Report 97-208

Ro-Ro general cargo vessel *Union Rotoma*

engine room fire

off the south-eastern coast of New South Wales, Australia

3 December 1997

Abstract

At 0200 on Wednesday, 3 December 1997, while the Ro-Ro general cargo vessel *Union Rotoma* was on passage from Melbourne to Auckland, fire broke out in the engine room disabling one of its two engines, and causing substantial damage to electrical wiring and control systems. The crew used a fixed carbon dioxide extinguishing plant to put out the fire, and after the crew spent several hours making temporary repairs, the vessel was able to proceed on one engine to Sydney, the closest port of refuge. The fire was caused when fuel oil from a displaced return-fuel line sprayed onto the hot surfaces of the adjacent turbocharger, and ignited.

Safety issues identified included the design of the connecting block assembly between the fuel line and pump, and the engine manufacturer's dissemination of safety information on a known problem, to owners of the engine type.

Safety recommendations were made to the engine manufacturer regarding the effective dissemination of safety information to owners of their make of engine.

Union Rotoma

Transport Accident Investigation Commission

Marine Accident Report 97-208

Vessel particulars:

Type:	Ro-Ro (roll-on-roll-off)
Class:	VII: Foreign going cargo vessel (SOLAS)
Classification:	Bureau Veritas
Length (overall):	207.38 m
Breadth (extreme):	29.57 m
Draught (summer):	9.586 m
Tonnage (gross):	29 040 t
Tonnage (dead-weight):	21 653 t
Construction:	Steel
Built:	Chantiers de France, Dunkerque in 1976
Propulsion plant:	Two 13 428 kW S.E.M.T. Pielstick 16PC3V-480 type diesel engines, connected via a reduction gearbox to a single shaft and controllable-pitch propeller
Service speed:	19 knots
Owner/operator:	Union Shipping New Zealand Limited
Port of Registry:	Auckland, New Zealand
Persons on board:	Crew: 19
Injuries:	Nil
Nature of Damage:	Substantial to electrical wiring, fittings and control systems

Location: Off the south-eastern coast of New South Wales, Australia; in position 37° 36.14' S 153° 21.75' E

Date and time: Wednesday, 3 December 1997, at 0200[1]

Investigator-in-Charge: Captain T Burfoot

Sources of information: The Marine Incident Investigation Unit (MIIU) of Australia, conducted the on-site investigation and produced a preliminary report, on which the Commission's report is based.

[1] All times in this report are NZDT (UTC + 13 hours) and are expressed in the 24 hour mode.

1. Factual information

1.1 History of the incident

1.1.1 At 0200 on Wednesday, 3 December 1997, *Union Rotoma* was in position 37° 36.14' S 153°21.75' E, on passage from Melbourne to Auckland. The machinery spaces were running in the unmanned mode, and the unmanned machinery space (UMS) alarm system was switched to the cabin of the second engineer, who was the duty engineer that night.

1.1.2 Shortly before 0200, an engine room alarm sounded and the second engineer made his way toward the elevator. At 0204, before he reached the elevator, the fire alarm sounded. He was carrying his ultra high frequency (UHF) radio and heard the officer-of-the-watch on the bridge saying that there was a fire indicated in Fire Zone 3, at the level of the engine-tops. This was followed shortly afterwards by an announcement over the public address system.

1.1.3 Instead of using the elevator, the second engineer went to the door between the accommodation and the boiler flat at the top of the engine room. After carefully opening the door, he smelt smoke, so he closed the door and made his way into the machinery control room using the control-room escape trunk on deck 5.

1.1.4 The chief and one other engineer caught up with him as he made his way down, and the three arrived in the control room together. From the control room windows, they could see smoke in the vicinity of the port main engine turbocharger, but saw no flame. They suspected that the smoke may have been caused by a leak in the exhaust bellows at the turbocharger gas inlet. They started to reduce the pitch setting on the propeller and called the bridge to inform the officer-of-the-watch that they were going to stop the port main engine. As electrical power was being supplied by a generator driven by the port main engine, they started and ran up two auxiliary diesel-driven generators. This was done remotely from the control room.

1.1.5 A number of fire-fighting suits were stowed at one end of the control room, and one of the engineers started to don a suit to enter the engine room to determine the cause of the smoke. At that moment, the first flames appeared and, within seconds, erupted into a fireball. The chief engineer used the emergency stop push-buttons to shut down both main engines.

1.1.6 As the door at the top of the control room escape trunk had been left open, and air pressure caused by the fireball in the engine room blew open the starboard control room door, smoke started to enter the control room. The engineers left immediately via the escape trunk, with the smoke overtaking them.

1.1.7 Once out of the escape trunk, the chief engineer informed the bridge that he was heading for the carbon dioxide (CO_2) station to release the engine room CO_2 flooding, and asked the officer-of-the-watch to activate all the emergency trips and shut-offs from the bridge. As there had been no time to connect the two auxiliary generators on line, the ship blacked out when the port main engine stopped. Lighting was restored when the emergency generator started automatically. On the bridge, the officer-of-the-watch operated the emergency trips for the ventilation and fuel tank quick-closing valves, and instructed the crew to close down all flaps and vents to the engine room.

1.1.8 A crew muster was conducted using UHF radios and, once the chief engineer received confirmation that all personnel had been accounted for, he released 10 t of CO_2 into the engine room. The first mate was with the fire party closing down the engine room and, about five minutes after the release of the CO_2, he reported to the chief engineer that most of the vent flaps had been shut down.

1.1.9 At about 0300, the emergency generator failed due to lack of excitation. By about 0500, the engineers repaired a broken wire in the exciter, and restored emergency electrical power. Meanwhile, the rest of the crew were waiting for the CO_2 to extinguish the fire and for the engine room to cool down.

1.1.10 Once emergency power had been restored, two engineers donned breathing apparatus (BA) and attempted to enter the engine room to assess the situation; however, they immediately encountered considerable heat, so they did not enter. Approximately half an hour later, the two engineers donned BA and went down to number 3 deck, which was over the engine room. They felt the deck in the area above the fire and found it was still hot. At about 0555, the engineers found the deck was much cooler, which convinced them that the fire had been extinguished. The second and third engineers, wearing BA and in radio contact with a backup party, carried out a quick inspection of the engine room. They were able to confirm that there was no fire, nor any remaining hot-spots.

1.1.11 A CO_2 extraction fan was situated in the engine room, at the bottom of the elevator shaft. The fan, which ran off a supply from the emergency generator, was run to extract the remaining CO_2 from the engine room. After some hours, the second and third engineers again donned BA sets and then collected the three ELSA[2] sets from around the engine room and an oxygen/toxic gas meter from the electrical store in the control room. The ELSA sets were then left outside the engine room while the two engineers carried out another tour of the engine room. The meter showed no shortage of oxygen in the engine room, although it recorded the presence of a small amount of toxic gases.

1.1.12 When it was decided that it was safe to re-enter the engine room, the three engineers, carrying the ELSA sets, opened all of the vents to the engine room and also those to the two pipe tunnels leading forward. Portable vent fans were rigged at the doors to the pipe tunnels to increase the airflow. At about 1300, one of the auxiliary generators was started and the main electrical power restored.

1.1.13 Damage to the engine room was assessed. A substantial amount of electrical wiring, and many of the copper control air pipes, had been destroyed. When the hydraulic pump for the propeller pitch control system was started, numerous hydraulic leaks were found at joints and in copper lines to gauges. The end cover of the scavenge belt on the starboard main engine was found to have a hole melted in it, and had to be swapped for that on the port engine.

1.1.14 Several hours were spent determining the state of the electrical systems. A number of electrical interlocks and trips had to be bypassed in order to start the starboard main engine. Eventually, the starboard engine was clutched in and a deviation to Sydney started at 2335.

1.2 Vessel information

1.2.1 *Union Rotoma* was a New Zealand flag Ro-Ro ship of 29 040 gross tonnes with an overall length of 207.38 m and a beam of 29.57 m. The ship was built in 1976 at Dunkerque, France, originally for French owners. It underwent a succession of name changes - *Rostand*, *CGM Rostand*, *PAD Australia*, *Kagoro* and *Rost*, before it was acquired by its present owners, Union Shipping New Zealand Limited, in January 1991 and named *Union Rotoma* under the New Zealand flag.

1.2.2 The ship operated a regular service between New Zealand and Australian ports at a service speed of up to 19 knots.

[2] Escape Life Saving Apparatus – a small, easily donned, breathing apparatus of limited duration used solely for escape from a smoke or gas-filled environment.

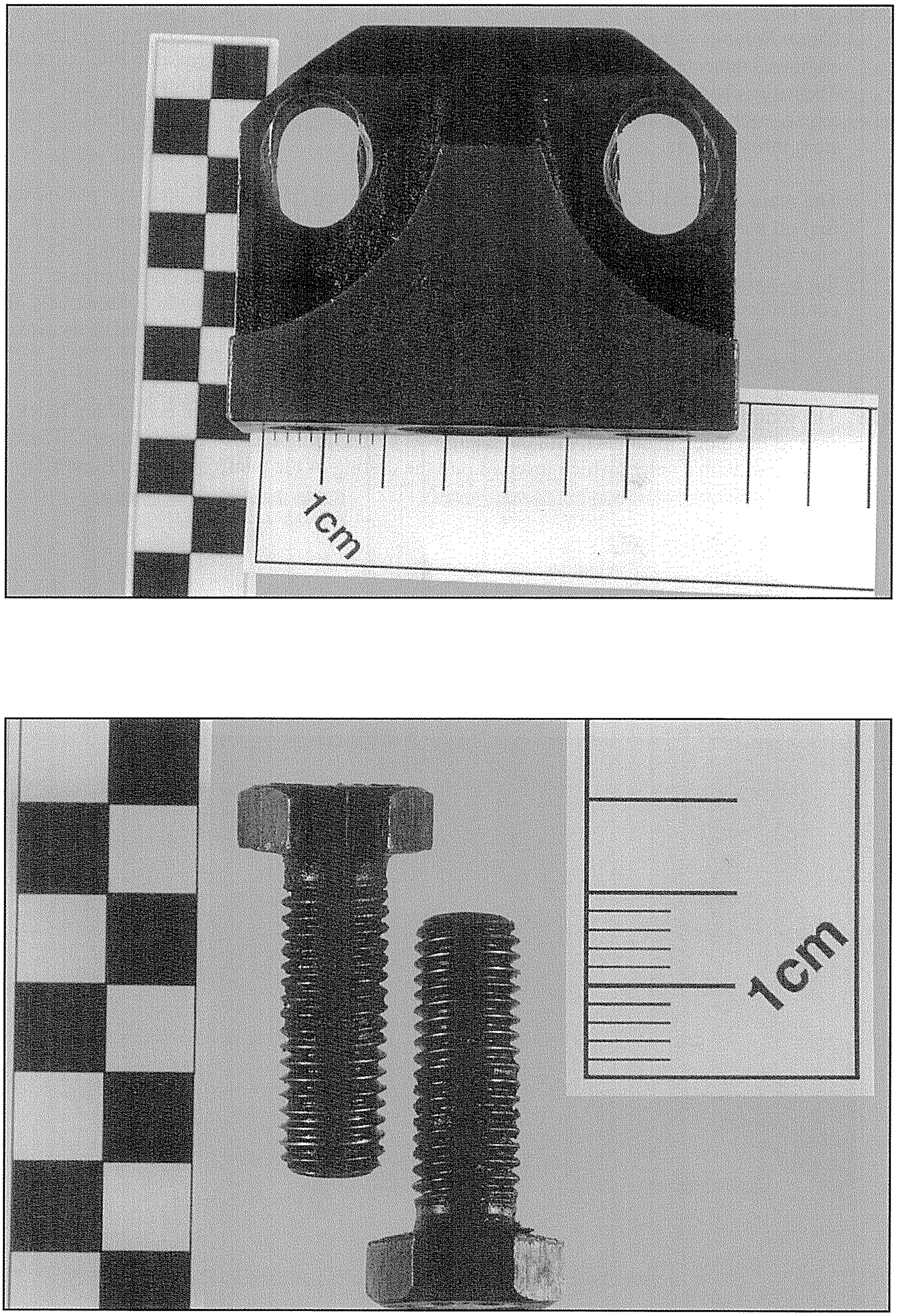


Figure 3
Photographs showing the return-fuel line connecting block and the two screws thought to have been securing it to the main body of number 9 fuel pump.

1.2.9 As a Ro-Ro vessel, the *Union Rotoma* was capable of carrying a large number of vehicles on the vehicle deck, so it was fitted with a bulk CO_2 fire fighting installation containing 37 t of liquid CO_2; sufficient to flood a number of spaces, including both the vehicle deck and the machinery spaces. The CO_2 was contained in two semi-pressurised, semi-refrigerated, bulk storage tanks situated in a CO_2 room on E deck. The control position for release of the CO_2 was on the weather deck, immediately outside the CO_2 room.

1.3 Post-fire investigation

1.3.1 After the fire, it was observed that the return-fuel line from number 9 fuel pump on the port main engine had separated from the pump body, the two screws intended to secure the flanged connecting block to the pump were missing. The pipe had sprung and the spigot on the connecting block had come part way out of the recess in the pump body, allowing a considerable flow of heated return fuel oil to escape at approximately 6 bar pressure. Evidently this escaping fuel oil was ignited by the hot surfaces of the turbocharger, close by the pump.

1.3.2 During the investigation, a number of set screws were found lying amongst debris on the top of the engine entablature alongside number 9 unit. Although others had the correct thread, only two were of the same length. These showed a relatively clean thread corresponding to the length of thread which would have screwed into the casting of the pump body. Therefore, these screws were probably the two which had secured the flange of the fuel return line to the body of the pump. The screws were undamaged (see Figure 3).

1.3.3 The flanged face of the connecting block had two oversize slots through which passed the two set screws, of 12 mm (nominal) diameter × 1.75 mm pitch, securing the flange to the pump. The slots averaged 13.8 mm in width and 21.8 mm in length, while the actual diameter of the set screws fitted was 11.8 mm. There was thus a clearance around the screws of 2.0 mm across the slot and 10.0 mm in the length of the slot. The hexagon heads of the set screws averaged 18.9 mm across the flats (21.5 mm across the corners). As a result, and as can be clearly seen in Figure 3, the underside of the head bore on a very small area on each side of the slot in the flange.

1.3.4 Only a few screws had a washer fitted to increase the surface bearing area. No washer was indicated in the parts list, or in the engine maintenance manual. No locking arrangement was provided for the screws and, again, none was indicated in the documentation.

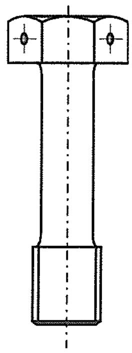
1.3.5 With such a small bearing surface on little more than the corners of the hexagon head, the edges of the slot were easily distorted, both when the screw was tightened on assembly, and by vibration. Examination of the 14 spare flanges, used prior to 1991, indicated that a dish-shaped indentation had been formed around the slots by the heads of the set screws. This would have led to a loss of the pre-load in the screws and facilitated their further loosening by vibration.

1.3.6 The few washers that were in place appeared to have been retrofitted to counter the effect of the dish-shaped indentation in the connecting block; however, as the washers were of light construction, they had bent into the indentation and the slot in the connecting block when the screws were torqued.

1.3.7 The investigator was told that engineers often experienced difficulty in aligning the fuel-return pipe with the pump body after maintenance work, and the indications were that the slots had been machined to facilitate this alignment. All the flanges on board, both new and used, were of this form.

1.3.8 S.E.M.T. Pielstick confirmed that the flanges had been originally manufactured with the wide slots to facilitate alignment of the pipe-work and to minimise stress in the pipes. No documentation had been issued on the subject of using washers under the heads of the screws.

1.3.9 In the parts manual carried on board *Union Rotoma,* the part number for these screws was given as 00.001.12.035.8. The current part number for the screws, provided by S.E.M.T. Pielstick was: 03 030 0031 00. A sketch of the screw corresponding to the new part number was also provided and is reproduced below:



1.3.10 As can be seen, the new screw was "waisted", to induce the screw to stretch when torquing, to increase its potential clamping force. The new screw was also provided with cross-drillings for fitting locking wire. The head, however, had the same dimensions as the old standard M12 screw, which corresponded to the old part number. S.E.M.T. Pielstick also advised that the new screws had a "higher mechanical resistance" than those in the original parts list.

1.3.11 In addition, it was stated in the advice from S.E.M.T. Pielstick:

> Remark: these screws must be locked by a lock wire

1.3.12 S.E.M.T. Pielstick further advised that these screws were designed in 1976 for the purpose of "increasing the reliability of the equipment". No Service Bulletin, however, had been issued by them on the subject of the new securing screws.

1.3.13 The maintenance manual did not state any specific torque to which the particular set screws fitted on *Union Rotoma* should be tightened, but it did provide a table listing the torque to which "common" screws and bolts of each size in general use should be tightened in non-specific assemblies. For M12×1.75 screws, this was listed at 4.5 m.daN (45 N.m).

1.4 Leakage detection

1.4.1 The supply and return pipes connected to the fuel pumps, and also the injector pipes connecting the fuel pumps to the injectors, were all sheathed pipes. The lower ends of the outer sheath were open to allow any leaking fuel oil to drain into a leakage detector trough mounted on the engine (see Figure 1). There were four leakage detector troughs on each engine, one at each end on each side. The troughs were fitted with a float alarm, but also had a small drain outlet, so that minor leaks would not allow fuel to fill the trough and activate the alarm, whereas a major fuel leak would fill the trough and activate the alarm.

1.4.2 An additional leakage detection trough had been installed on the inboard side, and ran the full length of each engine. This second leak detector was fitted with an alarm also. The second trough was below the first ones and was designed to be a "catch all" leak detector.

1.5 Maintenance and running hours

1.5.1 *Union Rotoma* was acquired by Union Shipping Limited of New Zealand from its English owners in 1991. When the vessel was handed over, no documentation or maintenance records were supplied and it was not possible to establish either the quality or extent of maintenance carried out on board prior to that time.

1.5.2 The port main engine of *Union Rotoma* had, at the time of the fire, run 124 502 hours. Number 9 fuel pump had been in service for 24 486 hours since being changed, while the low pressure (or return) fuel rail had been replaced on 27 September 1996, when the engine had run 118 507 hours. The maintenance record for the engine indicated no subsequent occasion on which it would have been necessary to disturb the connection between the return-fuel line and the number 9 fuel pump.

1.5.3 The engine-builder's maintenance manual made no reference to any specific maintenance or checks to be carried out on the fuel rail and connections. Nevertheless, a visual check of this part of the engine was usually carried out by the duty engineer during the course of his daily rounds. Rounds were carried out once each morning, afternoon and evening. The log sheets were completed during the morning rounds.

1.5.4 The previous evening, that of 2 December, the duty engineer (the second engineer) had finished work at about 1630. He had started his engine room rounds at 2100 and left the engine room at approximately 2200. During his rounds, he observed nothing amiss with the fuel system on the port main engine. At 2340, he was called out by the UMS alarm system to attend to a fuel leakage alarm on the starboard main engine. This was caused by a blocked drain in the fuel leakage detector trough and was not caused by a significant leak.

1.5.5 Engineers were familiar with the results of vibration in the Pielstick PC3 main engines on the *Union Rotoma*, and found it necessary to tighten frequently the various oil pipe connections, both fuel and lubricating oil, and to nip up bolts or screws to prevent minor leaks developing into bigger problems. Much of the piping was subsequently mounted on anti-vibration mounts. Approximately six months before this incident, a fuel pump and its holding components had worked loose, shearing the low pressure fuel pipe. In the seven years the vessel had been operated by Union Shipping, this was the first known incidence of a low pressure return-fuel line coupling vibrating loose.

1.5.6 Much of the vibration stemmed from the starboard main engine, the crankshaft of which had suffered damage at some time prior to Union Shipping purchasing the *Union Rotoma*. The crankshaft had been repaired, but the repair left two main and four bottom end journals under size. Since then, that engine had caused significant vibration. Because the two engines were clutched in as a single unit when at sea, the vibration from the starboard engine was transmitted to the port engine.

1.5.7 The loading on low pressure fuel lines for diesel engines was a topic under discussion among engineers world wide. Although the nominal pressure of the fuel oil was about 6 Bar, studies indicate that the pulse loadings in the low pressure fuel pipes caused by the fuel pump action can reach far in excess of this figure. A number of failures in low pressure fuel systems have been attributed to such pulse loadings.

2. Analysis

2.1 Design

2.1.1 With the set screws which secured the flange to the fuel pump body being fitted in oversized slots, the bearing area under their heads was reduced. With the reduced bearing area, the clamping force generated after torquing the screw was also reduced, leaving the screws prone to loosening. As they had no form of locking, they were free to back out of the fitting.

2.1.2 S.E.M.T. Pielstick's modification of the set screws in 1976, was probably made in response to similar failures; however, the modification did nothing to improve the load bearing surface between the flange and hexagonal heads.

2.1.3 While lock wiring of each screw would normally prevent it from loosening right off, the modification would have been more efficient had it included the fitting of a suitable heavy washer to each screw to increase the load bearing area. Without such a washer, the benefit gained by "waisting" the set screws was reduced. The absence of a washer would limit the clamping force achieved, and fretting between the coupling and the screws due to vibration could still occur. If a loosened screw is subjected to severe vibration, it is not uncommon for its locking wire to break.

2.1.4 Having made a modification to "increase the reliability of the equipment", a prudent equipment manufacturer would normally disseminate such information to all known customers. As S.E.M.T. Pielstick did not release a service bulletin, important safety information was not passed on from them to the owners of PC3 engines.

2.1.5 The S.E.M.T. Pielstick PC3 diesel engines on the *Union Rotoma* were known to suffer from high vibration levels. Several modifications had been made to the engines to reduce the potential damage caused by vibration. Some of the used return-fuel couplings retained on board were observed to have suffered similar distortion around the screw slots to that observed on the failed coupling from number 9 fuel pump. As information regarding the modified set screws was not disseminated to owners of S.E.M.T. Pielstick engines, and this was the first instance in seven years of a return-fuel line coupling vibrating loose, it is not surprising that the potential for this incident went undetected.

2.2 The fire

2.2.1 At approximately 0200, immediately before the fire, the second engineer had been on his way to attend to an engine room alarm. In the absence of any automatic alarm logger on *Union Rotoma,* it was not possible to ascertain what caused the alarm, as this event was overtaken by the subsequent fire. The alarm was probably a fuel leakage alarm on the detector at the aft inboard side of the port main engine, immediately below number 9 fuel pump. The functioning of this alarm could not be tested during the investigation, as the system had been damaged by the fire.

2.2.2 The engine room alarm call-out log, filled in manually by the duty engineer when called out after working hours, showed that the port main engine inboard fuel leakage detector, alarm channel 222, had activated on 25 November 1997, just one week before the fire. The indications are thus that the alarm was probably in working order. This being so, the fact that the alarm was activated shortly before the fire, together with the fact that the second engineer did not observe any leakage when completing his rounds earlier, indicates that the leak developed rapidly.

2.2.3 With the amount of vibration associated with the PC3 Pielstick engines in the *Union Rotoma*, and the pulse loading in the low pressure fuel rail, the coupling could be expected to begin to leak as soon as the set screws loosened. If it did not, one explanation is that the set screws both vibrated out over a period of time and the pipe was held in place by the fit of the spigot in the body of the fuel pump until the pressure and vibration overcame the friction fit, and forced the spigot out of the pump body.

2.2.4 Because of the rigidity of the low pressure fuel rail piping, the spigot was not forced totally out of the pump body. The fuel oil escaping under pressure from the pump body would have been partially atomised as it struck the spigot and flange of the coupling. The forced draft ventilator supplying fresh air to the turbo charger inlet, close by the source of atomised fuel, would have created an ideal atomised fuel/air mixture for the initial flames to erupt into a fireball.

2.3 Fire fighting

2.3.1 The fire was first sensed by the automatic fire detection system, which indicated a fire in Zone 3, the engine room tops. Within a short time, the other zones for the engine room were all in the alarm state, indicating a serious fire.

2.3.2 The crew muster was performed with a minimum of delay. As was the practice on *Union Rotoma*, all officers switched their UHF radios to Channel 1 upon hearing the fire alarm. As soon as the chief engineer realised that the fire could not be controlled by any other means, he decided to flood the space with CO_2 from the fixed fire extinguishing system. The initial response of the fire parties was to seal off the engine room while the chief engineer went to the CO_2 control room and released approximately 30% of the available charge.

2.3.3 The speedy and efficient manner in which the fire was extinguished was due in large measure to a well drilled and effective emergency response. This was facilitated by each officer having a personal radio, which allowed excellent communication by all involved, throughout the incident. It was evident that the fire drill regime on board provided effective training for this type of emergency.

2.3.4 This was the second incident in recent years involving an engine room fire on *Union Rotoma*. On 19 April 1994 a similar incident occurred when lubricating oil spraying from the starboard main engine was ignited by the hot exhaust manifold of the port main engine. That fire was also extinguished by means of flooding the engine room with bulk CO_2, and was investigated by the Australian Marine Incident Investigation Unit (Dept of Transport "Incidents at Sea" Report No. 68, published by the MIIU). This report identified the absence of oxygen and other gas monitoring/sampling equipment on board as a potential hazard.

2.3.5 The ship was subsequently equipped with such equipment, and the sampling of the engine room atmosphere after the fire had been extinguished was an important safety operation. As the engine room of any ship is more prone to fire than other areas, it would have been appropriate to have stored the gas sampling equipment away from this area.

3. Findings

Findings and safety recommendations are listed in order of development and not in order of priority.

3.1 The *Union Rotoma* was crewed, and its trading and classification certificates were valid, as required by the various rules and legislation.

3.2 The fire in the engine room was caused by a spray of fuel oil from a displaced connecting block on a fuel-return line, being ignited by the hot exhaust manifold and turbocharger casing.

3.3 The connecting block on the fuel-return line became displaced when two set screws securing the flange to the fuel pump body vibrated out.

3.4 Poor joint design, combined with engine vibration, contributed to the loosening of the set screws.

3.5 The set screws used on *Union Rotoma* were in accordance with the old part number shown in the parts list carried on board.

3.6 Set screws of a modified form should have been used to secure the flanges to the pump body.

3.7 There had been no Service Bulletin, or other notification, issued by S.E.M.T. Pielstick to inform owners of PC3 engines of the modification; therefore, important safety information was not disseminated.

3.8 The modification made by S.E.M.T. Pielstick in 1976 was incomplete, in that it did not address the issue of adequate load bearing surface under the screws.

3.9 The fast and effective response to the fire was a result of the crew being well drilled in fire fighting, having a good knowledge of their ship, and maintaining good communications throughout the incident.

3.10 The crew's response to the fire was fast and effective, prevented any injury and minimised the damage to the ship.

4. Safety Actions

4.1 Following the fire, substantial flat washers were fitted to each existing set screw to compensate for the lack of bearing surface in way of the oval slots in the connecting blocks. Additionally, each screw has been drilled and lock wired to prevent it loosening due to vibration.

4.2 Additional local shielding was fitted around each fuel pump, covering the low pressure pipe screws and the fuel pump low pressure pipe block bolts. The purpose of the shielding was to divert any fuel leakage, resulting from connection failure, away from the engine exhaust system.

4.3 The gas sampling equipment is now kept in the chief engineer's cabin, and must be signed out when in use, and signed in on return.

5. Safety Recommendations

5.1 On 17 July 1998 it was recommended to the Area Services Manager for S.E.M.T. Pielstick that the company:

5.1.1 Uses the most prudent and practical method available to them to disseminate information to owners of PC3 engines regarding modifications to the connecting block assemblies, (051/98); and

5.1.2 Ensures that it has an effective system for disseminating design and safety information to S.E.M.T. Pielstick owners in the future. (052/98)

6. Acknowledgement

The Commission appreciates the invaluable assistance provided by the MIIU (Australia) with this investigation.

Report approved for publication 5 August 1998

Hon. W P Jeffries
Chief Commissioner

Glossary of marine abbreviations and terms

aft	rear of the vessel
beam	width of a vessel
bilge	space for the collection of surplus liquid
bridge	structure from where a vessel is navigated and directed
bulkhead	nautical term for wall
cable	0.1 of a nautical mile
chart datum	zero height referred to on a marine chart
command	take over-all responsibility for the vessel
conduct	in control of the vessel
conning	another term for "has conduct" or "in control"
deckhead	nautical term for ceiling
dog	cleat or device for securing water-tight openings
draught	depth of the vessel in the water
EPIRB	emergency position indicating radio beacon
even keel	draught forward equals the draught aft
freeboard	distance from the waterline to the deck edge
free surface	effect where liquids are free to flow within its compartment
focsle	forecastle (raised structure on the bow of a vessel)
GM	metacentric height (measure of a vessel's statical stability)
GoM	fluid metacentric height (taking account the effect of free surface)
GPS	global positioning system
heel	angle of tilt caused by external forces
hove-to	when a vessel is slowed or stopped and lying at an angle to the sea which affords the safest and most comfortable ride
Hz	hertz (cycles)
IMO	International Maritime Organisation
ISO	International Standards Organisation
kW	kilowatt
list	angle of tilt caused by internal distribution of weights
m	metres
MSA	Maritime Safety Authority
NRCC	National Rescue Co-ordination Centre
point	measure of direction (one point = 11¼ degrees of arc)
press	force a tank to overflow by using a pump

SAR	Search and rescue
SOLAS	Safety Of Life At Sea convention
sounding	measure of the depth of a liquid
SSB	single-side-band radio
statical stability	measure of a vessel's stability in still water
supernumerary	non-fare-paying passenger
telegraph	device used to relay engine commands from bridge to engine room
ullage	distance from the top of a tank to the surface of the liquid in the tank
VHF	very high frequency
windlass	winch used to raise a vessels anchor