the propeller blades reached the astern stops then the pitch movement would also cease. When the hydraulic oil pressure was restored, the CPP would assume the pitch selected by the controlling position.

1.7.5 CPP indicator alignment checks

Because of reported variations in the pitch indicator positions at the bridge and ECR after the grounding, a full set of pitch indicator alignment checks was carried out on 12 July at Liverpool. The results of the tests are at **Annex E** and are discussed in more detail at Section 2.

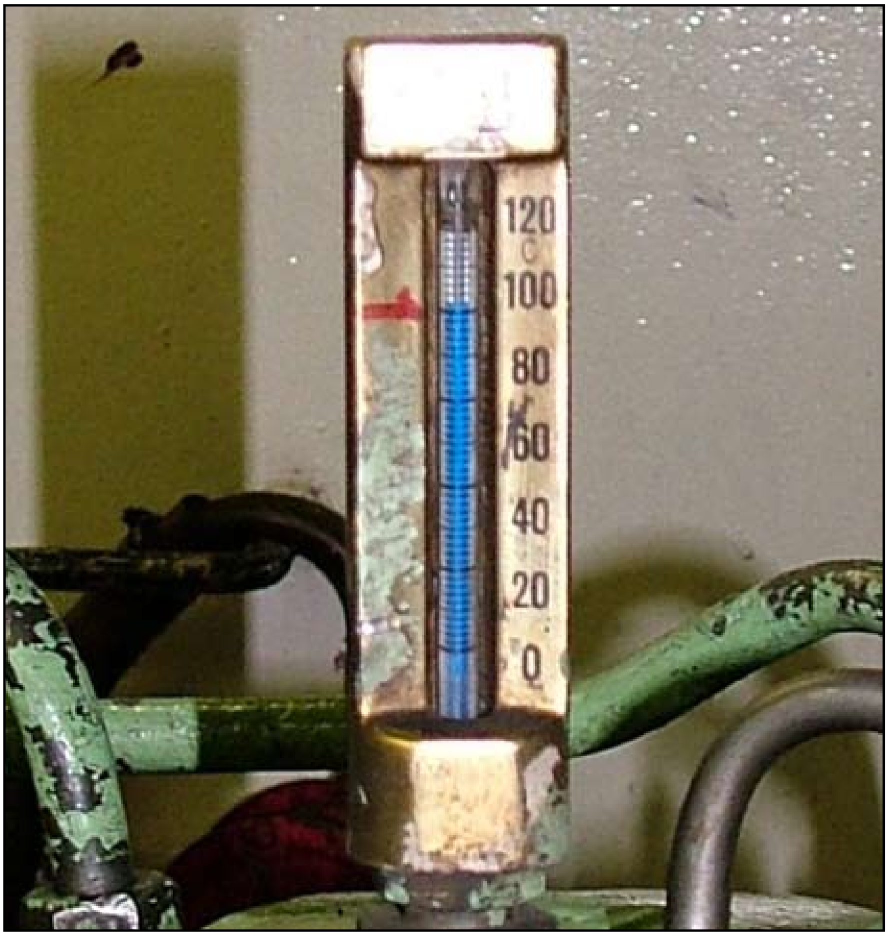
1.8 ELECTRICAL GENERATION AND DISTRIBUTION SYSTEM

1.8.1 Diesel engines

Moondance was fitted with two Deutz BA 8M 816 diesel engines in the engine room, each driving an AEG Type DKBH alternator. The engines and lubricating oil were fresh water cooled, and the fresh water was itself cooled by sea water. The fresh water/sea water cooler was fitted with a strainer on the sea water inlet side to collect debris. During operations in Carlingford Lough the sea water systems were prone to mussel contamination from the numerous mussel beds farmed in the confined waters, so the strainers were subjected to regular inspection and cleaning.

The fresh water temperature was monitored manually using a thermometer fitted to the engine fresh water rail **(Figure 19)**. It was noted that the engraved 20ºC graduations on the thermometer housing were misaligned to the graduations on the glass alcohol thermometer providing ambiguous temperature readings.

Figure 19



Port generator fresh water system thermometer

A red line on the housing was said to indicate 80ºC and this was used as the datum. Typical fresh water temperatures of 80-82ºC (using the red line datum), were recorded in the log when the load was between 100 -120kW.

1.8.2 Main alternators and shaft generators

Each of the diesel alternators was rated at 430 amps, 270kW, 440v and 60Hz and were designed to run in parallel.

There were two shaft generators fitted and these were rated at 900 amps, 550kW, 440v and 60Hz. The frequency of the shaft generators was controlled by the main engine speed. Setting the main engine speed at 600 rpm controlled the shaft generator frequency at 60Hz.

At the time of the accident, the starboard shaft generator was effectively out of action because of a defective varistor which was part of the generator's voltage regulation control system. Attempts had been made to repair the unit, and while subsequent trials showed some improvement, the voltage control remained unstable, rendering the generator unsafe for normal operation.

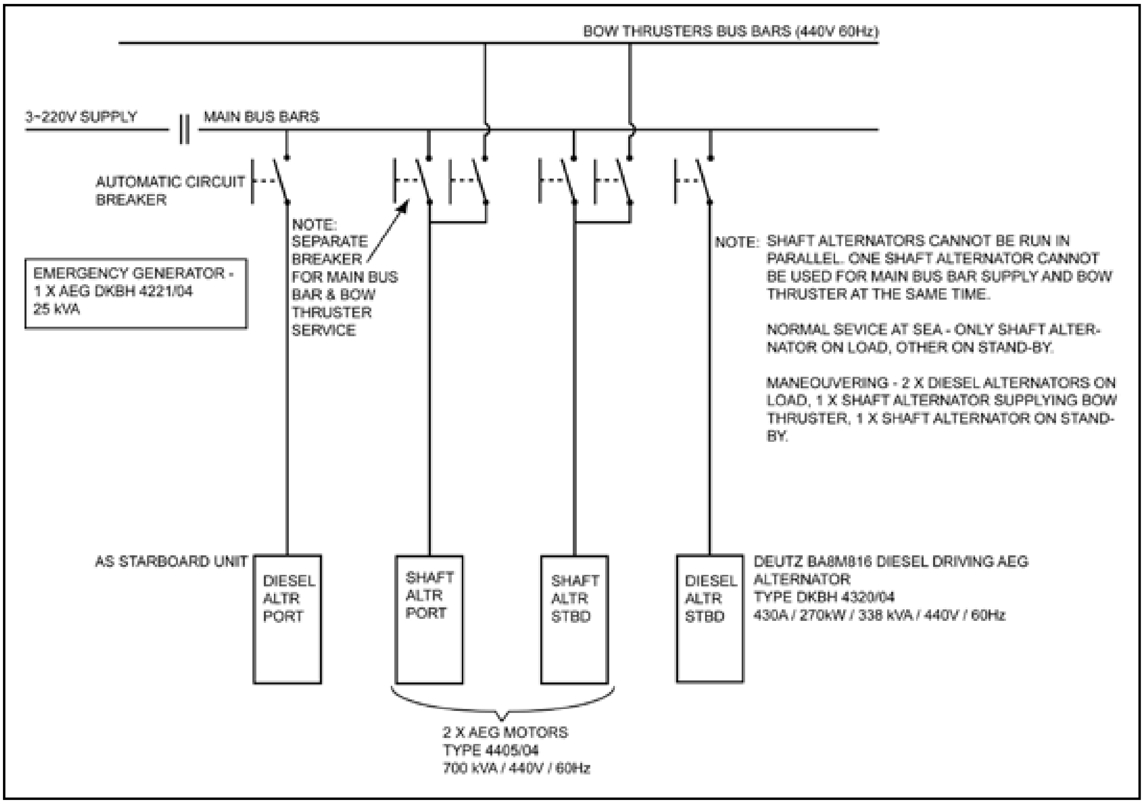
1.8.3 Emergency generator

A single, air cooled, three cylinder Lister diesel engine driving an AEG DKBH 440v, 20kW emergency generator was also fitted. It was designed to start automatically and provide essential supplies to an air compressor, steering motor, fuel pump and limited emergency lighting when a significant voltage drop was sensed indicating that the main generators had tripped. The generator control panel could be selected for both manual and automatic start. The panel could also be set to simulate a voltage drop and cause the generator to start for test purposes.

1.8.4 Distribution system

A schematic of the electrical distribution system is at **Figure 20**. The shaft generators were not designed to run in parallel. To prevent overload, the breaker arrangement prevented a single shaft generator from supplying both the bow thruster and main bus bar supplies at the same time.

Figure 20



Schematic of the electrical distribution system

At sea, a single shaft generator provided the electrical services. During manoeuvring i.e. in pilotage waters, both diesel alternators supplied the main bus bars, in parallel, and one shaft generator was connected to supply power to the bow thruster bus bars.

Emergency batteries provided a 24v emergency electrical supply to the Global Maritime Distress and Safety System (GMDSS), fire alarm panels, as well as selected control circuits and bridge and ECR instrumentation.

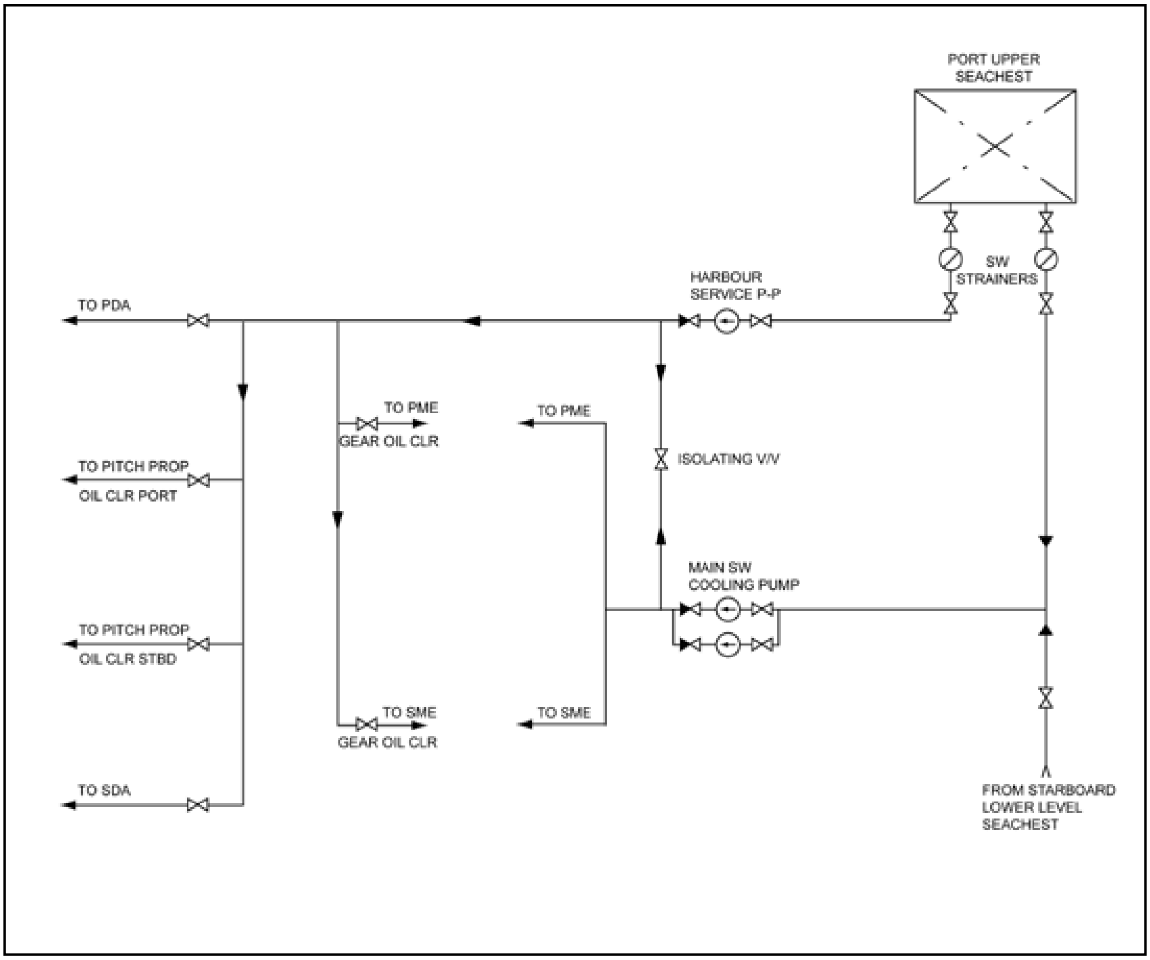
Automatic battery-supplied emergency lighting was fitted in the passenger cabins only.

1.9 SEA WATER COOLING SYSTEM

1.9.1 General description

Both the main engine and generator primary fresh water cooling systems were themselves cooled by supplies from the sea water system. A schematic of the engine room sea water system is at **Figure 21**.

Figure 21



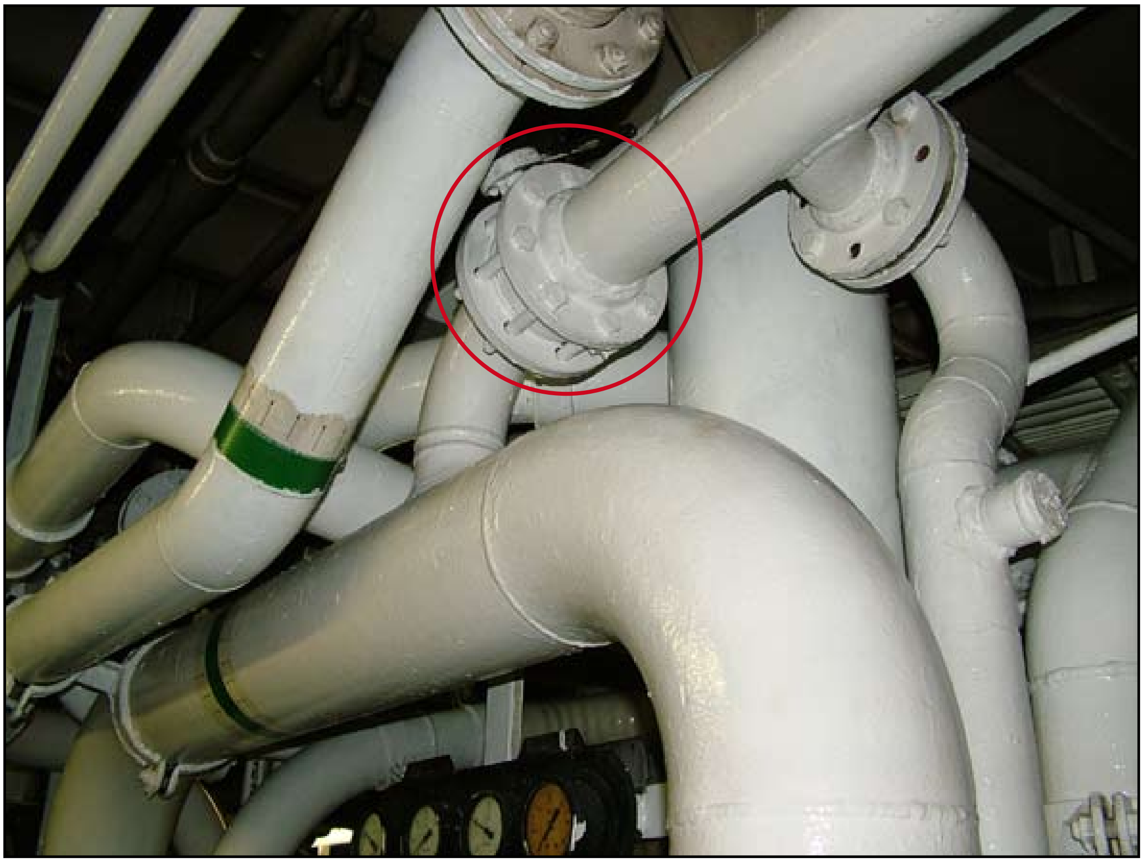
Schematic of the engine room sea water cooling system

In harbour, the generator sea water was supplied from the harbour service pump which took its suction through a strainer from the high level, port sea chest. Water was discharged at between 1.5 and 1.75 bar and was supplied to the port and starboard generator fresh water coolers via an “on engine“ strainer.

When the main engines were running, there was a significant increase in sea water cooling demand, and this was satisfied by running one of the two 230m^3/hour main service pumps, leaving the other pump on stand-by. Both pumps could take their suctions from either the high level, port sea chest or the low level, starboard sea chest. It had become normal practice to use only the port suction because of the risk of ingesting debris while in harbour, which would have increased had the starboard low level suction been used. The pumps discharged to the main engine coolers at approximately 2.4 bar. When a main service pump was running, the isolating valve **(Figure 22)** which connected the main service system to the harbour service system was opened to provide sea water cooling to the generators and CPP oil coolers. Once the valve was opened the harbour service pump was shut down.

The harbour service and main service pump port high level suction strainer arrangements are shown at **Figure 23**.

Figure 22

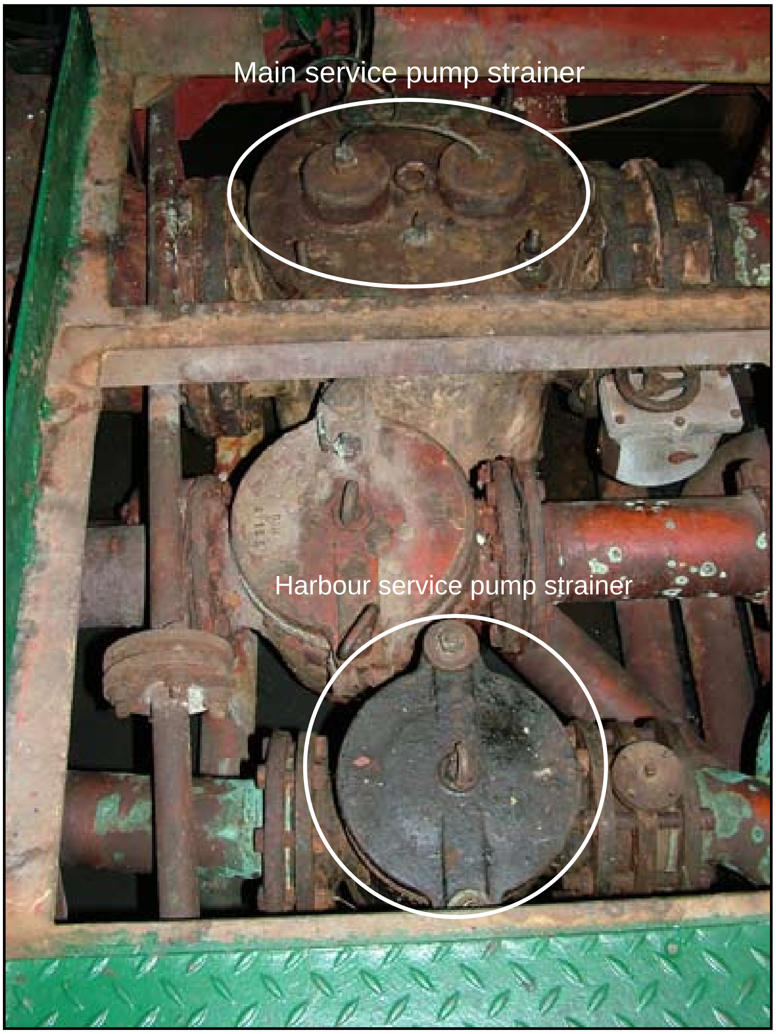


Main service to harbour service system isolating valve

1.9.2 System alarms

A low pressure alarm, set at 0.8 bar, was fitted to each of the main engines to alert watchkeepers of a potential supply problem which could lead to an overheating problem. There was no low pressure alarm fitted to the generator sea water systems.

Figure 23



Main and harbour service pump suction strainer arrangements

1.9.3 Marine growth protection system

The sea water system was protected from the build up of marine growth, which could cause blockage and affect heat transfer, by an Intakematic Marine Growth Protection System. The port and starboard main service pump suction strainers were fitted with sacrificial anodes **(Figure 24)** fed by a low, direct current (dc), electrical supply provided via a control panel **(Figure 25)**. The system operating instructions **(Annex F)** specified a normal current setting of 0.3 amps, but it was noted that the control panel was set to deliver 0.7 amps.

The system was treated by releasing controlled concentrations of anode copper ions into the water flow. Marine growth is controlled by the ions because it will not attach to surfaces where copper deposition is taking place.

The system anodes were last changed in October 2007.

Figure 24

Main service pump suction strainer Intakematic
Marine Growth Protection System sacrificial anode

Figure 25

Intakematic Marine Growth Protection System control panel

1.10 SEA WATER COOLING SYSTEM INSPECTION AND PERFORMANCE TESTS

1.10.1 Port and starboard sea suction inlet gratings and sea chests

On 10 July 2008 the port and starboard sea water inlet gratings and sea chests were inspected while *Moondance* was dry docked. The last time the gratings and sea chests were inspected and cleaned was during a scheduled dry docking in August 2006.

All gratings were found to be correctly secured. The mainly unused starboard, low level suction grating was largely free of marine and crustacean growth **(Figure 26)**, although there was a small amount of mussel growth inside the sea chest **(Figure 27)**. There was heavy mussel attachment to the outside of the port high level suction gratings for both the harbour service and main service pumps. Mussel attachment on the inside of the gratings was markedly worse. Mussels were also attached to the inside of the sea chest, although the pump suction stub pipes were clear **(Figures 28, 29 and 30)**.

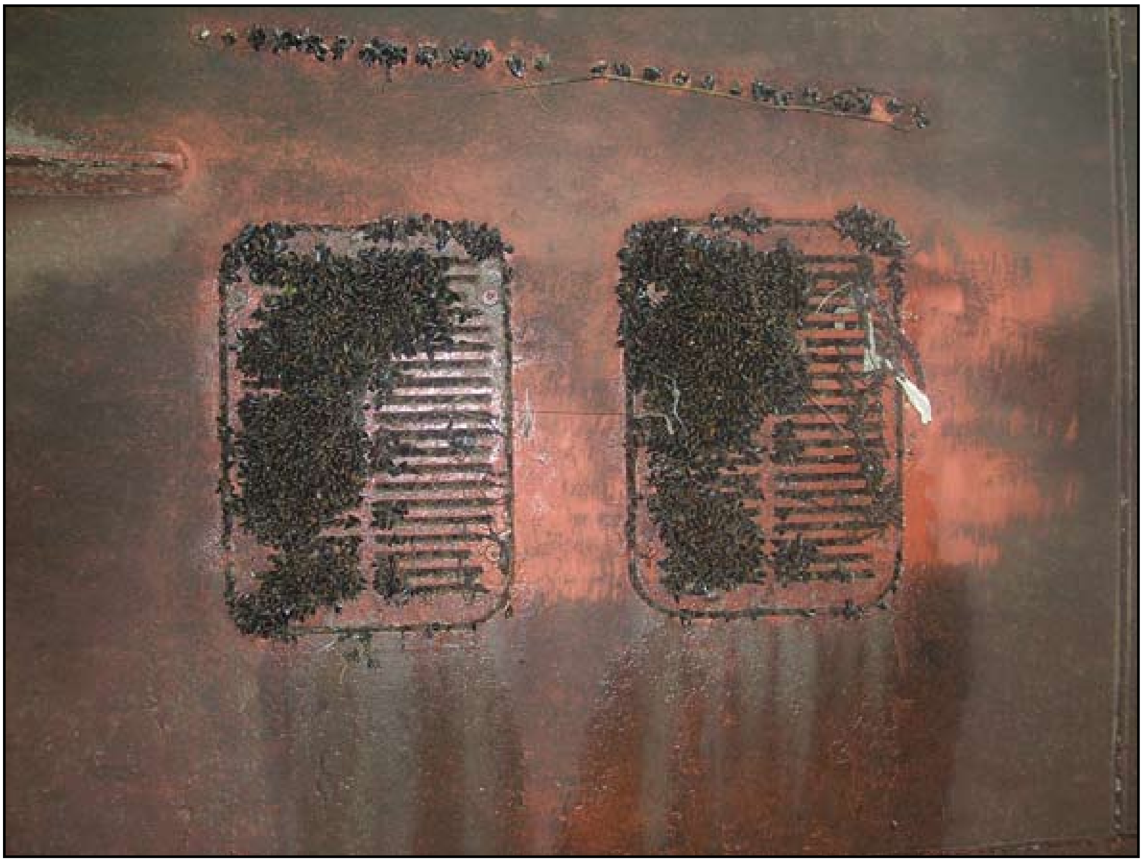
Figure 26

Starboard main service pump low level suction grating

Figure 27

Inside starboard main service pump low level suction sea chest

Figure 28



Port main service pump and harbour service pump
high level suction grating - external view

Figure 29

Port main service pump and harbour service pump
high level suction grating - internal view

Figure 30

Port main service pump and harbour service
pump high level suction sea chest

1.10.2 Pressure performance tests

Tests were carried out on the suction and discharge pressures of the harbour service pump and the two main service pumps before and after the sea chest inlet gratings were cleaned. The purpose was to determine the effect of the mussel growth on the performance of the pumps. The results are at **Table 1**.

The port and starboard main engine sea water system low pressure alarms were also checked and were found to operate, as designed, at 1.0 bar. Both alarms gave the correct indication on the ECR alarm panel.

	Before mussel removal		After mussel removal	
	Suction pressure (bar)	Discharge pressure (bar)	Suction pressure (bar)	Discharge pressure (bar)
Harbour service pump	0.0	1.6	0.0	1.7
No1 Main service pump	0.0	2.15	0.0	2.4
No2 Main service pump	0.1	2.6	0.0	2.4

Table 1: Results of sea water system pump suction/discharge performance tests

1.11 GENERATOR FRESH WATER COOLING TEMPERATURE TESTS

Checks were made on the port generator fresh water system high temperature alarm and trip levels. It was confirmed that the alarm was set at 85ºC and the trip level at 95ºC as specified on the ECR alarm panel set point chart – entry 113 **(Annex G)**.

The generator was running with 110kW load and the fresh water cooling temperature was 82ºC (when using the red line datum) when the sea water cooling supply was isolated. It took 3 minutes for the high temperature alarm to sound at 85ºC and a further 2½ minutes for the engine to trip at 95ºC. The ECR alarm panel visual red indicator and audible alarm functioned correctly.

1.12 CREWING ARRANGEMENTS

The British master, chief officer and chief engineer were employed and managed by Seatruck Ferries. The Polish second and third engineers, second officer and 12 ratings were contracted and managed by the Polish manning agency Morska, which was responsible for checking the suitability of the Polish crew for service with Seatruck Ferries. Further checks were made by Seatruck Ferries' Personnel Department, who identified the need for any additional training over and above the structured ship specific familiarisation training. No additional training requirement had been identified for the deck and engineering teams on board *Moondance* at the time of the accident.

The master was 61 years old and had been at sea since he was 15 years of age. He had served with Seatruck Ferries since 1999 and had wide experience as both mate and master on the company's vessels. The master was issued with a Pilotage Exemption Certificate (PEC) for Warrenpoint Competent Harbour Authority's area of jurisdiction on 8 November 1999. The PEC was revalidated on 1 August 2007 and was therefore valid at the time of the accident.

The 60 year old chief engineer gained his qualification in 1988 and had previously served in *Moondance* when the vessel was owned by Dart Line. He joined Seatruck Ferries in 2006 and had served in *Moondance* since then.

The Polish second engineer was 34 years of age. He held a limited Polish chief engineer's certificate valid for home trade service with a power limitation of 6000kW. He had served with Seatruck Ferries, on board *Moondance,* for about 4 months.

1.13 SAFETY MANAGEMENT SYSTEM

1.13.1 General

The requirement for management companies to establish a Safety Management System (SMS) is laid out in the International Safety Management (ISM) Code. The Code is contained in Chapter IX of the Convention for the Safety of Life at Sea (SOLAS) and came into force on 1 July 1998. Amendments to the Code came into force on 1 July 2002.

The Seatruck Ferries' SMS in support of *Moondance* had gradually evolved as a result of a number of ship management changes. In 1996 Crescent Ship Management Ltd was the ship manager and was responsible for developing the SMS. A number of company mergers followed within the Crescent group and, with them, the SMS responsibilities also changed. In February 2006, following a change of ownership of the Crescent group, Seatruck Ferries assumed responsibility for maintaining and developing *Moondance*'s SMS.

1.13.2 SMS documentation

A number of omissions in the content of the SMS, and inconsistencies between the chief engineer's technical instructions and those detailed in the SMS were noted. These were directly related to this accident and are discussed in more detail at Section 2.

It was also noted that the majority of the documentation in Section 4 of the SMS was stamped with the logo of the previous management company, Crescent Marine Services.

1.13.3 Certification

DNV conducted an ISM Code Certification audit on *Moondance* on 24 February 2006 and on 19 May 2006. Both audit reports confirm that no non-conformities were identified. The vessel held a valid Safety Management Certificate at the time of the accident **(Annex H)**.

Seatruck Ferries was issued with an ISM Document of Compliance by DNV on 21 July 2006. The first annual verification was completed on 10 September 2007. No non-conformities were identified. A copy of the Company Audit Report is at **Annex I**.

1.13.4 SMS internal audits

From February 2006 until February 2008 internal SMS auditing of the company's vessels was carried out by two company superintendents and chief officers serving in Seatruck vessels. From February 2008 the audits were carried out predominantly by the SQM Manager. The SQM Manager and one of the superintendents had attended an ISM Auditors' Course; the other superintendent and chief officers had no auditing qualifications.

A chief officer conducted the last internal ISM audit on board *Moondance* on 17 December 2007 while the vessel was in lay-over at Heysham. A copy of the audit report is at **Annex J**.

1.14 ONBOARD MANAGEMENT

1.14.1 General

The master's and Heads' of Department roles and responsibilities for managing the ship and departments were laid out in the SMS – Section 2 Company Structure and Procedures. The company superintendents and SQM manager visited the ship in Heysham and occasionally "searode" to provide management oversight, inspection and a degree of mentoring. The ship visits were unscheduled and without a clear structured agenda.

Seatruck Ferries management had an "open door" policy and senior ships' personnel were encouraged to visit the company's offices in Heysham. This gave the opportunity for the ships' officers to raise concerns, provide feedback on individuals' performances as well as receive feedback themselves on the management of their departments and the integration of new officers and crew.

1.14.2 Engineering Department Standing Orders

The chief engineers had developed a set of standing orders **(Annex K)** as required by the SMS. The orders complement and build on the broad guidance and responsibilities specified in the SMS. In addition, the chief engineers had developed a set of technical instructions prefixed "MD"1 to "MD"39.

1.14.3 Risk assessments

Objective 1.2.2.2 of the ISM Code requires management companies to

“establish safeguards against all identified risks ……..”

Seatruck Ferries instigated risk assessment procedures to mitigate against identified risks. Section 2 – Form SF004 of *Moondance*’s SMS lays out a Risk Assessment proforma. More detailed guidance is given in Section 3 - Operational and Technical Procedures – SP11.

The internal ISM audit carried out on 17 December 2007 identified that no risk assessments had been undertaken and there was no risk assessment file held on board *Moondance.* The results of the audit were de-briefed to the master. As a result, a Risk Assessment file was introduced as recorded in the ship’s Safety Committee Meeting Minutes dated 2 March 2008.

While the file itself could not be produced during the course of the MAIB’s investigation, two completed risk assessments, covering entry into ballast and fresh water tanks, were provided. These were dated 20 January 2008 and 28 January 2008 respectively.

1.14.4 Checklists

Section 5 of the SMS contained a comprehensive set of Emergency Checklists ranging from steering gear failure to helicopter operations. These were held on the bridge in the Bridge Emergency File.

A number of engineering related checklists had been developed by the chief engineers, one of which is MD 32-07- Port Departure Procedure. This checklist was held under a laminated cover on the ECR panel. The engineer officer of the watch (EOOW) would periodically refer to the checklist when preparing the machinery for departure and would tick the checklist items from memory after completing a number of the actions.

1.14.5 Bridge manning arrangements

On sailing, the bridge was routinely manned by the master and one AB. Immediately after slipping from the berth, the chief officer usually joined the master on the bridge until about 20 minutes after leaving pilotage waters, after which the second officer took the watch. On approaching Heysham and Warrenpoint the chief officer was called to the bridge about 1½ hours before the Helly Hunter and Lune Deep buoys respectively. The master normally took the con on arrival at the buoys, until berthing, allowing the chief officer to assume charge of the after mooring party. However, during manoeuvring exclusively in port, e.g from the lay-by berth to the linkspan it had become normal practice for the master to be alone on the bridge. The bridge manning arrangements at sea were detailed in SMS Section 4 – MD06 – Master's Bridge Watchkeeping Standing Orders **(Annex L)**. The manning levels during manoeuvring exclusively in port were not specified.

1.14.6 Engine room manning and alarm arrangements

The engine room was continuously manned at sea and in harbour, by either the second or third engineers. They kept the 0600 -1200 / 1800 -2400, and 2400 - 0600 / 1200 - 1800 watches respectively. During a lay-over period they were permitted to be available on an "on call" basis after having checked the engine room running machinery on taking over their watch. In this case they were alerted to problems by alarm panels located in their respective cabins.

On scheduled sailings the chief engineer usually positioned himself in the ECR from "stand-by" engines until leaving pilotage waters. The chief engineer's policy was inconsistent during manoeuvring in harbour in that he would not always be in the ECR. However, when not in the ECR he advised the EOOW of his whereabouts The Chief Engineer's Standing Orders did not specifically state what the engine room manning levels should be, either at sea or in harbour.

1.14.7 Emergency drills

The requirement for the conduct of emergency drills is laid out in Section 2 of the SMS. The drill schedule on board *Moondance* **(Annex M)** specified 22 drills. The machinery related drills included engine room fire, main engine failure and emergency steering. Local/emergency operation of pitch control was not included, and had never been practised.

There was no evidence that the engineering team had been drilled locally by the shore management staff, or that the chief engineer had carried out touch drills in lower level breakdowns such as generator high cooling water temperatures.

1.14.8 New crew training arrangements

New crew were contracted by the Polish manning agency and were subjected to a course of structured onboard familiarisation training.

1.15 GUIDANCE ON BRIDGE MANNING LEVELS

1.15.1 Port Marine Safety Code

The Port Marine Safety Code (PMSC) was developed by the Department for Transport for implementation in December 2001. The Code introduced the principle of a national standard for every aspect of port marine safety. These included the completion of formal risk assessments of marine operations in harbours and approaches, and the management of the risks through a safety management system.

Since the introduction of the Code, the MAIB has made wide-ranging PMSC related recommendations to the Port Marine Safety Code Steering Group (PMSCSG). Following the collision between *Amenity* and *Tor Dania* in the River Humber on 23 January 2005, the PMSCSG was recommended to provide guidance on the:

> *"Verification of the relevant bridge team manning arrangement, so as to ensure appropriate levels of support for the PEC holder during port movements"*

In October 2007 the MCA issued Marine Information Note - MIN 307 (M) – Port Marine Safety Code which amended, and added guidance to the Code. Annex III of the Note lays down the PEC Conditions of Use which includes the statement that there should be:

> *"Adequate bridge manning levels and support for the PEC holder"*

1.15.2 Warrenpoint Harbour Authority

Warrenpoint Harbour Authority addressed the manning level issue in 1998 with its Bye-Law 19 which states that:

> *"Except with the permission of the Harbourmaster, the master of a vessel which normally trades to sea shall at all times when his vessel is within the harbour ensure that his vessel is capable of being safely moved and navigated and that there are sufficient crew or other competent persons readily available-*
>
> *a. to attend to his vessel's moorings*
>
> *b. to comply with any directions given by the Harbourmaster for the unmooring, mooring and moving of his vessel; and*
>
> *c. to deal, so far as reasonably practicable, with any emergency that may arise."*

PECs issued by the Authority also direct the holder to refer to the Authority's Bye-Laws. A copy of the Bye-Laws was also held by Seatruck Ferries.

1.16 OTHER ACCIDENTS

1.16.1 Similar accident on board *Moondance*

In March 2008, the previous second engineer of *Moondance* was on watch and was preparing engines for sailing from Heysham. He forgot to open the generator sea water cooling supply valve when reconfiguring the systems from the harbour service pump to the main service pump supplies. The generator fresh water temperatures increased to the alarm level. However, the rapid intervention of the chief engineer, who was in the ECR at the time, prevented a blackout.

No procedural or system changes were made to prevent a re-occurrence of this hazardous incident.

1.16.2 Grounding of Seatruck Ferries ro-ro cargo ship *Riverdance*

On 31 January 2008 *Riverdance*, a sister ship to *Moondance,* grounded on Blackpool Sands in severe weather while on a scheduled passage from Heysham to Warrenpoint. The grounding resulted in the constructive total loss of the vessel, and is the subject of an ongoing MAIB investigation.

1.16.3 Other similar accidents

Previous accidents in which weak system knowledge and lack of training in emergency propulsion procedures were contributory factors include the following:

In January 1997 the motor shuttle tanker, *Tove Knutsen,* suffered an extensive engine room fire. While dealing with the incident, the crew's poor system knowledge resulted in incorrect system isolations, which led to about 50 tonnes of crude oil being discharged into the sea.

The refrigerated general cargo vessel, *Green Lily,* grounded in November 1997 off the Shetland Islands, with the loss of one life. The investigation found that poor knowledge of the sea water cooling system prevented a fractured pipe from being isolated. The resultant flooding situation led to a main engine failure and grounding.

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 ELECTRICAL BLACKOUT

The electrical blackout that occurred on board *Moondance* at approximately 1811 on 29 June 2008, which led to her grounding, was due to the port generator stopping after its fresh water cooling system temperature exceeded the trip threshold of 95ºC. The electrical load was automatically transferred to the starboard generator, however, almost immediately afterwards, this generator also tripped out on high fresh water cooling temperature, causing the total blackout.

2.3 CAUSE OF GENERATOR HIGH FRESH WATER TEMPERATURE

2.3.1 “On engine” possibilities

There are a number of “on engine” related reasons which can cause an increase in fresh water cooling temperature leading to trip levels. These include poor engine combustion timing, engine cooling passage and sea water/ fresh water cooler blockages, defective engine fresh water cooling circulating pump and blocked or damaged engine pipe work. All these causes manifest themselves by a gradual increase in temperature over time. These can be confidently dismissed because the overheating problem was rapid and was common to both engines. The temperatures on both engines had been normal and steady up to the point immediately prior to the trip conditions.

2.3.2 Trip threshold levels

It is possible that the engine fresh water trip threshold levels were incorrectly set, causing the engine to trip at a lower than designed temperature. Post accident trials confirmed that the alarm and trip levels were set correctly at 85ºC and 95ºC respectively.

It was observed that the fitted thermometers required a correction to be made because of misalignments between the graduations on the housing and the glass alcohol thermometer. This makes temperature reading ambiguous and fault finding more difficult.

2.3.3 Main service pump suction strainer

The suggestion that the plastic sheet **(Figure 11)** had come from the main service pump suction strainer, and had reduced the water flow to the main service pump and hence to the generator coolers causing the trip conditions, was a plausible explanation, but one that required further investigation. Had there been a strainer blockage problem, the second engineer's immediate action should have been to open the starboard main service sea suction valve, and this would have rectified the situation.

Inspection of the heavily mussel encrusted, port main service sea chest grating **(Figure 29)** confirmed that the plastic could not have passed into the strainer, so this scenario was dismissed. While inspection showed the mussel growth to be severe, main service and harbour service pump performance trials proved that its impact on pump performance was negligible. In addition, had there been a reduction in flow related to main service pump performance, i.e. through a strainer blockage, or a degraded pump, then the main engine sea water low pressure alarms would have sounded, but this was not the case. It can therefore be concluded that the sea water supplies to the main engines were satisfactory, but those to the generators were not, although these were supplied from the same source.

2.3.4 System reconfiguration

Both generator engine temperatures were stable, at about 82ºC, up to the point that the sea water system was reconfigured from the harbour service pump to the main service pump supplies. It was also known that after the generators were eventually re-started, and sea water supplies were restored using the harbour service pump, the temperatures again stabilised at about 82ºC. This evidence suggests that the overheating problem was related to the sea water supplies from the main service system.

2.3.5 Conclusion

Referring to **Figure 21**, it is concluded that the generators overheated because the isolating valve supplying the sea water to the generators from the main service system had not been opened, or at best had been only partially opened, during the system re-configuration.

2.4 MAIN SERVICE TO GENERATOR SEA WATER SUPPLY ISOLATING VALVE ERGONOMICS AND OPERATING INSTRUCTIONS

2.4.1 Valve ergonomics

The main service to generator supply isolating valve was positioned near to the engine room deckhead, in less than ideal lighting, making it vulnerable to mal-operation. The valve had a spring-loaded locking handle, which could be set to throttle the sea water supply in any of the six detent positions between fully open and fully closed. The second engineer was under pressure, on his own in the engine room, and preparing the engines during the system reconfiguration. It is probable that because of his workload, he either set the valve in an unintended intermediate position or omitted to open the valve at all.

Had the valve been more accessible, at waist or chest height, then it would have been far easier to operate and to notice if it was set in the wrong position.

2.4.2 Instructions

It is important that technical instructions and checklists are unambiguous if systems are to be operated safely. This is especially so for new officers and crew who may be unfamiliar with the machinery and system fit.

It had become custom and practice on *Moondance* to carry out the Port Departure Procedure detailed in Form MD32-07 from memory, and tick off the checklist items on return to the ECR. Item 7 of the "At 20 Minutes Before Stand-by" section of MD32-07 states:

> *"Stop harbour circulating pump and open isolating valve"*

It is implied that the "isolating" valve is the main service to generator sea water supply isolating valve. Although this was not the case in this accident, to the inexperienced officer this instruction is not explicit enough. It does not specifically state which valve should be opened, and the check item could easily refer to the engine sea water cooler isolating valve; the instruction merits review.

2.4.3 Checklist procedures

The use of active, detailed checklists serves as an effective risk control measure and they are widely used in the preparation of machinery and to identify actions that need to be undertaken in the event of an emergency.

The approach to using checklists within the engineering team on board *Moondance* appears to have involved performing a number of steps and then ticking off items on the list. This approach is vulnerable to omission errors and may help to explain why the main service to generator sea water supply valve was not correctly operated during the system reconfiguration. The risk is magnified when procedures are undertaken unsupervised, as was the case on 29 June.

2.5 SEA WATER SYSTEM – MARINE GROWTH PROTECTION SYSTEM

It is not uncommon for sea water systems to suffer from internal marine growth, which dramatically reduces flow and heat transfer rates. An effective marine growth protection system will reduce this risk considerably.

With the exception of the mussel growth in the sea chest and on the inlet gratings, there was no evidence of any significant marine growth found during the limited sea water system internal inspection. The protection system that was fitted released copper ions into the water flow, i.e. into the pipe work and components, such as coolers. The system had minimal effect in deterring mussel growth on the sea chest gratings because the flow conditions took the protective ions away from the sea chest and grating areas.

System effectiveness is dependent on the condition of the sacrificial anodes and the current applied. In this case, the recommended current was 0.3 amp, but 0.7 amp was being applied, which will rapidly increase the rate of anode consumption and so reduce the system protection. The operating instructions **(Annex F)** recommend contacting the manufacturer where there is a need to increase current from the designed level. The reason for the increased current setting warrants further company investigation.

2.6 EMERGENCY GENERATOR ELECTRICAL SUPPLIES

When an electrical blackout occurs it is crucial that the emergency generator is set to “auto start” so that essential electrical services can be restored to enable recovery from a “dead ship” condition as quickly as possible. To achieve this, the generator must be properly maintained and tested.

An essential element of the emergency electrical supply is the provision of limited lighting, which helps to provide safe access and aids fault finding. In this case, the situation in the engine room, following the blackout, was particularly chaotic. This was largely due to lack of lighting, which severely hampered the fault finding effort. Because no-one took firm control of the situation, it was not until about 15 minutes into the accident that consideration was finally given to manually starting the generator. When the emergency generator started, partial lighting was restored and, with it, the situation in the engine room became calmer.

The emergency generator failed to start automatically after the blackout because the control panel selector switch was set in the “manual start” position. There had been a long standing, unidentified defect that had spuriously initiated remote starts when the control panel selector switch was set to its correct “auto start” position. The problems had not been reported to the chief engineer, so he was unaware of an important safety limitation and was unable to apply the necessary pressure to address the defect.

2.7 CONTROLLABLE PITCH PROPELLER ISSUES

2.7.1 CPP default position

Most CPP systems default to the full astern position when a total hydraulic oil failure occurs while the shaft is rotating. Some systems are designed to default to full ahead, and a lesser number default to the neutral or zero pitch position. It is a matter of opinion as to which is the preferred default position. Each failure mode brings with it its own problems and risk of collision or contact. What is important is that crews understand the failure mode of their particular system and the methods of local control.

None of the deck and engineering officers, or the shore management team were aware of the default setting for the CPP system or of the default pitch indicators on the loss of electrical supplies. Additionally, none of the documentation for the system which was held on board *Moondance* provided any detail on this issue.

Moondance's CPPs defaulted to the full astern pitch position in the event of a CPP hydraulic oil failure while the shaft is rotating. This was the condition that followed the blackout on 29 June.

When the master noticed that the CPP pitch indicators had apparently gone to the full astern position he assumed that the chief engineer or the EOOW had changed the system to ECR pitch control, and had selected full astern without approval from the bridge, or that there was a defect with the CPP system. Neither was the case. The indicators had defaulted beyond the full astern position as a result of the loss of electrical supplies following the 'blackout'. Coincidentally, the propeller pitch had also defaulted to the designed full astern position. This led to an acceleration of sternway, for a short time, until the engines and shafts were stopped. Although the master was unsure of the true machinery status he was aware that the vessel was making sternway. Because of the rapidly changing situation he did not consider the option of stopping the main engines using the bridge emergency stops. Had he done so it is likely that the consequences of the grounding would have been reduced.

2.7.2 Local control of CPP

Because of the loss of hydraulic oil pressure it was inappropriate, on this occasion, to assume local control of the CPP. However, it is of note that the vessel's emergency drill schedule did not include a requirement for this drill, and no-one on board *Moondance* had carried out such a drill as an integrated bridge/engine room evolution.

Local control of pitch requires close co-ordination and effective communications between the bridge and the local control position in the engine room. It is only by practice that the bridge and engine room teams can become competent in this potentially critical emergency procedure.

2.7.3 Control lever changeover

There was a misconception on board that the ECR and bridge CPP control levers had to be in alignment before the control changeover switch for the system could be operated. Trials proved that this was not the case and that the CPP control system was proven to assume the position demanded at the control station regardless of any alignment variations. However, best practice dictates that control levers should be aligned to prevent unintended movement during changeovers.

2.7.4 CPP indication alignment checks

Because of reported variations in the CPP indications, alignment checks **(Annex E)** were carried out while *Moondance* was in dry dock. The ECR and bridge CPP control levers were adjusted in two graduation increments throughout the ahead and astern ranges. Positional checks were then made against the CPP indication on the bridge, bridge wings and ECR gauges. A maximum variation of 4º was noted between the bridge port CPP indicator and that showing on the port bridge wing indicator. While the indication variations were not significant, they do merit consideration for further adjustment.

2.8 ENGINE ROOM LOG

Moondance was not fitted with any machinery data recording equipment, so it was important that accurate entries were made in the engine room log. The log provided the only method of recording machinery parameters which were essential when reviewing trends, recording running hours and as an aid to fault finding.

In harbour there was no pattern when generator readings were taken, and there were no remarks or indications logged when generators were started and stopped. Therefore, accurate analysis for fault finding purposes was difficult. No guidance was provided by the company on the requirements for completing the log, and this led to recording inconsistencies.

2.9 ACTIONS TAKEN – ENGINE ROOM TEAM

2.9.1 General

The second engineer took over the watch at the critical time of about 1850 as the third engineer was part way through preparing the vessel's engines for the planned move to the linkspan. As he was reconfiguring systems, "stand-by" engines was established soon afterwards, thereby adding to his workload and time pressure.

The port generator high temperature alarm sounded a few minutes before the vessel left the quay. Rather than inform the chief engineer of the problem, as required by the Chief Engineer's Standing Orders, the second engineer attempted to identify the cause of the alarm. Once the subsequent cascade of alarms happened, the second engineer became overwhelmed because he had no-one to support him. He had only about 3 minutes to determine the fault and take corrective action. By the time he had decided that the problem was related to an interruption in the sea water cooling supply, it was too late to prevent the blackout. Had the second engineer alerted the chief engineer immediately to the problem it is likely that the chief engineer would have had sufficient time to contact the master to recommend delaying the vessel's departure. Alternatively, the second engineer could have informed the master of the situation directly.

There is no doubt that poor management of the engine room watch changeover, concurrent with the shift of berth, added significantly to the second engineer's ability to deal with the demands this imposed. It increased the risk of errors especially during system reconfiguration. It would have been prudent to either advance or delay the watch changes to ensure continuity during periods of high activity.

2.9.2 Attempts to reconfigure the electrical supplies

At the time of the blackout, the port shaft generator was connected to the bow thruster bus bars. It is possible that the second engineer could have opened the bow thrusters supply breaker and connected the port shaft generator to the general electrical distribution bus bars to restore electrical supplies. However, this would have meant taking bow thruster power away from the bridge during what he knew to be a manoeuvring situation. Instead, it was to the second engineer's credit that he attempted to connect the starboard shaft generator to the switchboard. But this failed because of the defective varistor affecting the generator's voltage stability.

2.9.3 Main engine usage

The immediate and coincident stopping of the main engines, by the chief and third engineers on their arrival at the ECR, were potentially dangerous actions. The third engineer did not consult with the chief engineer, and the chief engineer did not seek approval from the bridge before stopping the engines and effectively removing engine power from the master without knowing the navigational situation. The engines were not in immediate danger, and the master's approval should have been sought.

The later, unilateral decision by the second and chief engineers to start the main engines without discussing the situation with the bridge was equally flawed. The action could easily have resulted in damage to the propellers or hull, or in driving the vessel off the mud, into the path of other traffic. This is discussed further at Section 2.10.2.

2.9.4 Positioning of the chief engineer

The chief engineer regarded the move to the linkspan as a relatively low-level, routine operation. It was his habit, on occasion, to rely on his staff to report problems to him in his cabin, by telephone, rather than be present in the ECR at stand-by main engines as is normal custom and practice. This suggests a complacent approach, and represents an underestimation of the risks involved in starting up machinery and demanding significant changes in thrust and steering in a short period of time.

Paragraph 13 of the chief engineer's standing orders states:

> *"Whilst the vessel is manoeuvring the watchkeeping officer or the Chief Engineer must be in the control room at all times"*

To comply with this instruction it would be impossible for the EOOW to leave the ECR to investigate an alarm or attend to an emergency in the engine room if he were alone. Although not explicit, the order implies that during manoeuvring i.e. in pilotage waters and during shifts of berth while under power, the chief engineer should be in the ECR to provide support to the EOOW. Had he been present, it is possible that errors in preparing the cooling water systems would have been less likely.

2.9.5 Management and communications within the engineering department

The chief engineer faced a serious challenge when he entered the ECR immediately after the blackout. He viewed the situation as chaotic, and had difficulty in establishing his authority. Several factors probably played a part.

The situation was undoubtedly stressful. There was no illumination apart from the light provided by hand-held torches. This would have magnified the difficulties involved in moving around the engine room, reading indications, operating controls, and communicating, and would have added to the sense of urgency and danger. The team naturally communicated with one-another in Polish, and this would have exacerbated the chief engineer's problems in understanding and controlling the situation. Each member of the engine room team must have been experiencing some degree of alarm, and they appear initially to have pursued individually determined priorities. The situation was also novel in that they had not practised dealing with malfunctions in such circumstances.

2.9.6 Personality and cultural issues

The chief engineer's difficulty in imposing his authority on the team was probably exacerbated by the pre-existing nature of his relationship with them.

The chief engineer has been described as ebullient and direct in his manner. He had previously been given advice by management on dealing with his engineering team, which suggests that his style, or the team's perception of it, had provoked a reaction. His management style might have established a barrier between himself and his team, or reinforced a culturally-determined reticence on their part to communicate with him. Such a barrier would not have been easily removed even with significant effort on his part following the management advice.

It is likely that the cultural background of the Polish members of the engineering team militated against easy communication with the chief engineer. Societies vary in the way inequalities in status and power are handled. In societies organised on relatively authoritarian or paternalistic lines, consultation between superiors and subordinates is not expected (by either party). The probability of a subordinate challenging or contradicting a superior's decision is low. A respected superior is treated as more or less infallible. A superior who fails to command respect, despite his status, cannot be entirely ignored, but he will not receive support when it is needed. In a less authoritarian society, the emotional distance between leaders and those led is smaller. The barriers to consultation and co-operative decision making are less formidable. Hofstede and Hofstede (2005) have measured the strength of these attitudes and expectations in many countries in the form of a Power Distance Index. Latin and eastern parts of Europe tend to have a greater Power Distance Index than countries in northern Europe; Poland ranked about 28th and Britain about 64th in a worldwide study of 74 countries, which suggests markedly different approaches to power and status. Changing culturally-determined attitudes and expectations is not easy[3].

Thus, both cultural and personality factors affected the efficient and effective collaboration between the chief engineer and his team. This resulted not only in the team's failure to look to the chief engineer for guidance during the emergency, but also in the second engineer's failure to report the overheating problem when it first came to his attention; in the third engineer's unilateral shut down of the main engines without informing the chief engineer; and in the electrician's failure to inform the chief engineer of the state of the emergency generator (the latter did not know that the control panel was switched to "manual start" rather than "automatic start").

2.10 ACTIONS TAKEN – BRIDGE TEAM

2.10.1 General

As far as the master was concerned, the move to the linkspan was proceeding as expected and as briefed to the chief officer. It was not until the report from the forward mooring station, that power was lost to the winch, that the master was aware that anything was untoward. Attempts to manoeuvre the vessel were impossible as, firstly, the steering motors failed, followed very soon afterwards by the loss of the bow thruster and the CPPs defaulting to full astern pitch.

With only about 175 metres to the riverbank astern of *Moondance*, and with the engines now stopped, the master had no other choice than to let go both anchors. Although this partially slowed the sternway, it did not prevent the grounding. The subsequent actions of informing authorities and confirming the integrity of the hull were well considered and in accordance with the Bridge Emergency Procedures. However, the communications with the engine room were far less effective.

2.10.2 Communications between the bridge and ECR

During the early stages of the accident the master attempted to make contact with the ECR using the sound powered telephone located on the bridge, as there were no communication facilities on the bridge wings, but there was no

[3] Reference : Hofstede, G and Hofstede, G J. Cultures and Organizations: Software of the Mind. New York: McGraw-Hill USA, 2005, ISBN 0-07-143959-5.

response to his telephone call. Because he was alone, he returned to the port bridge wing so that he would have clear visibility of the relative position of the vessel to the quay. He also justified this action in not wanting to disturb the chief engineer further because he would have been pre-occupied in attempting to deal with the problems in the engine room.

The master preferred instead to use the chief officer to make contact with the ECR to investigate the power loss problems. This led to delays in ascertaining the situation, and possibly contributed to the apparent confusion over the later starting of the main engines.

The chief engineer, on the other hand, did not consider warning the bridge of his intention to shut down the main engines or, later, to start one. He was informed that the vessel was aground by the chief officer and not by the master on the bridge. It seems that direct communication between the bridge and the engine room was an early casualty of the lack of available personnel, and the stress and workload involved in the emergency.

2.10.3 Bridge manning

The master regarded the move from the lay-by berth to the link span as a routine operation which required only him to be on the bridge. Although this had little or no bearing on the course of events, except for the ability to talk directly to the ECR, it indicates a complacent attitude and an under estimation of the risks involved in manoeuvring the vessel in confined waters. Warrenpoint Harbour Authority recognised the importance of correct bridge manning levels when they conducted risk assessments in the discharge of their PMSC responsibilities. The assessment identified that the Authority's existing Bye-Law 19 covered the requirement. The Bye-Law was known to Seatruck Ferries, and the master's PEC also referred him to the Bye-Law requirements. Despite this, the master decided to man the bridge on his own. His action took no account of the Bye-Laws or of the safe operation of the vessel should he have become incapacitated.

2.10.4 Equipment knowledge

It was observed that the second officer did not know how to operate the bow thruster. His watchkeeping pattern had not required him to use the thruster because the master was always on the bridge during manoeuvring alongside when the thruster was required. While this deficiency may appear unimportant in respect of this accident, it was important to the overall safe operation of the vessel, and this shortcoming had not been identified during internal auditing. Officers of the watch should be familiar with the operation of all propulsion controls and bridge equipment from each control position.

The widest possible dissemination of skills among appropriate crew members, and the fullest possible technical knowledge about the state and operation of the ship (e.g. CPP default position), can only help to reduce risk and ensure an effective response in an emergency.

2.11 SAFETY MANAGEMENT SYSTEM

The Safety Management System is intended to provide officers and crew with comprehensive instructions and guidance to assist in the safe operation of a vessel and in the development and training of individuals and teams. Its effectiveness relies upon regular review, accuracy and effective internal auditing.

2.11.1 Engineering department instructions

Seatruck Ferries' SMS delegated responsibility to ships' officers to develop their own standing orders and routines. On *Moondance*, the chief engineer's standing orders and engineering procedures MD01/07 to MD39/07 were reviewed during the investigation, and a number of variations were identified when compared to the SMS. In particular, many of the chief engineer's "MD" prefixed procedures did not match those in the SMS Section 4 –Ship Specific Procedures, Forms and Guidelines. As an example, MD 11-07 in the chief engineer's instructions referred to "Change Over of Vessel's Power Source", while in the SMS, MD 11 referred to "ballasting procedures" – **Annex N**.

2.11.2 Omissions and SMS Section 4

A number of omissions in the SMS were noted during the investigation, which related specifically to this accident but which had not been identified during routine internal auditing.

These included:

- Lack of guidance on bridge and engine room manning levels (despite Warrenpoint Harbour Authority's bye-law requiring sufficiency of crew) while the vessel is in pilotage waters, including shifting berths.
- Use and management of checklists.
- Engineer officer of the watch and bridge officer of the watch, handover procedures during critical evolutions e.g. leaving the berth.
- Advice on the default position of the CPP in the event of a CPP hydraulic oil failure, e.g. in the case of a blackout.
- Omission in the drill schedule at SMS Section 3 – SP03 **(Annex M)** of CPP local/emergency operation of pitch control.
- Need for auditing the management of departments.

It was also noted that the majority of SMS Section 4 contained instructions bearing the previous ship management company, Crescent Marine Services' logo. The earliest was dated 21 October 2004. Those pages which are affected were not endorsed by a Seatruck Ferries' quality control stamp, so it is unclear whether these documents have been subjected to quality assurance scrutiny or whether they even comply with the current company policy.

Since 2006, there had been seven SMS reviews and updates, but there had not been an overall major review to align and control onboard documentation with the more generic instructions laid out in the SMS. However, Seatruck Ferries did conduct regular SMS internal audits. The audit carried out on 17 December 2007 identified eight observations, the most notable of which was the absence of a risk assessment file and any formal risk assessments.

2.11.3 Risk assessments

There was very little evidence that *Moondance*'s onboard management team had embraced the principles of risk assessment, even though the requirement has been in place for the past 10 years. There was no evidence that any risk assessments had been completed on any of the engineering department's activities.

The Internal SMS Audit carried out on 17 December 2007 recorded an observation that a risk assessment file was not held on board. While the issue was subsequently broadly discussed among the shore management team, there was no process to formally close this important issue off, with an instruction to the ship, an action plan or similar management process.

It is possible, that had an assessment been undertaken of the risks associated with entering, leaving, and manoeuvring in harbour then a total blackout would have been identified as a significant risk. In this case, it is likely that control measures such as the following would have been identified:

- Adequate manning levels (minimum of two persons) in the engine room and on the bridge while in pilotage waters.
- The emergency generator always to be in the “auto-start” mode and so provide emergency electrical supplies, including lighting.
- Advice on the CPP default pitch position.
- The need for effective communications between the bridge and engine room.

2.11.4 Internal SMS audits

Internal SMS audits are carried out to verify that ships are operated safely and in accordance with the instructions contained within the relevant SMS manual. The audits are also intended to check compliance of the SMS against the ISM Code.

It is important, wherever possible, that auditors are sufficiently detached from the vessel to avoid bias, and that they are suitably trained and experienced to carry out the task if a balanced assessment is to be made. In this case, a number of omissions and contradictions relating to the SMS and engineering department instructions were not identified during auditing; neither were the management and communication issues highlighted at Sections 2.9 and 2.10. Had these issues been acknowledged at an early stage then the management of Seatruck Ferries might have had the opportunity to address them, and take appropriate measures to reduce the likelihood of this accident occurring.

It is noted that Seatruck Ferries has identified a number of masters and chief engineers who are considered suitable as internal auditors to give a wide opinion, over time, of the safety of ship operations. Further work is ongoing to identify appropriate ISM auditing training.

2.12 SIMILAR ACCIDENTS

The accidents highlighted at Section 1.16 illustrate the importance of the need for thorough system knowledge and of the need to be drilled in emergency propulsion control procedures. A thorough understanding of these issues will ensure that actions are competently carried out and are instinctive in the case of an emergency. In many cases this knowledge will gain the vital minutes needed to avert a major accident which may well compromise the safety of the crew and ship.

2.13 FATIGUE

The officers and crew were well rested during the lay-over period. Both the second and third engineers had a full night's sleep on 28/29 June, having shifted into the harbour "on call" watchkeeping routine. Fatigue is not considered to be a factor in this accident.

SECTION 3 - CONCLUSIONS

3.1 SAFETY ISSUES DIRECTLY CONTRIBUTING TO THE ACCIDENT WHICH HAVE RESULTED IN RECOMMENDATIONS

1. The SMS was found to be deficient in a significant number of areas. [2.4.3], [2.7.1], [2.7.2], [2.8], [2.9.1], [2.9.4], [2.9.6], [2.10.2], [2.10.3], [2.11.2]

2. Communications within the engineering department were weak. The second engineer did not report the high generator temperatures and the electrician did not report the emergency generator defects. [2.3.3], [2.6], [2.9.1], [2.9.5], [2.9.6]

3. Engine room checklists were poorly used, which might have contributed to the second engineer failing to notice that he had not opened the generator sea water cooling valve. [2.4.2], [2.4.3]

4. The chief engineer had difficulty in establishing his authority during the post-blackout recovery phase in the engine room. This was underpinned by cultural and personality factors. [2.6], [2.9.5], [2.9.6]

5. Communications between the bridge and the ECR were poor. The main engines were stopped and later started without reference to the bridge, so the navigational situation was not taken into account. [2.9.3], [2.10.2]

6. The move to the linkspan was seen as a relatively low-level, routine operation, and the risks were underestimated by the master and chief engineer. This complacency, underpinned by long term routine, led to inadequate manning levels and resulted in the second engineer working under pressure and unsupervised during a critical phase in the departure. [2.9.4], [2.10.3]

7. Internal auditing had not identified poor ship knowledge, complacent procedures, weak departmental management and communications, missing guidance/instructions or contradictions with the chief engineer's technical instructions in the SMS. [2.10.2], [2.10.4], [2.11.1], [2.11.2], [2.11.4]

8. There was very little evidence of risk assessments being undertaken. [2.11.3]

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

1 The high generator fresh water temperature was caused by the main service sea water system to generator isolating valve being left shut or being only partially opened. [2.2], [2.3.4], [2.3.5]

2. The instrumentation measuring the port and starboard generator fresh water temperature was open to misinterpretation, and made fault finding difficult. [2.3.2]

3. The main service sea water system to generator valve is poorly positioned, and its design can lead to mal-operation [2.4.1]

4. The Port Departure Procedure Form – MD 32-07 was not sufficiently explicit in describing which isolating valve should be operated when reconfiguring the sea water systems. [2.4.2]

5. The sea water system Intakematic Marine Growth Protection System electrical current was far in excess of that recommended by the manufacturers, leading to increased anode consumption and eventual reduction in protection. [2.5]

6. The emergency generator failed to start automatically because of defects which the chief engineer was unaware of. This contributed to a delay in recovering from the blackout. [2.6], [2.9.6]

7. No-one on board *Moondance,* or the shore management, were aware of the full astern default position of the CPP in the event of a hydraulic oil pressure failure or of the default positions of the CPP indications in the case of a loss of electrical supplies. [2.7.1]

8. The emergency drill schedule did not include local emergency control of the CPP and the integrated bridge/engine room procedure had not been practised. [2.7.2]

9. Data recording in the engine room log was inconsistent. There was no record of generator changeovers. [2.8]

10. The engine room watch changeover at the critical time of shifting between berths added significantly to the risk of errors being made. [2.9.1]

SECTION 4 - ACTION TAKEN

4.1 MARINE ACCIDENT INVESTIGATION BRANCH

As a result of this accident, and the loss of MV *Riverdance*, the Chief Inspector of the Marine Accident Investigation Branch has written to Seatruck Ferries Shipholding Limited issuing the following urgent safety recommendations:

S2008/171 Take immediate action to verify the safe operation of all SeaTruck vessels and ensure, in particular, that such vessels operate at all times with adequate reserves of stability, which satisfy the Loadline Convention.

S2008/172 Conduct an urgent review of the fundamentals of the existing SeaTruck Safety Management system, to ensure these are adequate for the purpose in the short term, until a full review of the system can be completed.

4.2 SEATRUCK FERRIES SHIPHOLDING LIMITED

Seatruck Ferries Shipholding Limited has:

- Complied with recommendation S2008/171; with respect to Recommendation S2008/172, an internal review of the company's existing safety management system is ongoing following a full independent audit carried out by Det Norske Veritas on 5 September 2008.
- Instructed the master and chief engineer of *Moondance* on 16 July 2008 **(Annex O)** to:
    - Include the local and emergency control of the controllable pitch propeller in the emergency drill schedule with effect from 16 July 2008. The drill is to be exercised every 3 months.
    - Display notices at the engine control position on the bridge and in the Engine Control Room warning of the default position of the controllable pitch propellers in the event of a hydraulic failure when main shafts are turning.
- Written to all Seatruck vessels on 28 August 2008 **(Annex P)** to provide its fleet with the broad outcome of the company's investigation into the circumstances of the *Moondance* grounding.
- Advised all Seatruck vessels, of new instructions, pending a major review of the Safety Management System **(Annex P)**. These relate to:
    - **Engine room manning** – position of the chief engineer in the Engine Control Room in pilotage waters, including shifting berths and when engines are at stand-by.

- **Bridge manning** – minimum manning is to be master and an officer of the watch while in pilotage waters including shifting berths.

- **Engineer Officer of the Watch handovers** – handovers are to be re-scheduled to avoid critical periods to ensure continuity.

- **Checklists** – additional guidance on the routines for completing checklists and countersigning by the master and chief engineer.

- **Failure of controllable pitch propeller** – advising on the default position following a hydraulic oil pressure failure.

- **Manoeuvring indications** – advising that not all bridge indications are supported by emergency electrical supplies.

- **Main engine emergency stops** – reminding deck officers of the function of main engine emergency stops and the need to test these in co-operation with the engine room.

- **Recording times** – the need to record events accurately and to synchronise bridge and engine room clocks.

- **Communications** – reminding staff of the need for effective communications between the bridge and engine room in an emergency, especially in relation to starting and stopping main engines.

- Taken the following actions relating to the engineering safety issues:
  - **Generator main service sea water supply isolating valve** – investigations will be carried out to reposition the valve during the current dry docking period to facilitate easier access.

  - **Port and starboard generator fresh water system thermometers** – correct range replacement thermometers have been ordered and will be fitted on receipt.

  - **Emergency generator spurious starts** – all terminals have been checked. The switchboard has been cleaned and breakers overhauled. The generator's "auto-start" facility has been proven to work correctly.

  - **Intakematic Marine Growth Protection System** – ship's staff are investigating the reason for operating the system outside the manufacturer's recommended range.

- **Port Departure Form – MD 32- 07** – the content of the form is being reviewed and will comprise part of the new Operational Procedures Manual.

- **Engine Room Log** – a company memorandum has been sent to all vessels, reiterating the need for accurate record keeping, particularly regarding starting and stopping machinery and the recording of parameters.

SECTION 5 - RECOMMENDATIONS

Bahamas Maritime Authority is recommended to:

2009/109 Take urgent action to review the validity of Seatruck Shipholding Limited's Safety Management Systems to ensure they are sufficiently robust for safe operation of its vessels.

Seatruck Ferries Shipholding Limited is recommended to:

2009/110 Provide guidance to suitably trained internal ISM auditors on the scope of their responsibilities, including assessment of crew knowledge, departmental management and inter-departmental communications.

2009/111 Undertake a review of the onboard risk assessment procedures to ensure its vessels comply with Seatruck Ferries Shipholding Limited's policy.

Marine Accident Investigation Branch
February 2009

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