Office of the Chief Investigator
Transport and Marine Safety Investigations

Marine Safety Investigation
Report No 2007 / 01

Fire on board

Passenger charter vessel “Moonraker”

Popes Eye Marine National Park

14 January 2007

TABLE OF CONTENTS

THE CHIEF INVESTIGATOR

The Chief Investigator, Transport and Marine Safety Investigations is a statutory position established on 1 August 2006 under part V of the *Transport Act 1983*.

The objective of the position is to improve public transport and marine safety by independently investigating public transport and marine safety matters.

The primary focus of an investigation is to determine what factors caused the incident, rather than apportion blame for the incident, and to identify issues that may require review, monitoring or further consideration. In conducting investigations, the Chief Investigator will apply the principles of 'just culture' and use a methodology based on systemic investigation models.

The Chief Investigator is required to report the results of investigations to the Minister for Public Transport and / or the Minister for Roads and Ports. However, before submitting the results of an investigation to the Minister, the Chief Investigator must consult in accordance with section 85A of the *Transport Act 1983*.

The Chief Investigator is not subject to the direction or control of the Minister(s) in performing or exercising his or her functions or powers, but the Minister may direct the Chief Investigator to investigate a public transport safety matter or a marine safety matter.

1. EXECUTIVE SUMMARY

On 14 January 2007, the Sorrento based passenger charter vessel Moonraker left the Sorrento pier for Popes Eye Marine National Park in Port Philip Bay.

The vessel was carrying 41 passengers, a certified master and three crew members.

At approximately 1345[1], the Moonraker was being manoeuvred in the vicinity of Popes Eye Beacon in preparation for swimming and snorkelling activities when the vessel experienced an engine room fire.

The fire was extinguished by shutting off fuel and air to the engine room and subsequent use of portable fire extinguishers. There was moderate fire damage in the engine room.

The master called for assistance on the VHF radio, and all the passengers were safely evacuated onto several vessels that came to the Moonrakers assistance. There were no reported injuries to the vessel's passengers or crew.

The most probable cause of the fire was determined to be a faulty electrical connection igniting residual diesel oil that had accumulated from a leaking fuel filter.

The investigation found that the engine room fixed fire suppression system was not operational at the time of the incident.

The report recommends that Marine Safety Victoria reviews its survey processes especially with respect to modifications to vessels and survey requirements for critical safety equipment.

The report further recommends that Marine Safety Victoria reviews its crew competency requirements for passenger vessels and considers the implementation of a mandatory requirement for all passenger vessel operators to have a safety management plan for their vessel.

[1]All times are denoted in Australian Eastern Standard Time adjusted for daylight Saving (UTC + 11 hours)

2. CIRCUMSTANCES

2.1 The incident

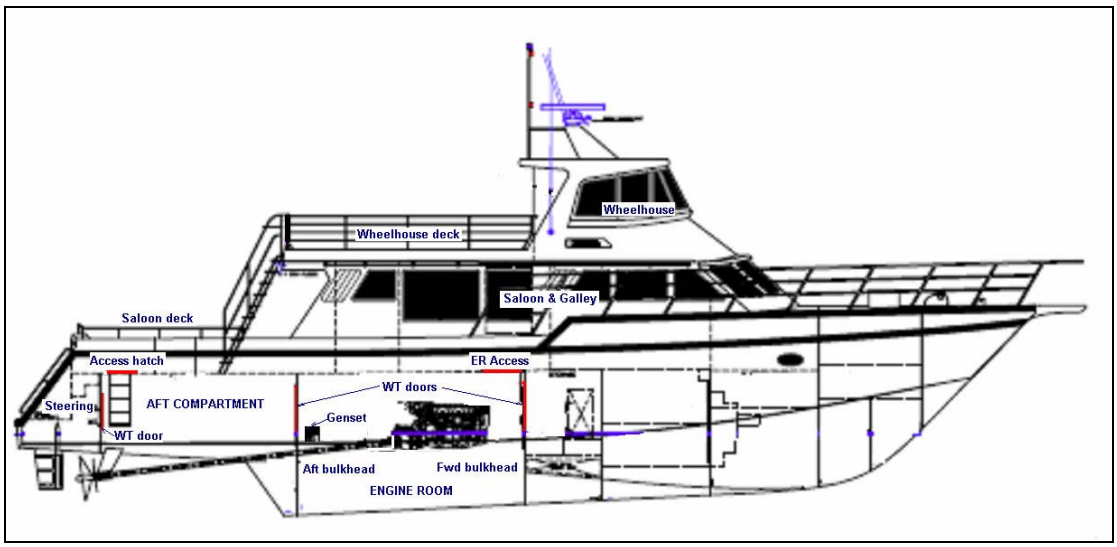

Figure 1 - General arrangement of Moonraker

The charter vessel Moonraker carries passengers on sight seeing, snorkelling, dolphin and seal swim tours. Typically cruises depart from Sorrento Pier daily during the warmer months, October to April, at 0900 and 1300. The vessel cruises through the seal colony at Chinaman's Hat to Popes Eye Marine National Park in Port Phillip Bay and returns to Sorrento after approximately three hours.

On 14 January 2007 the vessel departed at about 0900 on a cruise and returned to Sorrento Pier at about 1200, without incident. At approximately 1300 the vessel left Sorrento pier on its second voyage for the day to Popes Eye Marine National Park.

The vessel was skippered by a certified master and carried three other crew members and 41 passengers.

At about 1345, the vessel was manoeuvring approximately 200 metres south of Popes Eye Beacon (Appendix C) while the crew were preparing the passengers for swimming and snorkelling activities. The fire alarm sounded in the wheel house indicating an engine room fire and smoke was observed emanating from a storage space on the vessel's deck.

The master, who was in the wheelhouse at the time, disengaged the engines from the propeller drive train and instructed the crew to muster the passengers on the aft and upper deck spaces.

The master then shut the remote fuel shut-off valves, closed the vent flaps to the engine room and attempted to release the engine room fixed fire suppression system.

After approximately 10 minutes the master and a passenger entered the aft storage compartment through an access hatch in the saloon deck and made their way through to the engine room watertight door on the engine room aft bulkhead

(Figure 1). The master then released two dry chemical powder extinguishers in the vicinity of the area that was observed to be still smouldering.

The master called for assistance on the VHF marine radio by calling the dive vessels operating in the area on channel 77.

All the passengers were evacuated onto several vessels that came to the Moonrakers assistance. There were no reported injuries to the passengers or crew.

2.2 Damage

Electrical cabling, insulation and conduits mounted on the aft engine room watertight bulkhead and a heat detector, wiring and electrical lighting on the deck head sustained severe fire damage. The Genset, starting battery, fuel pipes and hoses in the vicinity also suffered heat damage. The two bilge float switches were completely destroyed and a bilge pump suffered minor heat damage.

3. FACTUAL INFORMATION

3.1 The crew

The vessel crew consisted of a skipper holding a Master 5 (trading) certificate of competency issued by the Western Australian statutory marine authority and a Marine Engine Driver grade 3 certificate of competency issued by Marine Safety Victoria. The master worked on the vessel as a general purpose hand (GP) from 2000 to 2002 and has been the skipper of the vessel from 2002 up to the time of the incident.

The vessel also carried three GPs. The GPs held no certification with respect to vessel navigation, engineering or safety operations. Two of the GPs hold dive master qualifications issue by Professional Association of Dive Instructors (PADI) and had been employed on the vessel for 2 months and 24 days. The other GP holds a certificate in First Aid and had been on the vessel for 27 days.

3.1.1 Crew qualifications and training

The performance criteria in the training for the Master 5 and Marine Engine Driver certificates of competency require the candidate to demonstrate competence in minimising the risk of fire and maintaining a state of readiness to respond to emergency situations involving fires. The criteria stipulate that the candidate has responsibilities for checking fire prevention equipment and systems and appropriate action is taken to ensure that they are operational at all times.

The performance criteria in the training for the Marine Engine Driver certificate of competency require the candidate to demonstrate competence in monitoring and carrying out basic service checks of machinery systems and identifying faulty components and initiating rectification.

A marine radio operators certificate of proficiency (MROCP) is a pre-requisite for the issue of a Master 5 certificate of competency. The holder of a MROCP is deemed to be competent and proficient in VHF radio communications and the protocols with respect to distress communications. The distress communication protocols are stated in the marine radio operators handbook that outlines the provisions governing the use of marine radio transmitters as laid down in the *Radiocommunications Act 1992.*

3.2 The vessel

The Moonraker is a cabin cruiser type charter boat built by Seachrome Marine (Conquest) of Fremantle, Western Australia in 1997. It is 21.0 metres in overall length, has a beam of 5.5 metres and has a 1.6 metres draft. The vessel is of fibreglass, foam and divinycell[2] sandwich construction.

The vessel design and construction were approved by the Western Australian Department of Transport. The vessel was issued a certificate of survey on 15

[2] Divinycell is an expanded plastics material based on polyvinyl which has properties that are specially designed for use as a load bearing core in a sandwich structure.

November 1997 by the department certifying that the vessel complied with the WA Marine Act and the Uniform Shipping Laws (USL code).

The vessel entered Victorian service in 2000 and operated under a Western Australian certificate of survey until it was issued a certificate of survey by Marine Safety Victoria on 04 April 2000.

Main propulsion is provided by two turbocharged 6 cylinder Caterpillar 3196 diesel engines, each producing 660 horse power at 2300 rpm. Each engine is coupled via a clutch into a twin disc gearbox model MG 5114A and drives two fixed pitch propeller at a reduction ratio of 2.1:1.

240V electrical auxiliary power is supplied by a 3 cylinder Onan Genset model 6.5MDKAL producing 6.5kVA at 50 Hz frequency. The Genset supplies power to the galley equipment, hot water service, air conditioning, and all general power outlets. Accommodation, engine room and navigation lighting systems are supplied via a 240V – 24V transformer and a 24V back up battery system.

A dedicated 12V battery supplies the radio communication equipment.

Twin 12V batteries connected in parallel supply power to the bilge system, toilet and fresh water systems, fire detection system and main engine clutching systems.

3.3 Engine Room

The engine room is approximately 4.4 metres long, 4.3 metres wide and 2.2 metres high and is enveloped by the forward and aft watertight bulkheads and the ship sides.

The engine room has two means of access. One access is through a hatch and stairway located on the saloon deck adjacent to the forward watertight bulkhead of the engine room (Appendix B – Fig 11). The other access is through the aft watertight bulkhead that has a watertight door leading to the aft compartment.

The vessel has four fuel tanks. Two fuel tanks of 1350 litres each are located in the aft compartment and two fuel tanks of 1250 litres each are mounted against the Port aft and Starboard aft sides of the engine room. Each fuel tank outlet leads through a fuel filter mounted on the aft watertight bulkhead to the two main engines (Appendix B – Figure 12).

A branch pipe off the main fuel lines lead to the Genset through a single fuel filter. All four fuel tank outlets have remote fuel shut off mechanisms that are operated from the saloon deck.

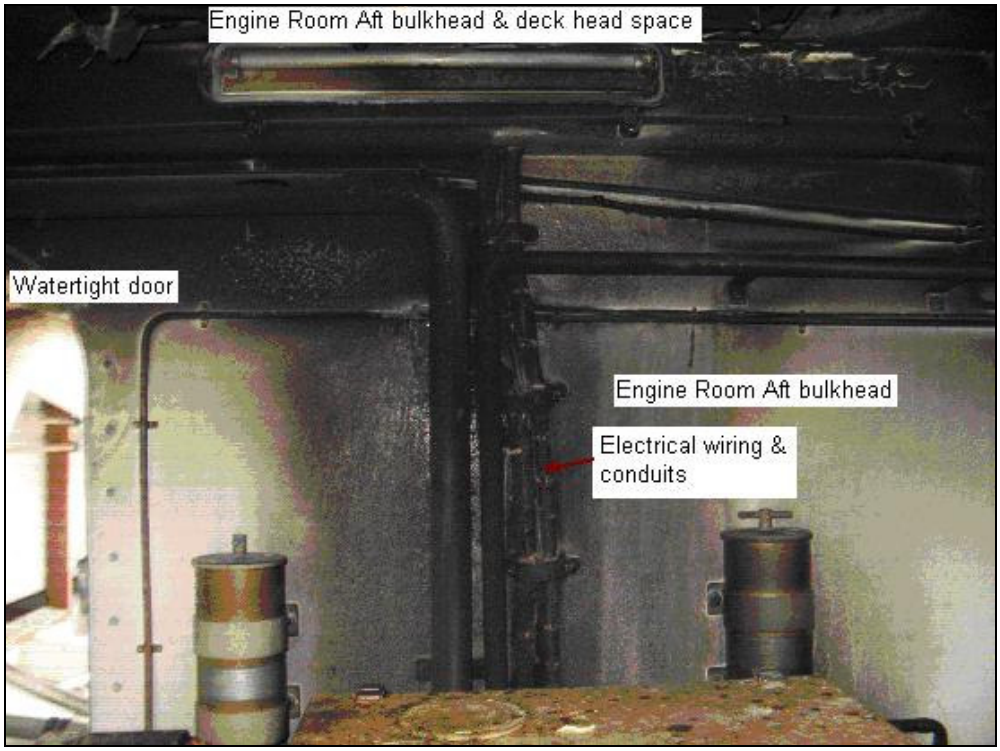

Figure 2 - Engine room aft watertight bulkhead

The starting battery for the Genset is mounted between the Genset and the aft engine room bulkhead and is also between and below the main engine fuel filters.

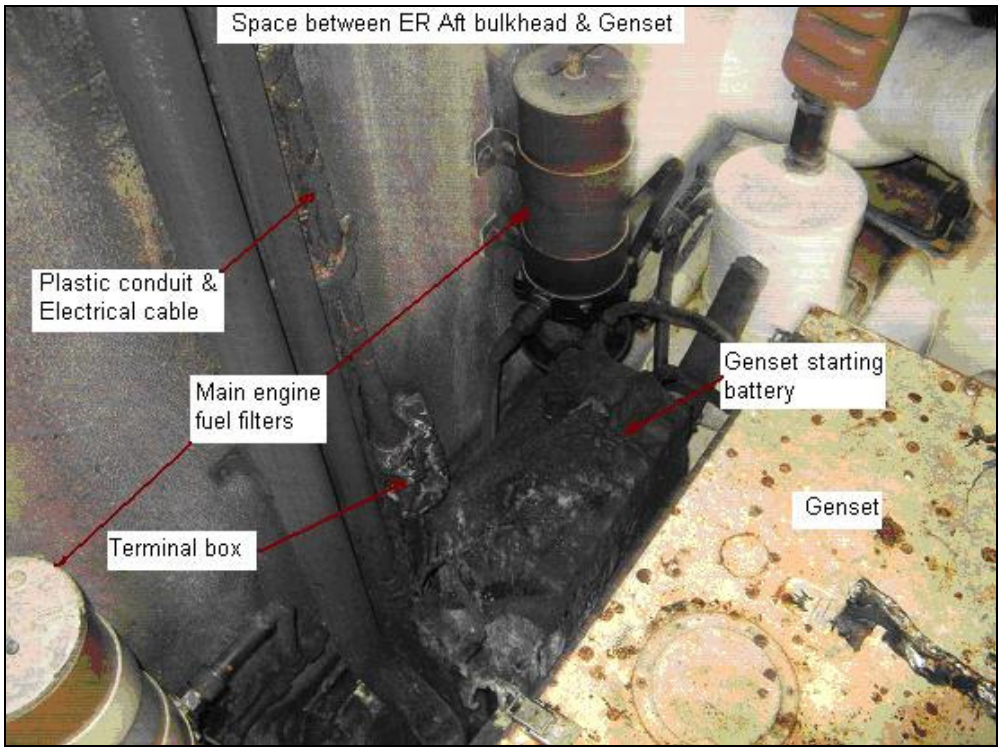

Figure 3 - Space between aft engine room bulkhead and Genset

The Genset is mounted on a plywood board located above a cofferdam space formed by longitudinal engine bearers, transverse frame and the aft engine room

bulkhead and is located 410 millimetres forward of the aft engine room bulkhead (Figure 8). The cofferdam space forms the aft engine room bilge well.

The Genset was in operation prior to the fire but ceased operation during the fire.

The seat of the fire was observed to be in the vicinity of the bilge well, against the aft bulkhead.

3.4 Fire detection and fire fighting appliances

The Moonraker has an ITIM Systems FA4 model fire detection system monitoring the wheel house, galley space, accommodation and the engine room. The indicator panel is located in the wheel house and fire detectors are located in each of the monitored spaces.

The vessel carried six portable dry chemical powder (DCP) extinguishers of 4.5 kg capacity and one water extinguisher of 9 litre capacity. The DCP extinguishers were located in the wheel house, bridge deck, saloon and the saloon deck. One DCP extinguisher and the water extinguisher were located in the engine room and one DCP extinguisher was located in the aft storage compartment.

A NAF S III[3] fixed fire suppression system consisting of a single 14 kg cylinder was also installed in the engine room. The method for activating this system is by a manual release mechanism located in a compartment on the saloon deck.

3.5 Life saving appliances

The Moonraker carried 81 life jackets with whistles and three life jackets with whistles and lights. The vessel also carried eight Carly floats stored under the bench seats on the bridge deck and two life buoys mounted on its wheel house deck railings.

The 24 person coastal life raft that is normally carried on board the vessel was being serviced at the time of the incident. The life raft was not required on board for the Class 1D[4] vessel operation being undertaken at the time of the incident.

3.6 Bilge alarm and bilge pumping systems

The vessel has several means of pumping the bilges. The primary system consists of two engine driven pumps operating through a valve manifold connected by pipes to each watertight compartment. A hand pump is also connected to the manifold. This system also takes suction from the sea and can be utilised as a fire hydrant system.

In addition to the above, the engine room, compartments forward and aft of the engine room have individual electric bilge pumps for pumping out each compartment directly overboard.

[3] NAF-S III is a Hydro-Chloro-Fluoro-Methane based fire extinguishing agent that extinguishes fires mainly by physical and chemical means.

[4] A Class 1D vessel is certified to carry over 12 passengers and operate in sheltered waters as defined in section 1, subclause 5.2 of the USL Code.

The electric engine room bilge pump is located in the cofferdam space and is automatically activated by a float switch. The float switch is mounted on the bilge floor such that the bilge pump is activated when the water level in the bilge is approximately 60 millimetres and switches off the pump when the water level drops below 28 millimetres. Another float switch is mounted approximately 250 millimetres above the bilge floor. The purpose of this float switch is to activate an alarm if the water level keeps rising due to the failure of the bilge pump or if there is a heavy ingress of water into the space.

3.7 Bilge system power supply

The Western Australian statutory authority approved electrical schematic drawing of the vessel indicates that the engine room bilge alarm and pumping system is supplied by the main 24V battery system. The schematic shows four 6V, 150 Amp Hour batteries connected in series supplying a 24V main switchboard in the engine room.

From the switchboard, the positive conductor of the 24V supply is routed through 32A circuit breaker to a bilge supply panel in the wheel house. The 24V circuit supplies an Auto / Manual change over switch and a running indicator lamp for the engine room bilge pump through a 10A circuit breaker. The positive conductor of the 24V system then runs back to the engine room where it supplies the pump activating float switch and bilge pump.

The existing on board electrical configuration for the bilge system is not consistent with the approved electrical schematic drawings. A 12V battery system supplies power for the engine room bilge pump, pump activating float switch, alarm float switch, visual and audible alarms. Two 75 amp hour batteries connected in parallel supply a 12V distribution board.

From the distribution board, the positive conductor of the 12V supply is routed through 32A circuit breaker to a bilge supply panel in the wheel house. The 12V circuit then supplies an Auto / Manual change-over switch and a running indicator lamp for the engine room bilge pump through a 15A circuit breaker. The positive conductor of the 12V system then runs back to the engine room where it supplies the pump activating float switch and bilge pump.

3.8 Fuel system

The vessels main propulsion engines and the Genset use marine diesel oil. The diesel fuel being used at the time of the incident was a Shell petroleum product, Shell Diesoline 50 delivered by a Shell mini tanker to the vessel. This fuel has a Flash point[5] of 79 ^{0}C as tested to ASTM D93 standard[6] and an Auto ignition point[7] of around 250 ^{0}C.

Inspection of the main engine fuel supply system found the system to be in satisfactory condition and this investigation did not find any defects or failures of the system.

[5] The Flash point is the lowest temperature at which a fuel can form an ignitable mixture with air when a source of ignition is applied.
[6] ASTM D93 is the international standard test for determining fuel oil flash points.
[7] The Auto ignition point is the lowest temperature at which a fuel will spontaneously ignite in normal atmosphere without an external source of ignition.

The Genset fuel filter was found to be leaking from the filter drain plug and there was a consistent dribble of diesel fuel from this filter drain point. The leaking fuel was accumulating in the cofferdam / bilge space under the Genset.

The area surrounding the Genset fuel filter was coated with diesel oil and the Genset battery support board was heavily impregnated with diesel oil.

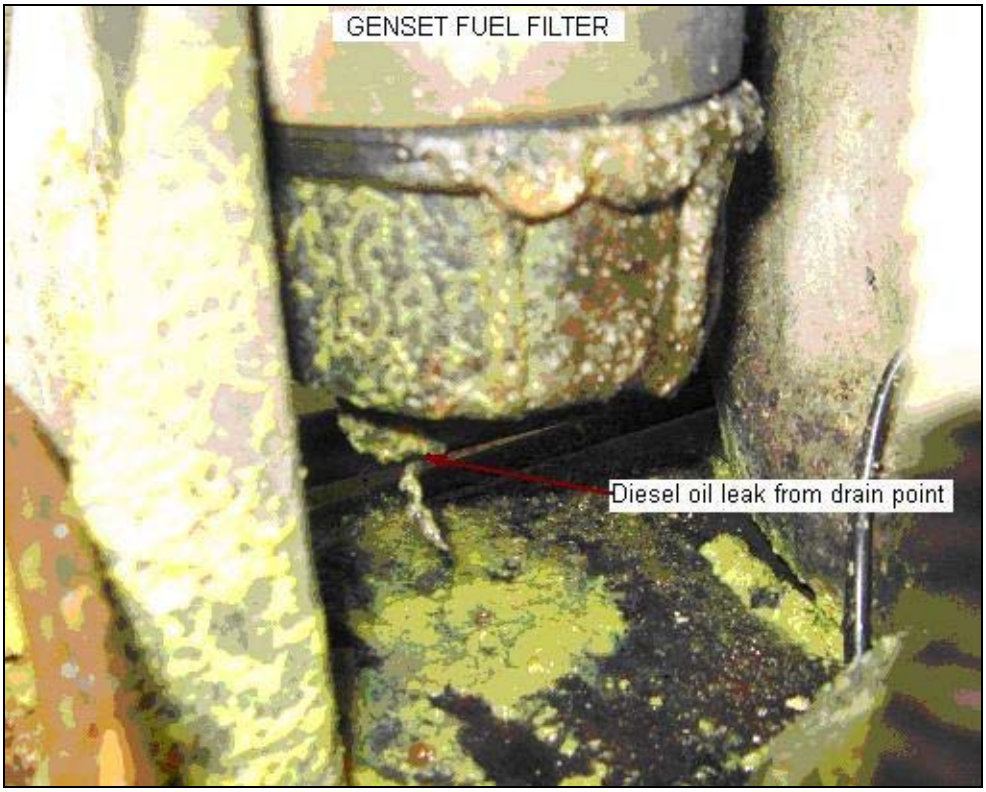

Figure 4 - Leaking Genset fuel filter

3.9 Equipment and system tests

3.9.1 Marine Genset & fuel system

The Genset consists of the diesel engine and the alternator. The diesel engine drives the alternator that generates the electrical supply. The Genset was inspected and tested by the authorised service agents. The agents report states that the overall condition of the unit is consistent with the age and running hours of the unit and confirms that the diesel engine is in operational condition. Fuel supply lines were pressure tested to 15PSI and found to be satisfactory.

No defects were identified with the alternator and the test report indicates that the unit is in operational condition. Insulation resistance and continuity tests conducted by the service agents on the alternator main windings found them to be within satisfactory operational parameters.

The Genset starting battery was tested and found to be functional with an output voltage of 12V. Apart from slight blistering of the battery case no other damage was sustained by the battery.

3.9.2 Bilge system components and wiring

The bilge system equipment and wiring was tested by a National Association of Testing Authorities[8] (NATA) approved laboratory. The bilge pump was a Rule, model 14A of 14000 litres per hour capacity and was fully functional under testing. The pump has an input current rating of 15.5A at 12V and 20.0A at 13.6V. The pump was tested by partial submersion in fresh water and drew a current of 16.5A when connected to 12V and drew 19.6A when connected to 13.6V. The bilge pump activating float switch was a Sure Bail product rated for a specified maximum current of 15A at 6-32V. The alarm float switch was Rule-A-Matic model 35 switch rated for a specified maximum current of 14A up to 32V.

Inspection of the junction boxes and the wiring loom revealed traces of diesel fuel. Although the junction boxes showed fire damage most of the wiring was in good condition with the insulation intact. An open twisted joint was found in the positive supply wire to the bilge pump (Figure 9). The connection was made by twisting two wires together without a connector providing mechanical compression to the joint. This connection showed evidence of copper oxidation. The connection also showed evidence of arcing and over heating.

The negative supply wire from the vessels wiring harness to the bilge pump also showed an inadequately soldered connection (Figure 10). The wire consisted of approximately 20 strands of which only four strands appeared to be connected by solder.

The float of the bilge pump activating switch and the top section of the enclosure of the float switch were completely burnt while the rest of the enclosure was intact.

The only evidence of the existence of the alarm float switch was the molten plastic remains of the switch found in the bilge.

[8] The National Association of Testing Authorities (NATA) is Australia's national laboratory accreditation authority. NATA accreditation recognises and promotes facilities competent in specific types of testing, measurement, inspection and calibration.

3.9.3 Fire suppression system

The fire suppression system consists of a cylinder containing the fire suppression medium NAF S III. The cylinder is released by a mechanism that includes a knob that has to be rotated clockwise such that an attached cable opens the valve on the cylinder.

Figure 5 - Fire system release cable & valve

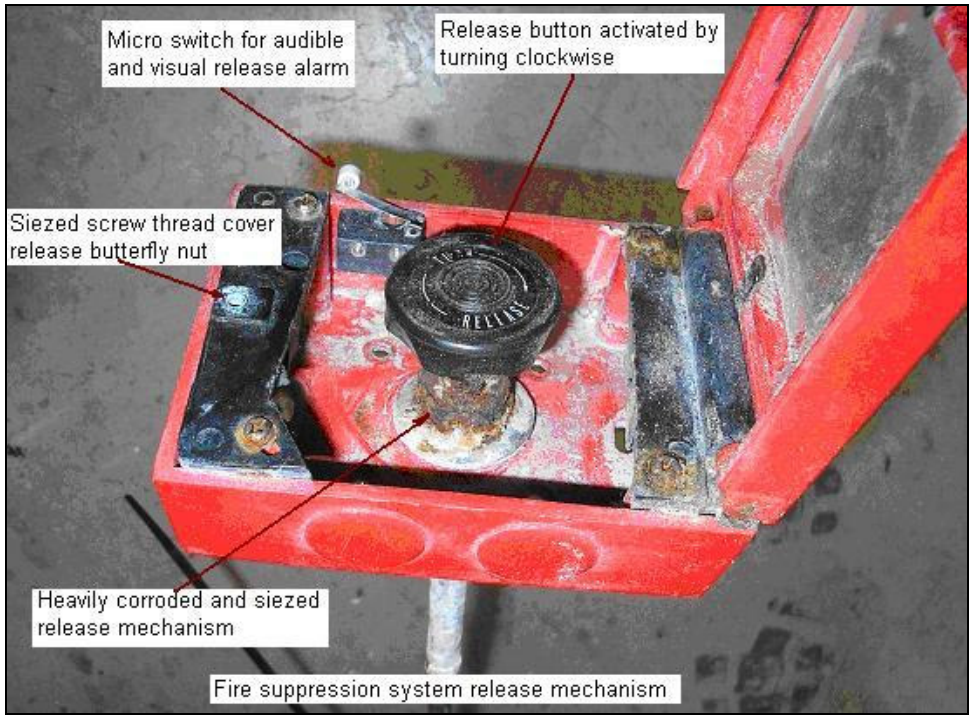

Figure 6 - Fire suppression system release mechanism

The investigation found that the engine room fire suppression system had not been released and did not contribute to the extinguishing of the fire. The fire suppression system release mechanism was not operational and the release cable was seized.

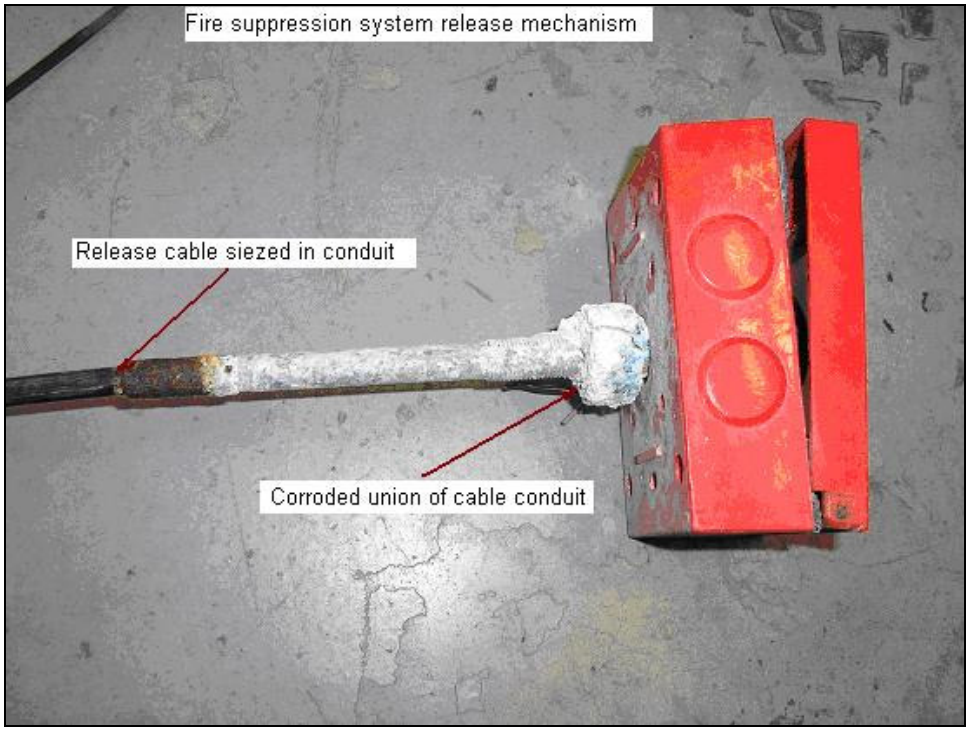

Figure 7 - Fire suppression system release cable and union

The vessel records indicate that the last inspection and service of the engine room fire suppression system was carried out in 2003. The 2003 service report states that an annual inspection on the NAF S III bottle was carried out; the cylinder was pressure tested and the system alarm tested. There is no reference to the function testing of the release mechanism of the system.

A post incident report submitted by the service agent states that the last service on the fire suppression system carried out by them was in 2003 and that the release mechanism operated satisfactorily during that service.

3.10 Other factual information

3.10.1 Master's evidence

The Master of the Moonraker stated that on 14 January 2007 the vessel completed its 0900 cruise to Popes Eye marine national park and back without incident. Then at approximately 1200 the vessel was brought alongside the berth at Sorrento from the moorings in order to prepare the vessel for its second cruise of the day. The vessel was cleaned and stores were replenished at the pier. The master stated that apart from an initial inspection of the machinery spaces at about 0830 the master or crew did not inspect the machinery space before or during the second voyage at 1300.

Passenger boarding was then carried out and passenger names were checked off on a boarding manifest. The vessel got underway at 1300. At 1345, the vessel was being manoeuvred approximately 200 metres south of Popes Eye Light-Beacon and the vessels crew were preparing the passengers for swimming and snorkelling

activities. During this period the fire alarm sounded in the wheel house indicating an engine room fire.

The master disengaged the engines from the propeller drive train and proceeded to the saloon deck and observed smoke emanating from a storage space on the vessel's deck. The master instructed the crew to muster the passengers on the aft and upper deck spaces.

The master then shut the remote fuel shut off valves, closed the vent flaps to the engine room and attempted to release the NAF S III engine room fixed fire suppression system. During the attempt to release the fire suppression system some difficulty was experienced in opening the control box containing the release mechanism due to the butterfly nut on the lid being seized on the screw threads. With the aid of a knife the control box was finally opened and the master pushed down on the release button with the intention of activating the system. As there was no movement of the button the master assumed that the system had been automatically released into the engine space.

After approximately 10 minutes the master accompanied by a passenger who was a friend of one of the crew members, entered the aft compartment through an access hatch in the aft deck and made their way through to the engine room watertight door on the engine room aft bulkhead. The master then released two dry chemical powder extinguishers in the area that was observed to be still smouldering.

The master then called for assistance on the VHF marine radio by calling the dive vessels operating in the area on channel 77.

All the passengers were evacuated onto several vessels that came to the Moonrakers assistance. The evacuation was completed by approximately 1530. There were no reported injuries to the passengers or crew.

At 1603 the master informed Coast Radio Melbourne on channel 16 that the Moonraker was disabled due to a fire on board and was being towed. The master requested information with respect to the ship movements in the channel as the vessel was traversing the South channel of Port Phillip Bay on its way to the Sorrento pier.

The master advised this investigation that she believed that the survey requirement of the Marine Safety Victoria survey of 03 October 2006 to "test E/R fire system & smoke alarms & report" was with respect to the fire detection system and that the system was tested and found to be satisfactory. The master further stated that Marine Safety Victoria did not require the fire suppression system to be tested.

3.10.2 Crew evidence

All the crew members corroborated the master's evidence and did not contribute any other factors of any significance.

3.11 Environmental conditions

The Bureau of Meteorology advised that at the time of the incident the weather was reported to be fair with clear visibility. At 1200 the wind direction was south south-easterly of eleven knots and changed to a southerly of 13 knots by 1500. The sea was calm with a long slow swell.

3.12 Emergency response

Other than the Masters VHF call to the dive boats at approximately 1355 on Ch 77 no other emergency action has been recorded. The passengers on the vessel were evacuated onto several vessels that came to the Moonrakers assistance. The evacuation was completed by approximately 1530.

The master called Coast Radio Melbourne on channel 16 at about 1603 to advise that the Moonraker was disabled and under tow and requested information on ship movements in the southern channel.

3.13 Statutory provisions, rules and guidelines

The requirement for the survey and the issue of a certificate of survey to a trading vessel is governed by the requirements of the *Marine Act 1988*, Marine Regulations 1999 and the USL Code.

The *Marine Act 1988* makes specific provisions in relation to the issue of certificates of survey by the Director of Marine Safety.

The Marine Regulations states specific requirements in relation to the survey, construction and equipment of commercial vessels.

Operations within a range of 30 nautical miles from the seaward limit of a designated smooth or partially smooth water area or of a safe haven are defined as "*Restricted Offshore operation"* or "C" waters.

Marine Determinations designate State waters as smooth waters or partially smooth waters, and areas landward (north) of an imaginary line drawn between Point Lonsdale and Point Nepean are designated partially smooth waters or "D" waters.

Commercial passenger vessels are categorised as class 1 vessels.

The Moonraker is in Marine Safety Victoria survey as a dual Class 1C and1D vessel. Under Class 1C the vessel is certified to carry 22 passengers and three crew members and in class 1D operation the vessel is certified to carry 81 passengers and three crew members.

The regulations require the owner of a vessel to report to Marine Safety Victoria any special factors which may influence the Authority's survey requirements for that vessel including any change of trade, operations and *alterations to structure or machinery which have occurred since the previous survey.*

The regulations require that the gas container of a fixed fire extinguishing installation is recharged and pressure tested at intervals not exceeding five years. There is no specific requirement in the regulations for the inspection and testing of the actuating mechanism of the fire suppression system.

3.13.1 Vessel survey

Marine Safety Victoria is the State regulatory authority responsible for the safe operation of vessels on State waters by coordinating waterway management, developing and implementing vessel standards and operator competencies.

The Marine Safety Victoria procedure for the renewal of Certificates of Survey requires a periodic survey of a vessel to be carried out by a designated surveyor.

The procedures define a "Periodic Survey" as a "*thorough examination of a vessel carried out at specified intervals that include tests and trials to verify, within the scope and depth of the inspections, the vessel's continued compliance with the applicable legislation and standards, subject to any program for the rectification of deficiencies*".

The designated surveyor is required to complete an "*Annual Survey Checklist*", and on completion of the survey complete a "*Survey Requirements Report*".

The procedures require the surveyor to sign a "*Survey Report and Declaration*" on completion of the survey and receipt of any documentation required in the "*Survey Requirements Report*", including signed deficiency rectification returns.

In addition to the periodic survey, Marine Safety Victoria surveyors and officers of the Victoria Water Police carry out random safety inspections of commercial vessels. Marine Safety Victoria requires that a minimum 15 percent of the commercial vessel fleet is inspected annually. A vessel audit checklist is used as a guide for the inspection. The list includes the checking of the portable fire extinguishers and the fire alarm, but not the fire suppression system.

The vessel records show that the last inspection of the vessel before the incident was carried out by a Marine Safety Victoria on 03 October 2006. On completion of the inspection Marine Safety Victoria issued a survey requirements report no.6743 to the vessel owner. Item (E) on the survey requirement report required the owner of the vessel to "*test E/R fire system & smoke alarms & report*".

On 16 November 2006 the vessel owner submitted a statutory declaration stating that all the deficiencies listed in the Marine Safety Victoria survey requirements report had been rectified.

On 29 November 2006 the surveyor completed a declaration stating that the items listed in the survey deficiency notice had been rectified by the vessel owner in accordance with the *Marine Act 1988* and Marine Regulations 1999. Marine Safety Victoria issued a Certificate of Survey No.S0010451 on 29 November 2006 with an expiry date of 23 November 2007.

The Marine Safety Victoria survey staff advised that the survey requirement with respect to the fire suppression system was that "E/R fire system" encompassed the fire suppression and detection systems and both these systems were required to be tested and a report submitted to Marine Safety Victoria.

Marine Safety Victoria further advised that the vessel owner or operator is required to inform Marine Safety Victoria when a modification to the vessel is carried out. This requirement has been publicised by Marine Safety Victoria at public forums, Marine Safety Victoria publications and verbally by vessel surveyors.

4. ANALYSIS

It was extremely fortunate that the fire did not spread beyond the localised area of the engine room. Had the fire taken hold of the vessel's aft fibre glass bulkhead, the fire could not have been contained to the engine room as the fire suppression system was not operational and a very serious incident could have resulted with injuries or even a loss of life of passengers and crew.

4.1 The Fire

Fires start when both a flammable or a combustible material in the presence of oxygen is subjected to enough heat. The common fire causing sources include a spark, another fire or sources of intense thermal radiation.

Mechanical and electrical equipment may cause fire if combustible materials used on or located near the equipment are exposed to intense heat.

A fire can be sustained by the further release of heat energy in the process of combustion and may propagate, provided there is a continuous supply of oxygen and fuel.

Based on the area of the most intensive and lowest burning, it is most probable that the fire started in the area of the cofferdam space under the Genset.

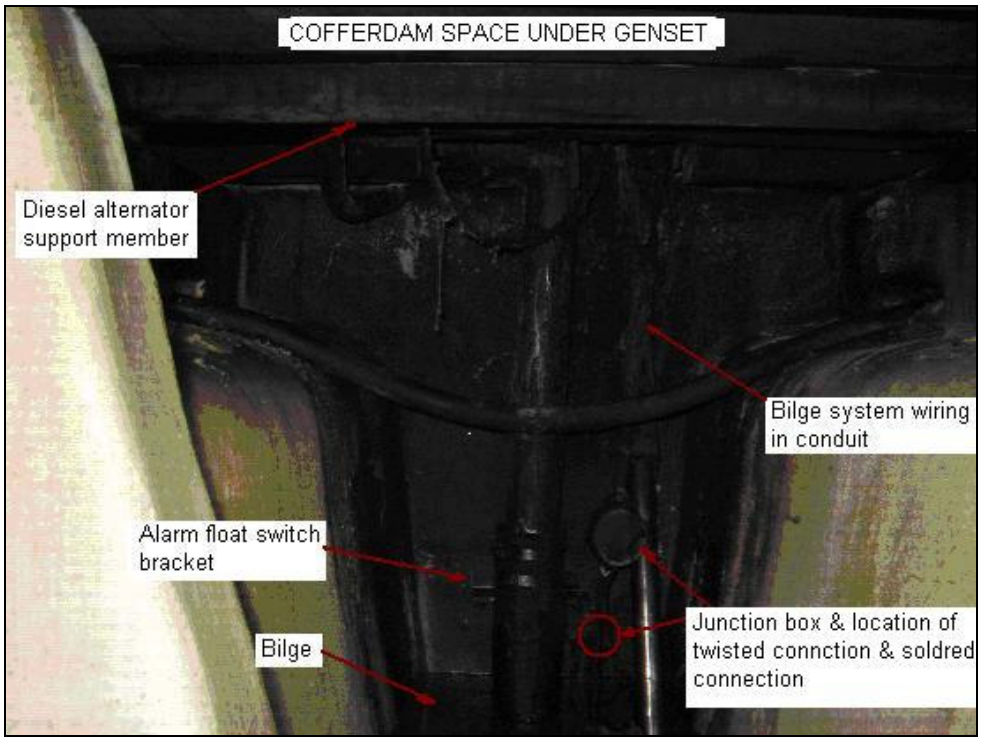

Figure 8 - Cofferdam space under Genset

The underside of the plywood platform supporting the Genset and the underside of the plywood battery support were both heavily charred, further indications that the seat of the fire was below both these units. The burn pattern of the bilge pump activating float switch indicates that the fire was external to this switch.

The alarm float switch located above the pump activating float switch was completely destroyed and the only evidence of the existence of this unit was molten plastic deposits in the bilge.

4.2 Source of ignition

4.2.1 Genset and battery

Although there was severe external damage to the Genset battery enclosure and cover, there was minimal damage to the battery itself. The battery terminals were firmly connected to the cables and no signs of arcing or sparking was observed at the terminals. Based on the above the Genset battery can be discounted as the source of ignition.

Inspection and tests conducted on the Genset indicate that the unit is in operational condition. The unit sustained external fire damage of a superficial nature and the evidence suggests that the source of ignition was external to the unit.

4.2.2 Bilge pump and components

The maximum current ratings of the pump activating float switch (15A) and the current rating of the bilge pump (15.5A to 20A) indicate that the float switch is under rated[9] for the application.

The approved design drawings indicate a 10A circuit breaker for the bilge pump and activating switch. The present configuration of the system shows a 15A circuit breaker.

The design drawings specify 2.5 mm^2 wiring for 15A circuits; however the vessel wiring is currently 1.5 mm^2 indicating that the wiring is significantly under rated.

Notwithstanding the above this investigation could not find sufficient evidence that overloading of wires or the bilge pump activating switch generated sufficient heat to be the cause of ignition.

4.2.3 Bilge system wiring and connections

The connection made by twisting two wires together to join the vessels wiring harness to the bilge pump positive conductor showed oxidation, signs of arcing and overheating (Figure 9). Inadequately compressed connections can become resistive[10] over time, thereby increasing the power dissipation within the joint. Traces of diesel oil were found on the wires and the connection was in close proximity to the bilge where approximately 5 litres of diesel oil was found.

[9] A component is electrically under rated when the maximum current flow through the circuit can exceed the components maximum current rating.
[10] Increase in resistance due to reduced area of contact as resistance is inversely proportional to the cross sectional area of the conductors.

It is reasonable to conclude that the heat generated by this connection could have been sufficient to increase the temperature of the diesel oil to its flash point of 79 ^{0}C. It is probable that at this temperature the diesel oil ignited due to a spark occurring at this connection.

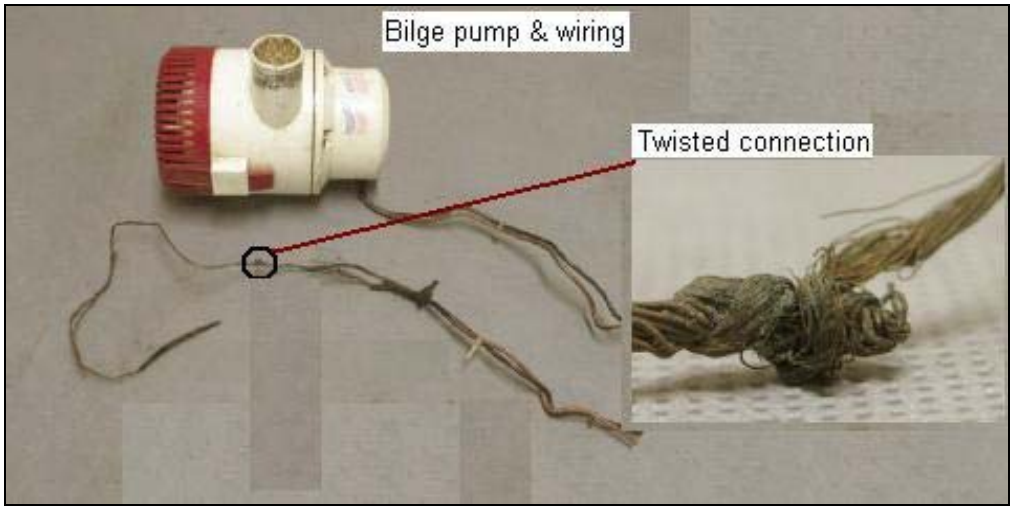

Figure 9 - Bilge pump wiring (positive lead connection)

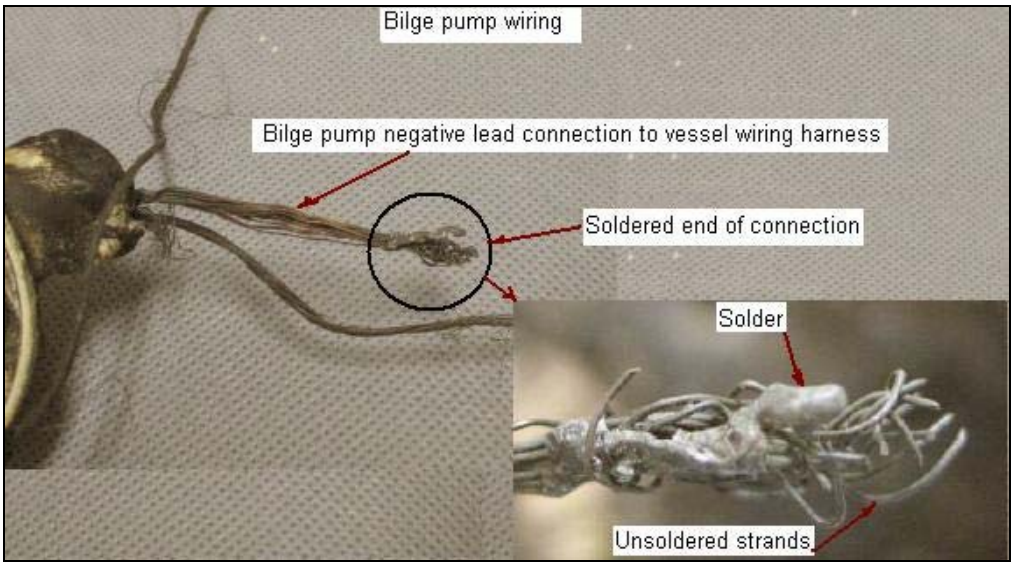

Figure 10 - Bilge pump wiring (negative lead connection)

The negative supply wire from the vessels wiring harness to the bilge pump also showed a poorly soldered connection (Figure 10). The loom with the soldered connection consisted of approximately 20 strands of copper wire. Only four of these wires appeared to be connected by the solder. The reduced cross sectional area due to the reduction of connected strands increases the resistance in the wire loom. This results in increased power generation and dissipation. The darkened ends of the wire strands indicate severe overheating. The solder used in this connection appears to be common electrical grade tin-lead solder which normally has a melting temperature of around 200^{0}C. Examination and laboratory analysis of the connection indicate that it is unlikely that external flames caused the melting of the soldered connection. It is reasonable to conclude that this connection could have been another source of ignition as the power dissipated at the connection could have been sufficient to heat the diesel oil to its auto ignition point.

4.3 Source of fuel

At the time of the inspection the cofferdam / bilge space under the Genset was found to contain approximately 53 litres of bilge fluid. Analysis of the bilge fluid indicated that approximately 10% (5.3 litres) of the bilge fluid consisted of diesel oil. This investigation concludes that the diesel fuel found in the bilge space came from the leaking Genset filter and was the major source of fuel for the fire.

4.4 Fire suppression system

The engine room fire suppression system was not released as the system release mechanism was not operational and the release knob and the release cable were seized. The investigation concluded that no inspection or testing of the fire suppression system has been carried out since 2003 and the deterioration of the release mechanism has occurred since the last service carried out in 2003.

The USL Code requires that the gas container of a fixed fire extinguishing installation is recharged and pressure tested at intervals not exceeding 5 years. The code does not make a reference to the testing of the other components of a fire suppression system. Good survey practice would be to require the vessel owner to employ an authorised service agent to carry out the testing of all components of the fire system. A certificate of survey should only be issued when a satisfactory report is received from the service agents. In this instance this practice was not followed. Annual inspection and testing of the system should be a mandatory survey requirement.

Marine Safety Victoria advised this investigation that the survey requirement with respect to the fire suppression system was that the “E/R fire system” encompassed the fire suppression and detection systems and both these systems were required to be tested and a report submitted to Marine Safety Victoria. The vessel master stated that this survey requirement was with respect to the fire detection system which was tested by her and reported by way of the statutory declaration.

It is the responsibility of a master of a vessel to ensure that critical safety equipment is maintained in operational condition. The fire system of a vessel comprises of a detection system and a fire suppression system. As a qualified Master 5 and Marine Engine Driver Grade 3 it is reasonable to assume that the vessel’s master has an understanding of the system and should have ensured that all components of the system were maintained in operational condition.

4.5 Crew qualifications and response

4.5.1 Master's qualifications and actions

The master of the vessel was appropriately qualified for the operation of this vessel.

The master took appropriate action in dealing with the fire with respect to shutting the fuel tank remote shut off valves and the engine room air intakes.

In the attempt to release the fire suppression system the master pushed down on the button instead of turning the button clockwise, the correct means of activating the system. This erroneous action did not affect the outcome as the system release mechanism was unserviceable and the fire was extinguished by fuel and air starvation.

The master did not inspect the machinery spaces before or during the second voyage of the day. It is good practice to carry out regular inspections of machinery spaces during vessel operations.

The fact that the master of the vessel was the only certified person on board made it difficult for the master to carry out both navigation and machinery monitoring duties.

In an emergency situation a vessel master is required by distress communication protocols to transmit a distress message "MAYDAY" or in the case of urgency a "PAN PAN" message on VHF channel 16. In this instance a "PAN PAN" message would have been the appropriate distress communication that the master of the vessel should have transmitted. Instead of an urgency message the master relied on a call on VHF channel 77 to the dive vessels in the vicinity to come to the Moonrakers assistance.

4.5.2 Crew qualifications and actions

The crew members of the vessel were qualified only in dive operations and were on the vessel for coordinating passenger activities and providing hospitality services. None of the crew members were qualified or trained to assist the master in vessel handling or in the use of fire fighting appliances or life saving appliances.

During their period of employment on board the Moonraker none of the crew members had undergone a vessel induction or participated in an emergency drill with respect to fire or survival craft.

In the event that the master became incapacitated, none of the crew members would have been capable of competently carrying out the emergency procedures with respect to fire fighting, communication or deploying life saving appliances.

4.6 Statutory provisions

4.6.1 Crewing

Presently there is no requirement in the legislation, the USL Code or by Marine Safety Victoria for general purpose hands to have any training or qualifications in vessel handling or vessel safety operations.

Although not consequential to this investigation this incident highlights a risk with respect to single person operation of passenger vessels. This investigation deems that it would be reasonable to require that at least one general purpose hand has competencies in vessel emergency procedures and knowledge of life saving and fire fighting appliances on passenger carrying vessels.

4.6.2 Adequacy of survey requirements

The original electrical schematic for the vessel indicate that the bilge system is supplied by a 24V system. No evidence could be found that the 12V volt system found on the vessel and the components used in the system were approved by any statutory authority.

Modification of electrical systems without due consideration towards the matching of components, the use of correctly rated cables or connections that do not conform to good electrical practice could lead to short circuits, overloading, overheating and the resulting consequences of electric shock or electrical fires.

During an annual survey Marine Safety Victoria required that the vessel's fire system be tested and a report be submitted. The vessel owner submitted a statutory declaration stating that all the requirements in the survey report had been completed. This declaration was made as the master believed that the survey requirement to "test E/R fire system & smoke alarms & report" was with respect to the fire detection system and the system was tested and found to be satisfactory.

The survey requirements report did not clearly identify components that required testing; hence there was potential for different interpretation of Marine Safety Victoria requirements.

This incident highlights the fact that a statutory declaration may not provide adequate proof that the survey requirements have been completed.

4.6.3 Safety plans and procedures

At the time of the incident the vessel did not have any safety plans or procedures in place to deal with the emergency. All passenger vessel operators should be required to carry out a risk assessment of their operations and have safety procedures in place to deal with incidents and accidents.

5. CONCLUSIONS

5.1 Findings

Machinery space inspections were not carried out before or during the voyage.

There was a leak in the Genset fuel system.

Modifications had been carried out to the vessels electrical system without the required approval from a regulatory authority.

Electrical equipment and wiring used on the vessel was under rated for the applications.

Electrical connections in the wiring systems were not in accordance with acceptable industry standards.

The engine room fire suppression system was not operational.

Marine Safety Victoria survey requirements report did not clearly list fire system components that required testing.

The owner of the vessel submitted a statutory declaration stating that the survey requirements were completed based on a misinterpretation of the survey requirements.

A certificate of survey was issued by Marine Safety Victoria based on a statutory declaration submitted by the vessel master.

The engine room fire suppression system was not serviced as required by the Marine Safety Victoria survey of the vessel.

5.2 Contributing factors

Poor workmanship with respect to electrical connections in the electrical systems.

A lack of monitoring of the vessel's machinery space leading to the Genset fuel supply system leak not being detected.

6. SAFETY ACTIONS

6.1 Safety actions taken since event

Marine Safety Victoria has carried out a re-inspection of the vessel and issued a survey requirements report to the vessel operator.

The fire suppression system has been inspected and tested by an approved fire service agent.

6.2 Recommended safety actions

RSA 2007001

Marine Safety Victoria reviews its survey processes with respect to repairs or modification to commercial vessels.

RSA 2007002

Marine Safety Victoria reviews its survey requirements with respect to critical safety equipment on commercial vessels.

RSA 2007003

Marine Safety Victoria reviews the requirement for commercial passenger vessel operators to implement safety management plans for their vessel.

RSA 2007004

Marine Safety Victoria reviews its crew competency requirements for passenger vessels with respect to the vessels operating with a single certified master.

6.3 Marine Safety Victoria responses to draft recommendations

The following are Marine Safety Victoria's responses to the above recommendations made in the draft report.

RSA 2007001

"MSV requires notification of modifications to commercial vessels and that they comply with survey requirements. There is a culture where MSV are not notified of many repairs and modifications – particularly 'simple' ones like the low voltage electrical system modifications cited in this report – which are carried out as part of routine maintenance. MSV is working to rectify this problem. The requirement for notification has been publicised in recent publications and stakeholder forums".

RSA 2007002

"The National Standard for Commercial Vessels (NSCV) will shortly start amending the USL Code. The amendments will replace prescribed servicing intervals with the manufacturer's requirements. MSV will adopt the amendments to the USL Code as a result of the new NSCV requirements. There therefore seems little point in reviewing survey processes when the new system will be in place when adopted legislatively in the near future".

RSA 2007003

"This recommendation has already commenced for vessels in the Yarra precinct which will be followed by the balance of commercial passenger vessels. MSV is currently implementing Part E of the NSCV which requires safety management plans or safety management systems on all vessels under survey. MSV has been proactive in encouraging all passenger vessels to implement these plans and have completed a large number of forums specifically for this purpose this year. Requirements for these plans will be progressively phased in across the State over the next few years. The first sector requiring plans are passenger vessels in the Melbourne metropolitan area. It is planned to have draft plans for all passenger vessels in the Yarra precinct in place by December 2007. Safety management plans for other passenger vessels operating within Victoria will form the next tranche of plan development".

RSA 2007004

"This recommendation is also in the process of review by MSV. Part of the work on Yarra Precinct vessels mentioned above has involved the reassessment of the crewing policy for commercial vessels within Victoria. An identified issue is the operation of vessels by crew where a single certified person holds both master and engineering qualifications. An options paper is in the final preparation stage. The recommended option is that MSV adopt the principles of Part D of the NSCV as the basis for crewing. Part D includes a risk assessment of crewing against vessel operations. Single certified person crewing will be assessed under this framework for commercial vessels under part D".

7 APPENDIXES

Appendix A – Vessel particulars & equipment

Name	Moonraker
Registered port	Sorrento
Survey authority	Marine Safety Authority
Identification no:	MB 300
Survey class	1C and 1D
Year built	1997
Builder	Seachrome Marine (Conquest)
Length overall	21.0 metres
Measured length	19.85 metres
Draft	1.6 metres
Beam	5.5 metres
Engine Type & model	Twin 6 Cylinder Caterpillar 3196, Turbocharged
Engine output	660 horse power@2300 revolutions per minute
Gearbox	Twin Disc MG 5114A
GB Reduction ratio	2.1:1
Electrical installation	240V, 24V, 12V

Appendix B – General arrangement of engine room & storage compartment

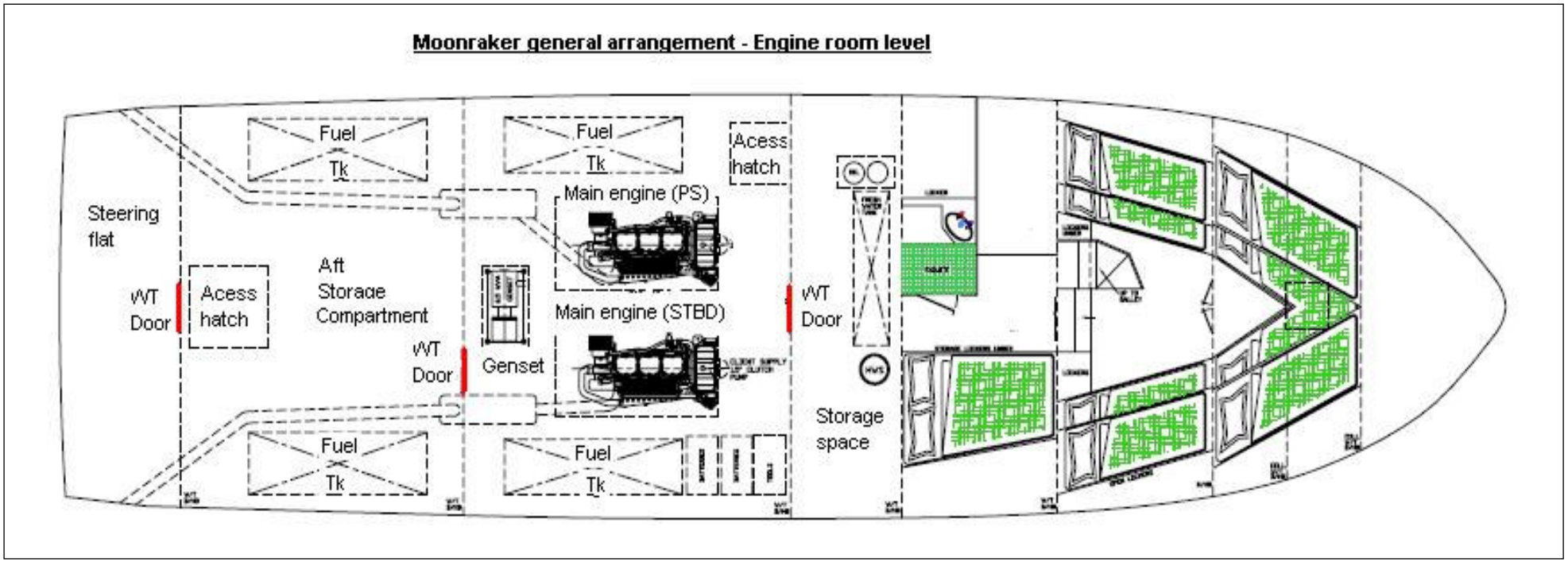

Figure 11 - General arrangement ER and adjacent spaces

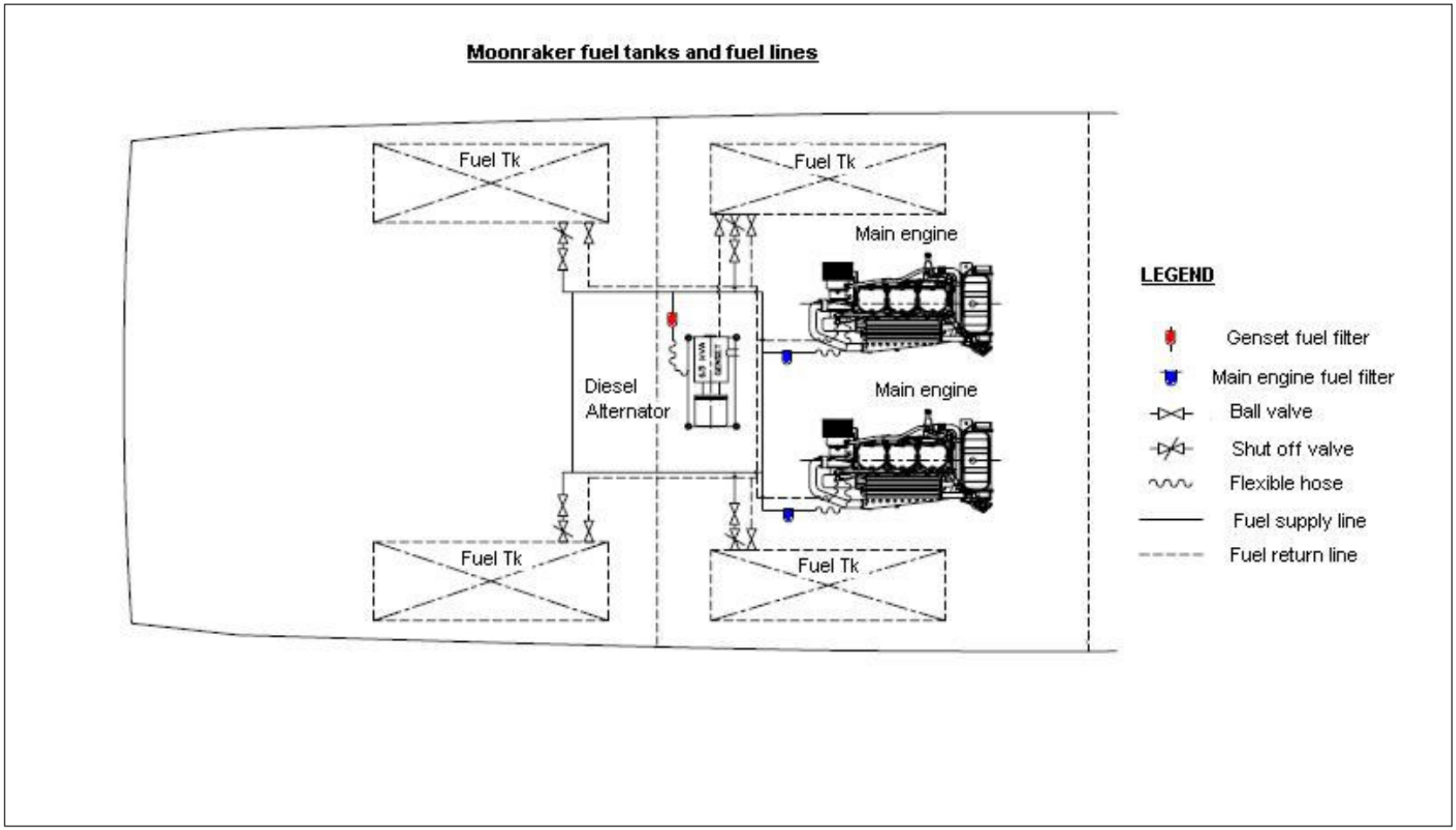

Figure 12 - Fuel tanks and filter arrangement

Appendix C – Location of incident