Report 01-208

coastal passenger and freight ferry *Arahura*

machinery space flooding

Cook Strait

7 June 2001

Abstract

On Thursday 7 June 2001 at about 2332, the passenger and freight ferry *Arahura*, with 63 passengers and 68 crew on board, was approaching Wellington when a machinery space fire alarm that had been activated was being investigated. On opening the sliding watertight door to the machinery space the engineers were met by water pouring from the space at a height of about 1.6 m above the floor plates. The door was closed again and pumps started to pump the water overboard. Prior to the flooding being discovered the watchkeeping engineer had been pumping engine room bilges for some time. On inspection it was found that an incorrectly configured sea suction valve was not completely closed and had allowed sea water to be pumped into the space via a bilge water collection tank overflow pipe. There were no injuries to passengers or crew and the damage to machinery and electrical systems was moderate.

Safety issues identified included:

- parts of the training and familiarisation for engineer watchkeepers
- the manning level of the engine room
- some of the watchkeeping and alarm monitoring practices aboard the *Arahura*
- the incorrectly configured sea suction valve of which the crew had been aware for 18 years.

Safety recommendations were made to Tranz Rail Limited to address the safety issues.

Arahura

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Glossary

aft	rear of vessel
bilge	space for the collection of surplus liquid
bridge	structure from where a vessel is navigated and directed
cable	0.1 of a nautical mile
Class	category in classification register
deckhead	nautical term for ceiling
free surface	effect where liquids are free to flow within a compartment
gross tonnage	a measure of the internal capacity of a ship; enclosed spaces are measured in cubic metres and the tonnage derived by formula
heel	angle of tilt caused by external forces
knot	one nautical mile per hour
list	angle of tilt caused by internal distribution of weights
port	left-hand side when facing forward
stability	property of a ship by which it maintains a position of equilibrium, or returns to that position when a force that has displaced it ceases to act
starboard	right-hand side when facing forward
tundish	a reservoir similar to a funnel

List of Abbreviations

cm	centimetre(s)
GM	metacentric height (measure of a vessel's statical stability)
ISM Code	international safety management code, International Maritime Organisation
kW	kilowatt
m	metres
m^2	square metres
mm	millimetres
MSA	Maritime Safety Authority
nm	nautical mile
t	tonnes
UTC	universal time (co-ordinated)

Data Summary

Vessel particulars:

Name:	*Arahura*
Type:	passenger and freight ferry (roll-on roll-off)
Class:	II (coastal passenger)
Classification:	Det Norske Veritas ✣1A1, R2 (NZ coastal waters) Car and Train Ferry A
Length (overall):	148.4 m
Breadth (extreme):	20.5 m
Tonnage (gross):	13 621 t
Built:	1983 in Denmark
Propulsion:	4 diesel-driven 3800 kW generators supplying power to 4 electric propulsion motors coupled to 2 shafts, each with a 4-bladed controllable-pitch propeller
Service speed:	19 knots
Owner:	Tranz Rail Limited
Operator:	Interisland Line Limited
Port of registry:	Wellington, New Zealand
Maximum passenger capacity:	997
Persons on board:	passengers: 63 crew: 68

Location:	Cook Strait
Date and time:	Thursday 7 June 2001, at about 2332[1]
Injuries:	passengers: nil crew: nil
Investigator-in-charge:	Captain W A Lyons

[1] All times in this report refer to New Zealand Standard Time (UTC+12 hours) and are expressed in the 24 hour mode.

1. Factual Information

1.1 History of the voyage

1.1.1 The roll-on roll-off passenger and freight ferry *Arahura* was operating on a scheduled Interisland Line service between Wellington and Picton (see Figure 1). At 2000 on Thursday 7 June 2001, an engineer watchkeeper started his 4-hour watch, assisted by an electrician. As part of the handover the on-coming watchkeeper asked how much was in the bilge water collection tank, tank 102, and was told about 3 t. At 2029 the ship arrived in Picton and the exchange of passengers and cargo commenced.

1.1.2 After arrival in Picton the electrician left the machinery space control room (control room) to inspect the passenger areas, while the watchkeeper conducted rounds of the machinery spaces and ancillary machinery rooms (engine room). At 2102 the forward propulsion motor room bilge high-level alarm sounded. As the watchkeeper had recently passed through the space he cancelled[2] the alarm without re-inspecting the space. During the loading or discharge of rakes of rail wagons it was not unusual for the ship to list up to 5 degrees, causing water in the bilges to flow to one side and activate the bilge high-level alarm. Both the watchkeeper and electrician returned to the control room for departure standby and at 2122 the watchkeeper accepted all the cancelled alarms. The bilge high-level alarm for the forward propulsion motor room immediately sounded again and the watchkeeper once again cancelled it without re-inspecting the space.

1.1.3 At 2126, the *Arahura* departed Picton for Wellington. On board were 63 passengers and 68 crew. After the ship departed, the watchkeeper remained in the control room. At 2137 the watchkeeper again accepted all the cancelled alarms.

1.1.4 At about 2140 the electrician left the control room to conduct his rounds of the engine room. At 2154 the forward propulsion motor room bilge high-level alarm sounded again and the watchkeeper once again cancelled it as he was aware that the ship was rounding Dieffenbach Point, a course alteration of about 90 degrees, which caused the ship to heel. He assumed that this was the cause of the alarm being activated again. At about 2210 the electrician returned to the control room and reported everything was okay to the watchkeeper before departing the engine room.

1.1.5 At 2214 an alarm sounded that was displayed on the monitor as "770 SPARE". The watchkeeper was not familiar with this alarm message so he cancelled it and took no further action at that time. He later stated, "…when the spare alarm channel came up I suspected it was a glitch in the CSI [alarm system]. I had never encountered it before." At 2215 the control room was put on standby for the transit of Tory Channel.

1.1.6 The *Arahura* cleared Tory Channel at 2224 and shortly afterwards the watchkeeper left the control room to start his rounds of the machinery spaces. He started at the forward engine room and was working his way aft, checking each space as he went. At 2248 the aft propulsion motor room bilge high-level alarm sounded. The watchkeeper had not by then reached that space so he cancelled the alarm with the intention of checking the bilge when he got there (see Figure 2).

1.1.7 The watchkeeper was still on his rounds when at 2252 the aft engine room starboard bilge high-level alarm was activated. From his previous rounds he was aware there was water in that bilge so he returned to the control room and using the remote fire and bilge pump mimic panel he set the valves to pump from the aft engine room starboard bilge to tank 102, the bilge water collection tank, and started the emergency fire and bilge pump. He then returned forward to the forward engine room to continue his rounds.

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[2] Cancelling the alarm silenced the audible alarm and stopped the rotating light. The alarm continued to flash on the monitor, but could not sound again for the same alarm condition. Accepting an alarm had the effect of resetting it so that it would sound again if the alarm condition recurred.

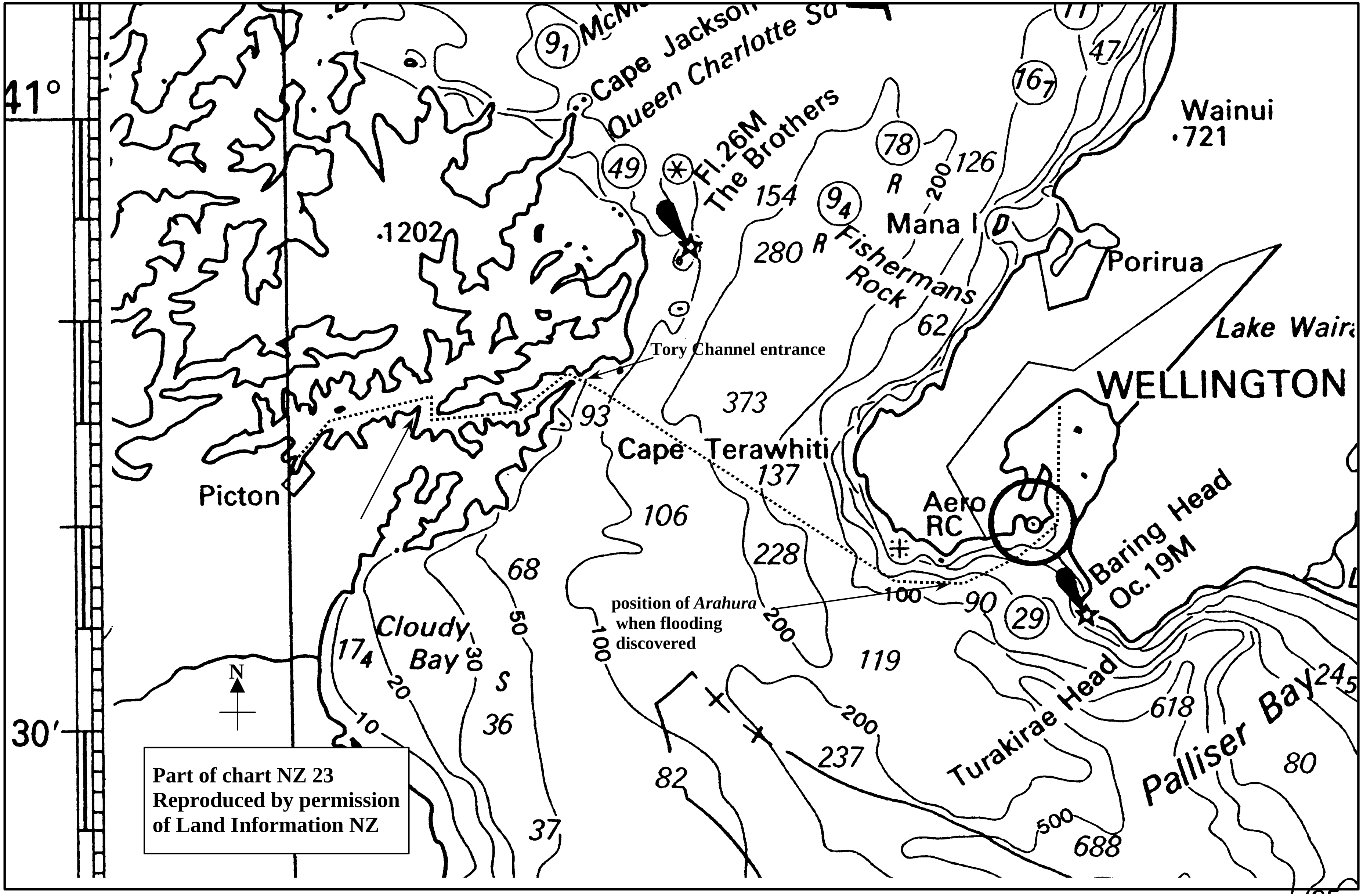

Figure 1
Part of Chart NZ 23 showing the route of the *Arahura*

1.1.8 Earlier that day the emergency fire and bilge pump had been tested as part of the weekly routine checks and the sea suction valve had been opened and closed as part of that test. The task had been signed off as having been completed by the watchkeeper on the previous 4 to 8 watch, who could not recall what time of day or how he conducted the checks. When the watchkeeper at the time of the incident set up the system to pump the aft engine room port bilge, the sea suction valve indicator on the mimic panel showed the valve as closed and the watchkeeper did not operate the valve or physically check it was closed.

1.1.9 At 2315 the aft engine room port bilge high-level alarm was activated so the watchkeeper returned to the control room and changed the valves on the remote mimic panel to pump from the port side. At 2324 the watchkeeper was still in the control room when a fire alarm sounded for fire zone 32, the forward propulsion motor room. He immediately telephoned the bridge and informed them that he was going to check the fire zone, and then left the control room.

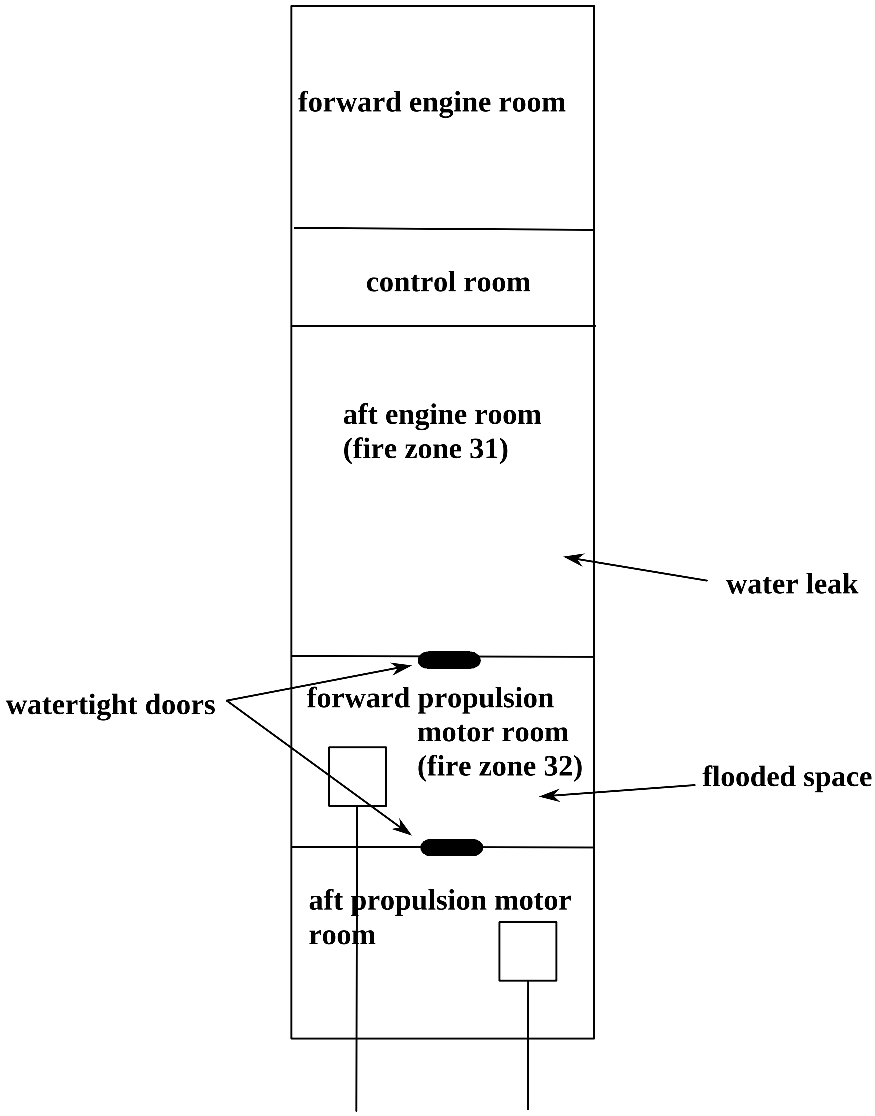

Figure 2
Machinery space layout
(not to scale)

1.1.10 As the watchkeeper entered the aft engine room he noticed a high-pressure jet of water escaping from a thermometer pocket plug in a pipe from a salt water cooling pump. The water jet was hitting the deckhead and spraying over electrical equipment. The watchkeeper immediately stopped the pump and closed the discharge valve. He then telephoned the first engineer, who was asleep in his cabin, and requested assistance. Around the same time a bridge watchkeeper telephoned the engine room to enquire about the fire alarm. The watchkeeper informed him that he was in fire zone 32 and there was no fire but he had discovered a water leak and the spray had probably activated the fire alarm. Shortly after, the first engineer arrived and isolated the leak by closing the valve on the suction side of the pump.

1.1.11 The watchkeeper then mentioned to the first engineer that a fire alarm had sounded for fire zone 32 and when he went to investigate he discovered the leak, which must have activated the alarm. The first engineer realised that they were not in fire zone 32, but actually in fire zone 31, so together they proceeded to fire zone 32, the forward propulsion motor room. When they started to open the sliding watertight door separating the 2 spaces they were met by water pouring from the space at a height of about 1.6 m above the floor plates (see Figure 3).

1.1.12 The first engineer left the watchkeeper to shut the watertight door and went to the control room where he sounded the general engineer's alarm. He then telephoned the bridge, informed them there was water ingress in the forward propulsion motor room and requested that they reduce the propeller pitch on the port shaft so he could stop the port propulsion motors.

1.1.13 The first engineer then went to the remote fire and bilge mimic panel and noticed that the emergency fire and bilge pump was running. He suspected that the water had come from the overflow pipe from tank 102, which vented into the flooded space, so he changed the pump valves to pump the water from the forward propulsion motor room overboard.

1.1.14 The chief engineer and other engineers started to arrive in the control room and the first engineer briefed them on the problem. The first engineer and another engineer went up to the rail deck and entered the forward propulsion motor room through its emergency escape hatch. They saw that the water was about halfway up the propeller shaft. The level was later measured to be about 2.1 m above the tank top or 1.6 m above the floor plates (see Figure 4).

1.1.15 The first engineer then entered the aft propulsion motor room through its emergency escape hatch to see if any water had entered that space. The first engineer said that although the watertight door between the spaces was shut they could see there was water in the space, but it was still below the floor plates. The first engineer climbed down to the plates and soon discovered that water was entering the space via a 25 mm pipe that ran from a tundish[3] on the oily water separator in the aft propulsion motor room back to tank 102. He shut the valve on the pipe and the flow of water ceased.

1.1.16 The first engineer sent other engineers to start pumping the water from the aft propulsion motor room and he returned to the forward propulsion motor room, where he could see the level of water was dropping.

1.1.17 Meanwhile, the night master had joined the second and third mates on the bridge after he heard the engineer's alarm sound. The ship had a starboard list of about 4 degrees at that time. At 2335 when the *Arahura* was 1.5 nm off Sinclair Head the course was altered to 130 degrees true. At that point the ferry was about 5 miles from the entrance to Wellington Harbour and the bridge team wanted to allow more sea room while the engineers assessed the situation before approaching the harbour entrance. Owing to the port propeller being stopped the speed had reduced to about 10 knots.

[3] A reservoir similar to a funnel.

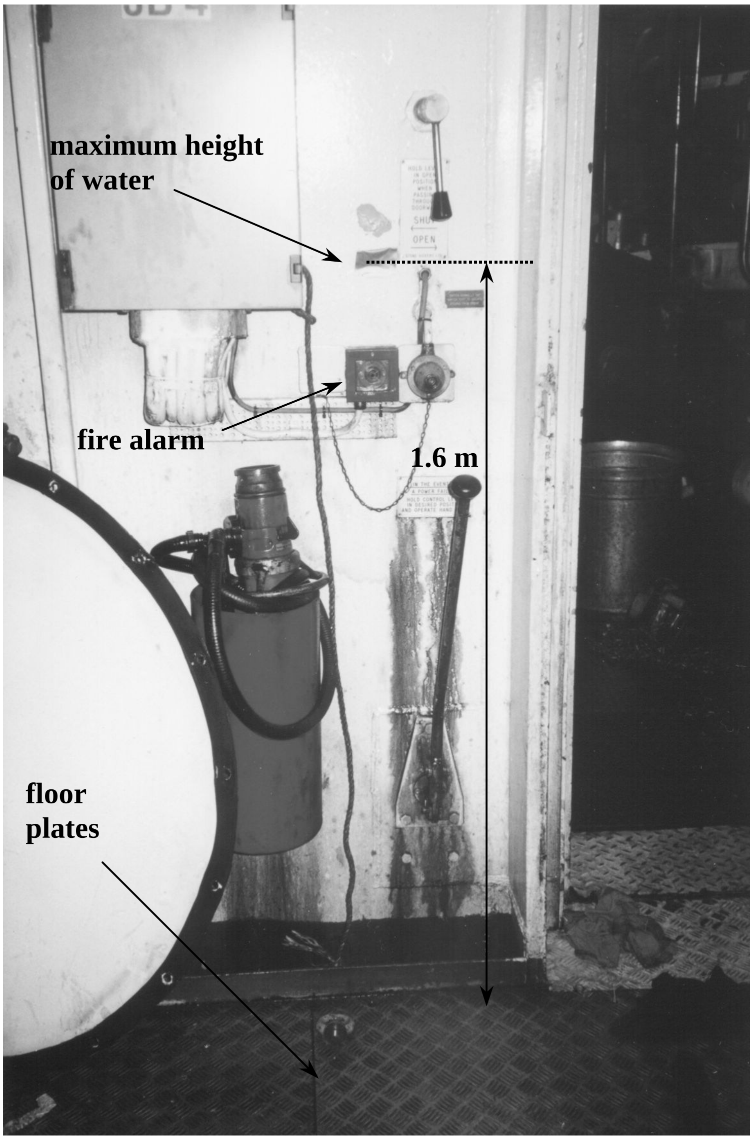

Figure 3
Fire alarm and water level

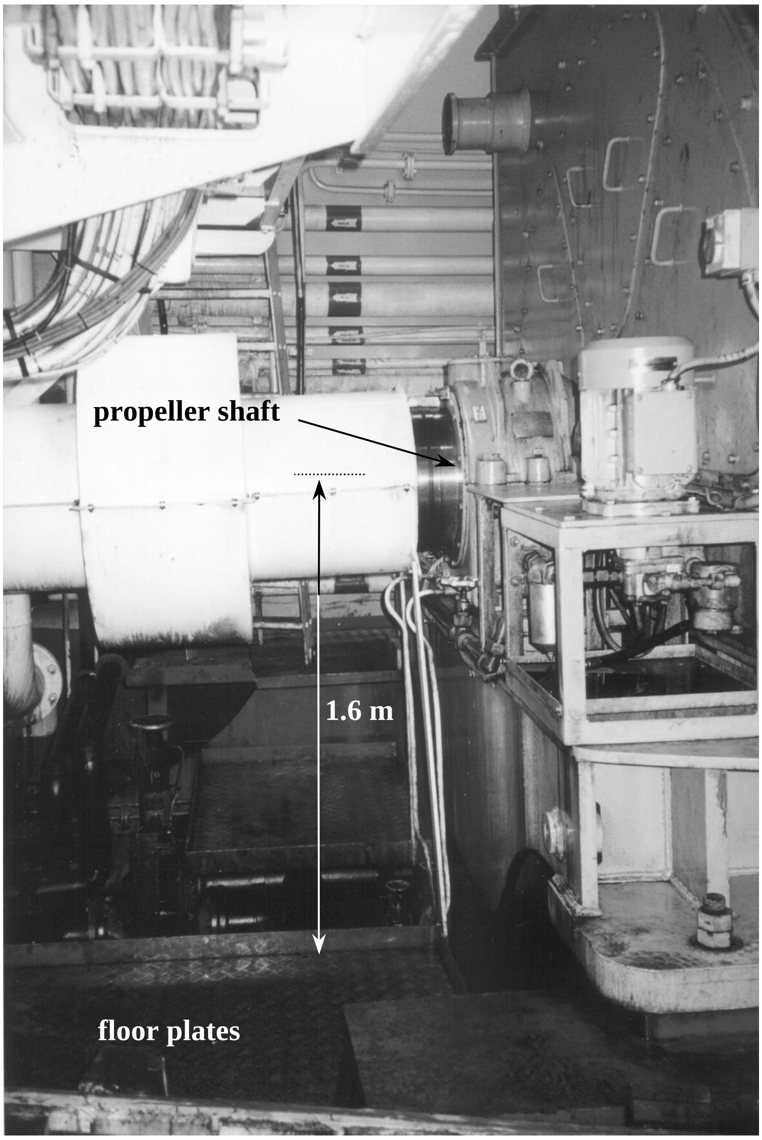

Figure 4
Rear of propulsion motor and water level

1.1.18 Soon after the night master had altered course, the chief engineer telephoned him and confirmed that the port propeller shaft had been stopped because there was water ingress in the forward propulsion motor room. Over the next few minutes the chief engineer telephoned the night master on a number of occasions to inform him that they had all available pumps running and the situation appeared to be under control. However, at no stage did he relay the full extent of the flooding to the night master. The night master later stated "I did not realise the extent of it [the flooding] until afterwards. I always thought that it was just water around the [floor] plates".

1.1.19 At some time off Sinclair Head the day master arrived on the bridge and discussed the situation with the night master. The night master contacted Beacon Hill by mobile telephone to inform them of the situation and request they pass the information on to the Wellington harbourmaster. The day master then took over the telephone communications.

1.1.20 The first mate arrived on the bridge and the night master asked him to calculate the loss of GM[4] due to the free surface effect of the water in the forward propulsion motor room. From the stability data calculated before departing Picton he estimated that the GM would be about one metre, which the night master thought was adequate. This calculation was based on only one space being flooded up to the floor plates.

1.1.21 At 2347 the chief engineer advised the night master that the situation was under control; the level of water was dropping and that he could guarantee propulsion on the starboard shaft. The course was then altered back for the harbour entrance.

1.1.22 In the engine room the engineers were still unable to conclusively determine the source of the water but as the level was dropping they were fairly confident that the first engineer's original assumption was correct and continued to pump the water overboard.

1.1.23 The *Arahura* berthed at the ferry terminal at 0100 and the discharge of cargo and passengers commenced. The ferry still had a starboard list of about 1.5 degrees and the water level in the forward propulsion motor room was just below the floor plates.

1.2 Damage

1.2.1 On inspection after the space was pumped dry, the following damage was found:

- the propulsion motors had been saturated and had about 10 cm of water in the bottom of the casing at the aft end
- the propulsion motor pedestal bearings were filled with water
- the heeling pump starter panel had been completely immersed
- the machinery space alarm system was inoperable
- the fire alarm in the space was inoperable
- the emergency fire and bilge pump start/stop controls were inoperable
- all terminal and junction boxes in the space were inoperable.

[4] Metacentric height (measure of a vessel's statical stability)

1.2.2 The deck area of the forward propulsion motor room was about 97 m² and the depth of water in the space reached 2.1 m above the tank top. Allowing a permeability of 0.85, about 177 t of water had entered the space. After the accident the first engineer conducted a test whereby he pumped sea water into tank 102 with the sea suction valve fully open and observed a rate of 3.9 t per minute. During the incident the pump was running for about 40 minutes, which equates to about 156 t.

1.2.3 After the incident the length and breadth and the maximum depth of water reached in each of the forward and aft propulsion motor rooms and the aft engine room was measured by the deck department. They then calculated the total loss of GM allowing for free surface in each space. For the aft engine room they allowed a depth of 0.6 m, for the forward propulsion motor room a depth of 2.1 m and for the aft propulsion motor room a depth of 0.3 m.

1.2.4 Using the figures obtained, the Commission checked the calculations and found the total loss of GM as a result of free surface due to the 3 spaces being flooded was about 0.55 m. On departure from Picton the GM was 1.316 m.

1.3 Vessel and route information

1.3.1 The *Arahura* was a roll-on roll-off passenger and freight ferry capable of carrying 997 passengers. The cargo decks were capable of carrying road vehicles and rakes of rail wagons. The ship was purpose built in 1983 and operated on a scheduled 24-hour service across Cook Strait between Wellington and Picton.

1.3.2 The duration of the voyage from berth to berth was about 3 hours and comprised 3 sections: a 60-minute passage through the Marlborough Sounds, an 80-minute crossing of Cook Strait, and a 40-minute transit of Wellington Harbour.

1.3.3 At its narrowest point Tory Channel entrance is about 3 cables wide with steep-sided headlands on both sides, making it a "blind" corner that requires a course alteration of about 80 degrees. Tidal flows through the entrance are strong and can reach about 6 knots during spring tides. The *Arahura* usually transited the entrance at full speed.

1.3.4 At 2335 the weather conditions were a south-easterly wind of about 20 knots with a slight to moderate sea and one metre southerly swell, which caused the ferry to roll easily. The sky was overcast and the visibility was good. High tide was predicted at 0034 the next morning.

1.3.5 The propulsion system of the *Arahura* was diesel electric with the engine room divided into 4 main machinery spaces, 2 engine rooms and 2 propulsion motor rooms. A control room equipped with video monitoring of the main spaces was situated between the 2 engine rooms. There were several ancillary machine spaces within and fore and aft of the main spaces. The engine room was subdivided by watertight doors to comply with the damaged stability criteria for passenger ships, and to ensure propulsion redundancy in the event of fire or flooding.

1.3.6 The forward and aft engine rooms each contained 2 propulsion generators and 2 auxiliary generators as well as other machinery to enable them to operate independently. The forward and aft propulsion motor rooms each contained 2 high-voltage propulsion motors and their associated switchgear.

1.3.7 There was a total of 10 electro-hydraulic sliding watertight doors separating the machinery and ancillary spaces. These doors were operated remotely from the bridge but each door could be opened or closed locally from either side using the hydraulics or manually by hand pump. There was also a manual hydraulic pump for each door on the rail deck.

1.3.8 When the *Arahura* was built the overflow pipe for tank 102 was routed to discharge on the funnel deck above, but during the delivery voyage the tank overflowed oily water over the accommodation and decks. To avoid a recurrence the overflow pipe was rerouted to discharge into the bilge of the forward propulsion motor room. To comply with the watertight subdivision requirements the rerouted overflow pipe was run vertically from the tank through to the rail deck above and then back down into the forward propulsion machinery room bilge. A high-level flow alarm was fitted to the overflow pipe just above the top of the tank and connected to the engine room alarm system.

1.4 Bilge pumping system

1.4.1 A common bilge main ran down each side of the 4 machinery spaces and was connected at the forward end. There were 4 pumps connected to the bilge main. The one in use at the time of the flooding was the emergency fire and bilge pump, which was situated in the forward propulsion motor room and was submersible. All the pumps were capable of pumping directly overboard, to the fire main, or to tank 102. In each space where a pump was situated there was also a direct bilge suction, which was a direct suction from that space to the pump and not connected to the bilge main. The bilge high-level alarms were mounted outboard in each space about 150 mm above the tank tops (see Figure 5).

1.4.2 Previously the bilge and general service pump had been used to pump the machinery space bilges as well as being used as a fire pump, but this was found unsatisfactory because residual oily bilge water occasionally found its way into the fire main. About a year before the accident the decision was made to dedicate the submersible emergency fire and bilge pump to the machinery space bilges.

1.4.3 The machinery space bilges were monitored by the watchkeepers and pumped dry as necessary. The oily bilge water was initially pumped into tank 102, which was capable of holding about 9.5 t. The tank was fitted with a level indicator that was situated in the forward propulsion motor room. From tank 102 bilge water was put through an oily water separator that separated the oil from the water. The clean water was then pumped overboard and the sludge collected in a separate tank to be later pumped ashore.

1.4.4 The valves in the bilge pumping system were all operated pneumatically from the engine control room or manually at the valve. They could also be operated from the emergency control centre situated on the bridge. The remote systems consisted of a mimic panel showing the valves, pipe work and pumps. Each valve had an open and close button below the mimic panel and an open and closed indicator in the valves position on the mimic panel. When the indicator button was protruding the valve was closed and, when flush, open (see Figure 6).

1.4.5 To open a valve from a remote mimic panel the valve open button had to be pushed; when the valve started to open the indicator button moved in until flush. To close a valve the close valve button had to be pushed and when the valve was fully closed, the indicator button would pop back out.

1.4.6 Valve 25 was the sea suction valve for the emergency fire and bilge pump. It was a Cupedo model butterfly valve. When the *Arahura* was built the actuator for the valve was misaligned by 90 degrees. This had the effect of reversing the conventional direction for manually closing the valve from clockwise to anticlockwise. Tests after the accident revealed that this also affected the valve open/close indicator at the mimic board whereby the indicator did not show the valve as open until it was fully open and showed it was closed as soon as it started to close.

1.4.7 Valve 25 had remained in this condition for the life of the ship. The engineers accepted this as one of the small idiosyncrasies found aboard ships from time to time. Some other watchkeepers and the chief engineer said that they usually either operated or checked the sea suction valve manually or kept the close button on the mimic panel pressed in after the indicator showed closed to ensure the valve was fully closed.

1.4.8 After the flooding, tests were undertaken on the valve and it was found that after remotely closing the valve from the mimic panel in the control room it could still be manually closed about one turn at the valve. By opening a drain cock on the inboard side of the valve with the valve in the closed position as indicated on the mimic panel, a large volume of water was observed flowing past the valve.

1.4.9 After the flooding, the valve was dismantled and aligned correctly, which took about 30 minutes to complete.

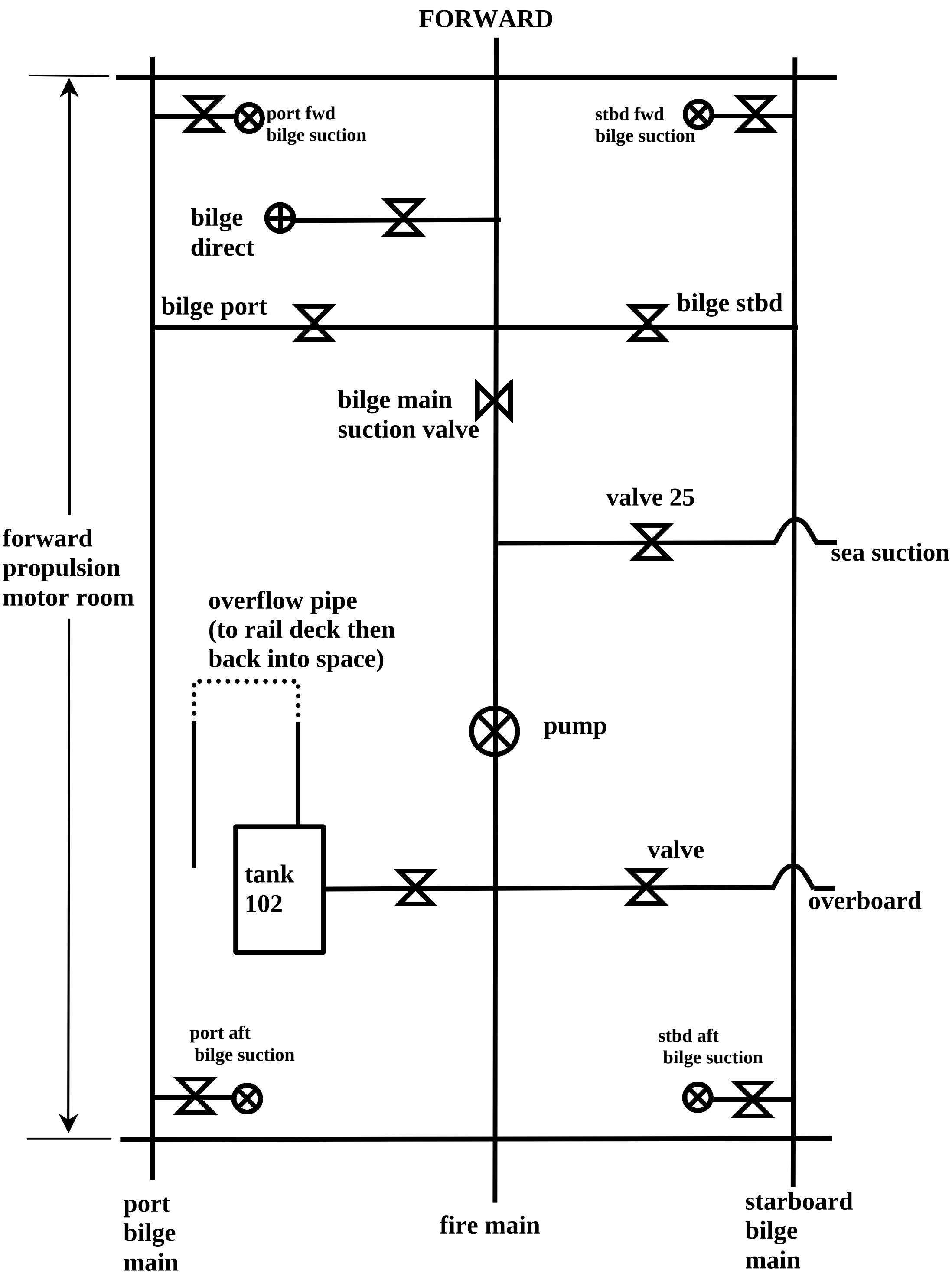

Figure 5
Bilge pumping arrangement

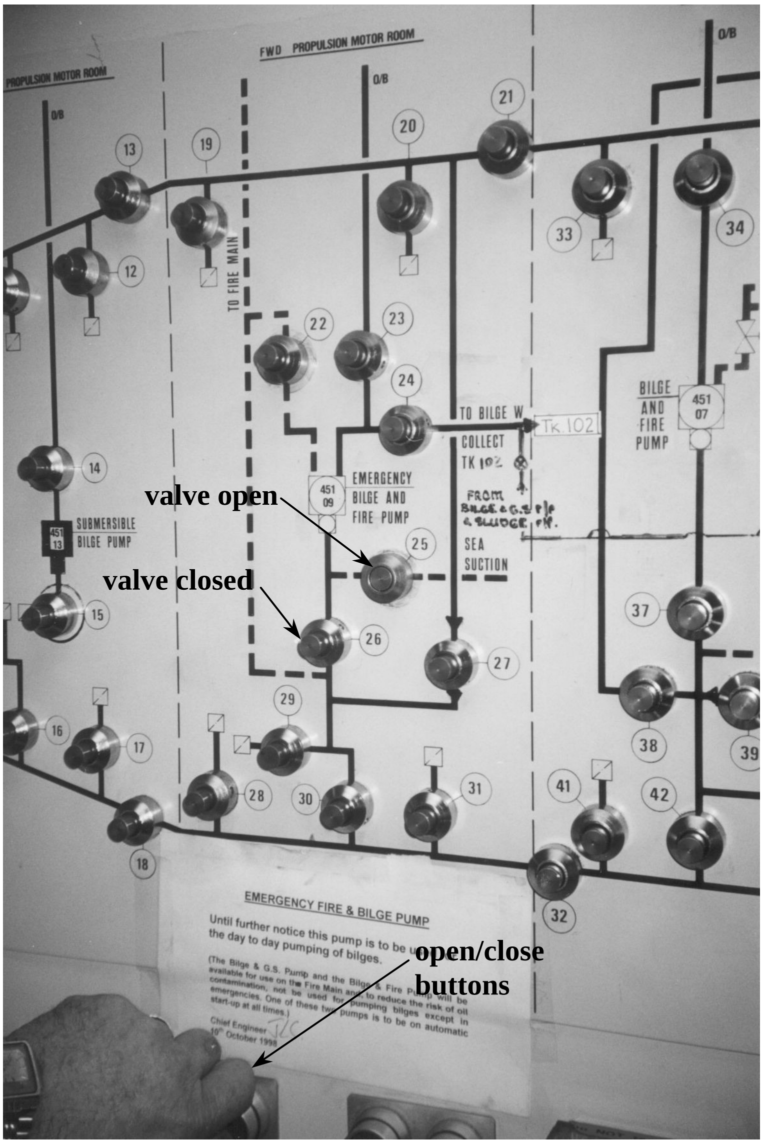

Figure 6
Mimic panel

1.4.10 The 25 mm pipe that drained from the tundish on the oily water separator in the aft propulsion motor room was about 600 mm above the tank top. It joined into a 60 mm pipe that ran back to tank 102 in the forward propulsion motor room. The 25 mm pipe was fitted with a valve that when open allowed any oil residue in the tundish to drain back to tank 102 . If tank 102 was full and had sufficient head on it, and the valve was open, water would flow back through this line into the aft propulsion motor room bilge (see Figure 7).

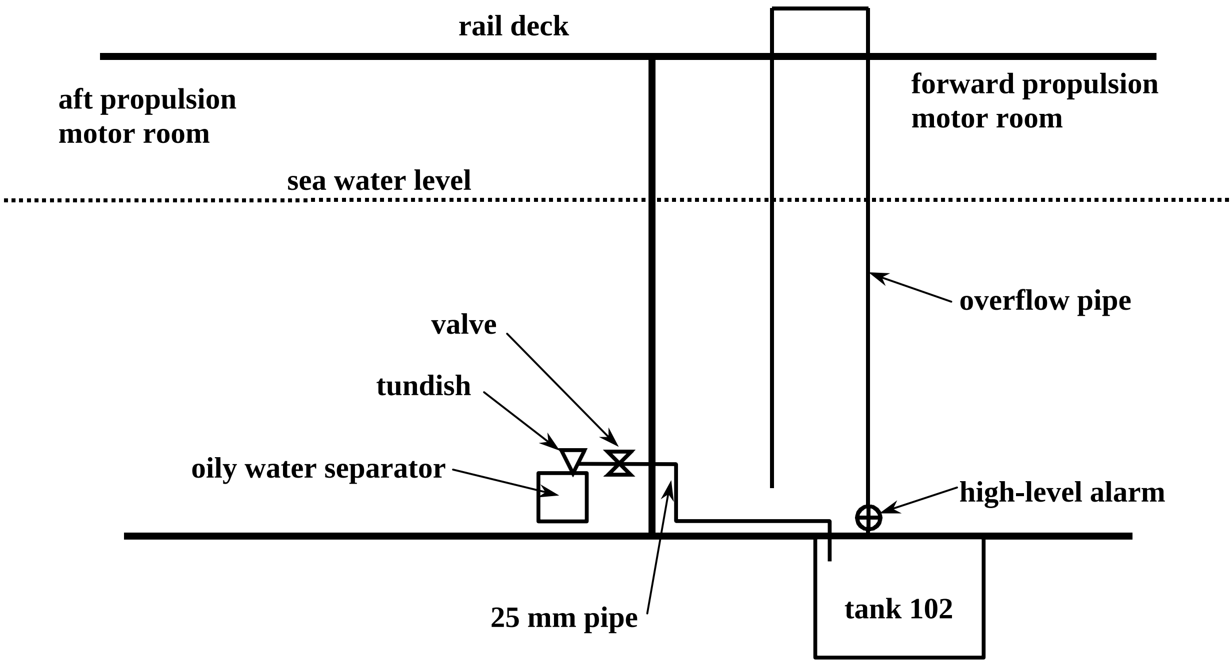

Figure 7
Pipe from tundish to tank 102

1.4.11 The tank valve for tank 102 was a screw-down, non-return valve that stopped water returning from tank 102 back into the bilge system.

1.5 Engine room alarm system

1.5.1 The machinery spaces aboard the *Arahura* were monitored by an alarm system. The main alarm panel was situated in the control room but each machinery space had an alarm monitor and keyboard so that alarms could be monitored locally. When an alarm condition existed it set off a siren and a rotating light in the control room and a rotating light in each machinery space. There was an indicator tower in each space that identified the type of alarm by lighting the relevant symbol. On the alarm monitors the alarm identification number and legend flashed on the screen.

1.5.2 When an alarm was cancelled the legend remained flashing on the screen regardless of the alarm condition. When an alarm was accepted and was still in alarm condition the legend remained steady on the screen rather than flashing. If the alarm condition no longer existed the legend would disappear and the alarm reset. If an alarm was not cancelled within 90 seconds, a loud siren sounded throughout the machinery spaces. If this was not responded to for a further 90 seconds the engineer’s general alarm sounded in the accommodation. If no alarms were activated for 27 minutes the system automatically activated a “dead man alarm” which had to be accepted by the watchkeeper within 3 minutes otherwise it too would activate the engineer’s general alarm.

1.5.3 When fitted there was no designated channel in the alarm system for the overflow pipe from tank 102. When the flow alarm was fitted channel 770, a spare channel, was used. At the time of the incident it was the only spare channel in use and as such the only channel that showed the legend “spare” when activated. All other alarms showed an identification number and a brief legend describing the alarm condition.

1.5.4 The alarm software had not been altered to give alarm 770 the appropriate legend, so to remind watchkeepers, a dyno-tape label had been placed on the top left corner of each alarm monitor that read “770- TK 102 HIGH LEVEL”. In the control room was a folder that listed all the alarm channels and their respective legends; channel 770 had not been altered and remained listed as “spare”.

1.5.5 Each machinery space was monitored by 2 video cameras, one at each end of the space. The picture was displayed in the engine control room on 2 sets of black and white monitors. One set of monitors was situated on the bulkhead and the other set at the desk of the control room. The monitors were programmed to sequentially display the view from each camera. Each view was displayed for a few seconds, every 35 seconds.

1.6 Personnel information

1.6.1 The engineer watchkeeper started his sea-going career in 1983. He spent 4 years as electrical officer with Interisland Line, worked ashore for 5 years, then returned to Interisland Line for a further 7 years as an electrical officer. About 2 years before the incident, he was approached to retrain as an engineer watchkeeper, to which he agreed after some consideration. At the end of June 2000 he obtained a marine engineer Class 3 motor certificate. He completed 5 weeks familiarisation training on the *Arahura* and had been rostered as watchkeeper on the ferry since.

1.6.2 The first engineer started his sea going career in 1978 with Interisland Line. Over the years he was employed on various ferries as engineer, which included the *Arahura* for its delivery voyage in 1983. He had also been employed on the *Arahura* on various occasions since. In September 1985 he obtained a New Zealand marine engineer Class 1 certificate. Recently he had spent 4 summer seasons on various fast ferries as both second and chief engineer. For the past 2 years, except for a short time sailing on the *Aratere*, he had continuously been rostered on the *Arahura* as first engineer.

1.6.3 The chief engineer started his sea going career in 1963 on British ships and joined Interisland Line in 1971 as first engineer and was promoted to chief engineer in 1972. In 1983 he stood by the building of the *Arahura*, completed the delivery voyage, and had been rostered as chief engineer on the ferry almost continuously since then.

1.6.4 The night master had started his sea going career as cadet with the Shipping Corporation of New Zealand in 1980. He obtained an Australian master foreign going certificate in 1990 and joined Interisland Line in 1993 and had been employed on various ferries since. In 1995 he was promoted to acting master and in 1999 permanent master. He had sailed on the *Arahura* on numerous occasions over the preceding 7 years.

1.7 Training

1.7.1 Maritime Rule Part 32.23 specified that to become eligible to sit a Class 3 marine engineer certificate the watchkeeper had to complete 6 months supervised sea time as a watchkeeper and complete a Maritime Safety Authority (MSA) approved engineer’s training portfolio. He then attended a 3-month watchkeeping course which culminated in 2 written and one oral examination. He also had to be medically fit and have valid first aid, advanced fire fighting and proficiency in survival craft certificates.

1.7.2 In his former role as electrician the watchkeeper had little to do with the day-to-day monitoring and attendance of the engine room and fire alarm systems. He was however involved in the electrical maintenance of both systems. The watchkeeper later stated that he had never been made aware of the channel 770 spare alarm or that the sea suction valve was fitted incorrectly and needed to be checked manually, nor was it mentioned during his training or familiarisation. Other watchkeepers and the electrician later stated that they were also unaware of what the channel 770 spare alarm was for.

1.7.3 The training portfolio that the watchkeeper had to complete had to be submitted to the MSA for inspection before the watchkeeper became eligible to sit the examination. Page 8 of part 1 of the portfolio was entitled "Duties at Sea Record" and was a summary of the tasks the watchkeeper had completed and a declaration by the chief engineer that the watchkeeper was competent to carry out those tasks. The page was required to be signed and dated by the watchkeeper and each set of tasks as well as the declaration was required to be signed and dated by the chief engineer. This page contained a declaration to the MSA that the portfolio had been satisfactorily completed. The MSA reviewed the page and acknowledged its completion. In the watchkeepers portfolio the tasks were dated and signed off by the chief engineer but the declaration was not, nor was the page dated and signed by the watchkeeper.

1.7.4 Part 1 also included ship-specific information and a progress record, which contained a section covering familiarisation with fire fighting and lifesaving equipment, which had not been signed off by the supervising engineer, or by the chief engineer.

1.7.5 Part 2 contained 27 assignments, each dealing with a different aspect of watchkeeping duties. Each assignment had guidance notes and various associated tasks, which had to be dated and signed off on completion. Assignments 2, 3 and 4 were entitled "pumps and systems", "engine room tanks and enclosed spaces" and "bilge and tank pumping". Sections of these assignments required the watchkeeper to search out and draw a line diagram of the bilge system and to physically pump out all bilges in the vessel. Other assignments covered the alarm and automatic systems. These assignments were all completed and signed off between 27 July 1999 and 24 January 2000.

1.7.6 After the incident the Commission conducted a random check of the MSA records of 7 other candidates for Marine Engineer Class 3 certificates, chosen at random. The records sighted were all found to be signed and fully completed.

1.7.7 Tranz Rail Limited had a Document of Compliance issued on 16 February 2000 that, subject to periodical verification, was valid until 31 December 2002. The *Arahura* had an International Safety Management (ISM) Certificate issued on 15 February 2000 that was valid, subject to periodical verification and provided the Document of Compliance remained valid, until 31 March 2003. Det Norske Veritas issued both certificates.

1.7.8 Section 6.3 of the ISM Code stated:

> The Company should establish procedures to ensure that new personnel and personnel transferred to new assignments related to safety and protection of the environment are given proper familiarization with their duties. Instructions which are essential to be provided prior to sailing should be identified, documented and given.

1.8 Shipboard work practices and procedures

1.8.1 The crew of the *Arahura* worked a one week on, one week off roster, changing each Thursday. At the time of the incident there was a chief engineer, first engineer, second engineer, 3 third engineers, 2 electricians and 2 extra engineers, who were making familiarisation trips, aboard the *Arahura*. The chief, first and a third engineer were day workers, leaving the second and remaining 2 third engineers for watchkeeping, working the conventional 4-hours on, 8-hours off watch system. All the engineers worked outside these hours if required. The watchkeeper at the time of the accident was working the 8 to 12 watch. The electricians broadly worked a 12-hours on 12-hours off system.

1.8.2 The engine room was put on standby for arrivals and departures and for the transit of Tory Channel. When on standby the control room was required to be manned by the watchkeeper or if he was required to attend the machinery spaces, a standby watchkeeper or electrician. It was later established that this procedure was not routinely followed for the transit of Tory Channel, with only the watchkeeper being immediately available to man the control room and attend to other duties in the machinery spaces.

1.8.3 The watchkeepers rounds of the machinery spaces required him to visually check equipment in each machinery space and the ancillary machinery rooms. The watchkeeper could not see the rotating lights indicating an alarm from the ancillary rooms, and from several “blind spots” in the main machinery spaces. Without any interruption it generally took about 40 minutes to complete the rounds.

1.8.4 During the day and occasionally at night, in port or at sea, there were other engine room staff and often shore-based contractors working throughout the machinery spaces. At all times the engineer watchkeeper was responsible for the routine running of the machinery spaces and the monitoring of alarms.

1.8.5 The deck department comprised a day master, night master, first mate, second mate and 2 third mates. The masters broadly worked 12 hours each. The deck officers did the same but there were 2 on duty at any time with the chief or second mate working with a third mate.

1.8.6 When a fire alarm was activated it displayed on a fire alarm panel on the bridge, identifying which fire zone was affected. If the alarm was in a machinery space it sounded as an alarm in the machinery spaces and was indicated by a fire symbol on the alarm towers. It was the responsibility of the bridge watchkeeper to cancel, but not accept, the alarm and investigate its cause. In the machinery spaces it was the responsibility of the watchkeeper to identify which fire zone had alarmed, check the fire zone and contact the bridge to advise them of the situation.

1.8.7 On the bridge and in the control room the fire alarm panel identified the fire zones by number. In the control room a list of the machinery spaces and their fire zone numbers had been posted next to the panel. Each of the main machinery spaces also had the fire zone number stencilled on the bulkhead. When the bridge watchkeeper reported a fire alarm to the engine room they generally referred to the fire zone by number.

1.9 Procedures and watertight doors

1.9.1 The engine room procedures section of the *Arahura's* Interisland Line Ship Procedures Manual, stated in part:

> **<u>DEPARTURE</u>** **1.**
>
> …**<u>AT ALL DEPARTURES</u>**
>
> The Bridge will give 5 minutes notice of departure Standby
>
> <u>At 5 Minutes To Standby</u>
>
> The Watchkeeping Engineer and Standby Engineer/Electrician are to be in the Control Room unless circumstances dictate otherwise…
>
> **<u>SPECIAL NOTES:-</u>**
> …
> At the Telegraph command "Enclosed Waters", the Duty Electrician will carry out an inspection of the Machinery Spaces. The watchkeeper is to remain in the Control Room to wind up the engine power as set out below, and to do any ballasting required from the bridge before doing his rounds. He is also to be in the control room 20 minutes after departure Wellington for Barretts Reef and the outer buoy….
>
> **<u>WATCHKEEPING</u>** **4.**
>
> …10 Before going off duty, the Watchkeeper will inform the relieving Engineer of:
>
> - any special orders relating to ship operations, maintenance or repairs
> - the nature of all work being carried out on machinery and systems, personnel involved and potential hazards
> - the level and condition, where applicable, of water or residue in bilges, fuel tanks, ballast tanks and sewage tanks.
> - voyage timekeeping, re standbys, arrival, departures.
> - visitors in Engine Room…
>
> …12 The following terms will be used to describe the operational status of the vessel.
>
> **Stand By** When the vessel is entering or leaving a berth or during the transit of Tory Channel entrance, or during any other time when the external circumstances require this status of increased vigilance.
>
> **Enclosed Waters** When the vessel is within Wellington Harbour or within the Marlborough Sounds.
>
> **Open Waters** When the vessel is in Cook Strait or at sea…
>
> 4.1.1 <u>Engine Room On **Stand By**</u>
>
> The control room will remain manned at all times.
> During Stand By periods the Watchkeeper retains charge of the watch unless relieved as in 10 above.
> During Stand By periods entering or leaving a berth, the Watchkeeper will be assisted as the circumstances require.
> No operations with the potential to effect the security of propulsion, steering or auxiliary power will be carried out unless some unforeseen condition develops that could cause a greater hazard.
> The Chief Engineer is to be informed whenever the Engine Room is placed on Stand By for any unexpected reason. This does not include normal arrival, departure or Tory Channel passage.

4.1.2 Vessel in **Enclosed Waters** (Extract from Navigation in Enclosed Waters Critical Operations Procedure)

The Control Room should remain manned at all times when the vessel is navigating in Enclosed Waters, the Bridge should be informed if this cannot be achieved. The Bridge should also be informed whenever an operation which could effect the propulsion or steering of the ship is to be carried out.

4.1.3 Vessel in **Open Waters**

The Watchkeeper will remain within the machinery spaces, attend to the operation of the machinery and respond to the machinery surveillance system…

4.1.8 Watertight Doors

Refer to Onboard Management Manual…

1.9.2 Maritime Rule Part 23 was entitled "Operating Procedures and Training". Section 23.33 stated in part:

Passenger ships
23.33 Openings in watertight bulkheads
(1) The master of a ship to which this rule applies must ensure that all watertight doors in watertight bulkheads are kept closed while the ship is at sea, except that a watertight door in a watertight bulkhead may be opened while the ship is at sea –

(a) to permit the passage of crew, in which case the door must be closed when the transit through the door is complete; and
(b) when work in the immediate vicinity of the door necessitates it being opened, in which case the door must be closed as soon as the task that necessitated it being open is finished or ceased; and

in any case must be ready to be immediately closed.

The MSA later defined "at sea" as from berth to berth.

1.9.3 The section of the Onboard Management Manual covering watertight doors stated:

WATERTIGHT DOORS

Watertight doors are to be shut in enclosed waters. The doors may be opened for access but must be closed immediately afterwards. Outside enclosed waters the watertight doors should be kept closed except when it is required to be open for the working of the ship. When open the door shall be kept clear of obstructions that could prevent its rapid closure in the event of damage. When alongside, the doors may be left open but should be closed if the engine room is left unmanned.

Watertight doors will be closed

- Before leaving the berth
- Before entering enclosed waters
- In reduced visibility
- If risk of collision or grounding is deemed to exist
- At any time where the Master or a crew member deems it to be prudent

Unless an emergency situation exists the watertight doors should be reset after closing from the bridge.

It must be strongly emphasised that the Master, or Bridge Watchkeeper, is to Immediately close the watertight doors whenever a grounding or collision is likely.

1.9.4 The Interisland Line Ship Procedures Manual, *Arahura* engine room procedures, section 35 further states:

> **<u>WATERTIGHT DOORS</u>** **35.**
>
> Watertight doors are to be shut in harbour limits and enclosed waters.
> Telegraph operated RED indicator lights beside each door are ON when the vessel is in these confines and the doors are to be closed.
>
> The over-rides on all the doors are permanently in the OFF position which means that the Bridge cannot open the doors.
> When the vessel departs from Wellington the Bridge will close the doors at Stand By. To allow the passage through the doors they will be opened and closed locally by all personnel while the indicator lights are ON. After reaching the outer buoy and the indicator lights are OFF, the doors can be left open.
>
> At Standby for Tory Channel the Bridge will again close the doors, the indicator lights will be on and the doors must be opened and closed locally until FWE [finished with engines] on arrival at Picton.
>
> From Picton to Wellington the same procedure will be carried out with the doors being closed in the Sounds and Wellington Harbour.

1.9.5 When the engine room was put on standby, the watertight doors in the machinery spaces were closed from the bridge and reset, which allowed them to be opened and closed locally. On the bridge green lights on the operating panel indicated that the doors were closed. At each door a red light indicated that the ship was in enclosed waters and the doors should be kept closed except for access.

1.9.6 When the ship entered open waters the bridge pushed a "full away" button that was acknowledged in the control room. The red light at the watertight doors was then switched off indicating that the doors could be left open if required. When the engine room was put on standby again the doors were again closed from the bridge.

1.9.7 After the flooding the operation of the watertight door between the aft engine room and forward propulsion motor room was timed. It was found that it took about 35 seconds each way to half open and shut the door and about 65 seconds each way to fully open and shut the door.

2. Analysis

2.1 In any kind of operation decisions are constantly being made, and acts are being performed. Poor decisions or unsafe acts can result in unsafe conditions that may lay dormant for some time, just waiting for an unfortunate sequence of corresponding events to culminate in an accident or incident. These unsafe conditions are often referred to as latent failures.

2.2 There were a number of latent failures that contributed to this flooding incident aboard the *Arahura*, namely:

- a combination of poor procedures and work practices
- questionable standards of training
- the level of experience for the tasks at hand
- questionable use of the available human resources
- disunity between the bridge and the engine room staff

- poor crew resource management when dealing with the events that unfolded
- acceptance of an incorrectly configured item of machinery.

2.3 Probably the most significant latent failure that contributed to the flooding was the acceptance by the ship's staff, for some 18 years, of the condition of sea suction valve number 25 and the expectation that staff would be aware that it was incorrectly installed, operated contrary to convention, and that the valve position indicator on the remote mimic panel was unreliable. The sign the crew posted on the pump once the valve had been dismantled and correctly installed after the incident is enlightening:

> CAUTION: The Sea Water suction valve for the Emergency Bilge and Fire Pump now operates in the conventional manner i.e. Anticlockwise Open and Clockwise Shut.

Tank 102, sea suction valve and stability

2.4 After the flooding it took about 30 minutes to dismantle valve 25 and reinstall it in the correct position. Other watchkeepers were aware that the valve did not operate correctly and checked the valve manually or held the remote close button down to ensure it closed. When the watchkeeper set the mimic panel to pump the bilges he saw that the sea suction valve indicated closed and as he did not need to operate the valve for the task he was undertaking, he accepted that it was closed.

2.5 The sea suction valve had been operated during the previous watch and although it indicated closed on the mimic panel it had probably remained partially open, as it did during tests after the flooding. For seawater to be able to enter tank 102 the tank valve must have been open as well. This would allow water to slowly gravitate through the pump into the tank, filling the tank, setting off the alarm and travelling up the overflow pipe to sea level, at which level it remained until 2252 when the watchkeeper started to pump the aft engine room bilges. At that point the forward propulsion motor room began to flood.

2.6 From the time the pump was started until the engineer's assistance alarm was sounded was 40 minutes. During that time about 177 t entered the forward propulsion motor room space. There was also water in the aft propulsion motor room that had flowed through the pipe to the oily water separator tundish, and water in the aft engine room from the leaking cooling water pipe.

2.7 At the time of the flooding the first mate calculated the stability and estimated that the loss of GM due to the flooding was acceptable. At that time he was not aware of the extent of the flooding nor was he aware of the possibility that the other 2 spaces had significant amounts of water in them. After the incident further calculations were made using the estimated water levels in each space.

2.8 It was estimated that there was about 177 t of water in the forward propulsion motor room at its highest level. It was feasible the reported 0.3 m of water in the aft propulsion motor room entered through the pipe from tank 102 to the oily water separator. This water would have been entering the space from about 2214 when the tank 102 high-level flow alarm was activated. The 0.6 m measurement taken in the aft engine room after the flooding would have been the maximum level the water reached, taking account of surge in the bilge and any list or rolling of the ferry. Even allowing for the list, other than water that entered the space through the high-pressure, low-volume water leak, the estimated amount of water in the space remains unexplained. It is unlikely that this volume of water came from the water leak alone.

2.9 The investigation into the flooding revealed that someone may have partially opened the watertight door between the aft engine room and the flooded forward propulsion motor room to quickly lower the water level in the latter to minimise water damage to the propulsion motor and associated switchgear. This would provide a logical explanation for how so much water entered the aft engine room, and would have been an effective way to lower the water level in the forward propulsion motor room, which would have allowed additional pumps to be used to extract the water from the ship.

2.10 The effect on the ship's stability of having 2.1 m of sea water in the forward propulsion motor room would have been twofold: an increase in stability due to adding a weight low down in the ship, and a reduction of stability due to free surface effect of the water. The reduction in GM due to water in this space and the 0.3 m observed in the aft propulsion room was calculated to have been about 0.31 m. Subtracting this from the known GM and allowing for the added weight gave a fluid GM of about 1.08 m.

2.11 The aft engine room was a much larger space than the propulsion motor rooms, which meant any water entering this space would have had a bigger effect on reducing stability due to the free surface effect. If water was allowed to flow through the watertight door into this space, this would have lowered the level of the remaining water in the forward propulsion motor room. The combined effect due to free surface in all 3 spaces was to reduce the GM by about 0.55 m. Although the ship would still have been stable at this point, its stability was significantly reduced.

2.12 It would have been prudent to inform the bridge of the exact status of the flooding so an accurate assessment of stability could have been made before deciding on whatever method was to be used to pump the water from the ship.

Bilge alarms and watchkeeping

2.13 While the ship was alongside in Picton and again when it rounded Dieffenbach Point the forward propulsion motor room bilge high-level alarm sounded. The bilge alarms are situated low in the bilges so when the ship heeled or listed it only took a relatively small amount of water to activate the alarm. Bilge alarms were obviously a common event on the *Arahura*, and this has probably contributed to a degree of complacency on how they were dealt with. A better way to deal with recurring alarms is to rectify the cause. In this case the crew probably need a better bilge monitoring system that results in the bilges being pumped on a more regular basis.

2.14 The cause of all alarms should be determined by physical inspection. The watchkeeper chose to cancel the bilge high-level alarms assuming they were caused by the movement of the ship. Although the alarms were coincidental with the ship listing or heeling, this could have been the initial warning of a bigger problem. Cancelling an alarm instead of determining and rectifying its cause before accepting it, effectively took the alarm out of the system, as it could not be activated again until it had been accepted.

2.15 The watchkeeper was reluctant to pump the bilges while the ship was in enclosed waters, but after the ship had cleared Tory Channel at 2230 he elected to start his rounds at the forward end of the machinery spaces and work aft. Having received bilge high-level alarms in the aft spaces it would have been prudent to start his rounds aft and inspect the spaces that were the source of the alarms.

2.16 At 2248 while the watchkeeper was forward, the aft motor room high level bilge alarm was activated and the watchkeeper cancelled it without inspecting the space. Four minutes later the aft engine room starboard high-level bilge alarm was activated and also cancelled. By now the watchkeeper had received bilge high-level alarms in 3 machinery spaces and had not inspected any of the spaces immediately after the alarms had been activated. Instead he returned to the control room and started pumping the starboard aft propulsion motor room bilge to tank 102.

2.17 The bilge high-level alarm in the aft engine room was probably caused by the water leak from the salt water cooling pipe. If he had inspected the space he would probably have found the leak. At 2315, after having been pumping the bilges for some 23 minutes, the port bilge high-level alarm was activated but the watchkeeper still did not inspect the space; instead he returned to the control room and changed the suction to the port side. The fact that he had been pumping the space for this period of time and was still getting high-level alarms would probably have caused someone with more training and experience to investigate why.

2.18 According to the Ship Procedures Manual the machinery spaces had to be manned by a watchkeeping engineer and a standby engineer or electrician while the engine room was on standby. It also stated the transit of Tory Channel entrance was deemed as a standby. The electrician departed the control room after completing his rounds at 2150 and did not return for the transit of Tory Channel, leaving the watchkeeper in the machinery spaces alone. It appeared that a single watchkeeper routinely manned the engine room for the transit of Tory Channel. This routine violation of company procedures was probably a product of the repetitive nature of trade the vessel was on.

2.19 Considering the size and complexity of the machinery spaces aboard the *Arahura* and the fact that it can carry up to 997 passengers and operated in enclosed waters for over half of the total passage time, it is debatable whether the engine room manning for standby was adequate both in numbers and experience. Ships of similar size and complexity usually have a senior engineer in the control room while on standby. To achieve this aboard the *Arahura* it may be necessary to change existing work practices.

2.20 On average it took about 40 minutes for a watchkeeper to complete rounds of the machinery spaces. On the day of the flooding it was about 54 minutes from the time the watchkeeper started his rounds until the fire alarm sounded yet he had not reached the aft engine room by that time. This unusually long time to complete rounds of the forward spaces remains unexplained.

2.21 Having the watertight doors closed restricted the movement of the engineers and arguably compromised their ability to reach or physically monitor the spaces. The alarm system and video monitors were designed to substitute for this, making it all the more important that each alarm was cancelled, physically checked and accepted to provide maximum protection. Considering the size and design of the engine room, and the fact that the *Arahura* spent most of its time in confined waters, it probably should have someone in the control room at all times.

Crew resource management

2.22 When the bridge notified the control room of the activated fire alarm they identified it by number alone. It may have been prudent to identify the space by name as well to avoid confusion. If this had been the case the watchkeeper may have realised that the source of the fire alarm he was supposed to be investigating was in another space.

2.23 At 2324 when the fire alarm was activated, the watchkeeper went to inspect fire zone 32 and on his way discovered the water leak. He thought that the water spray had activated the fire alarm and reported this to the bridge. Even though the fire zone numbers were stencilled on the bulkhead in each space he became so focused on the task of stemming the water leak he did not realise his mistake. Fortunately the water leak was stopped shortly after the first engineer arrived and the watchkeeper mentioned the fire alarm by zone number, alerting the first engineer to the mistake.

2.24 On opening the watertight door to fire zone 32, the water ingress was discovered. When the watchkeeper started pumping the bilge at 2252, tank 102 was already full, as evidenced by the high-level flow alarm for the tank activated at 2214. Unbeknown to him the sea suction valve was not fully closed, as was indicated on the mimic panel, and water had gravitated from the sea into the tank. For this to happen, the tank valve for tank 102 must have been open as well. According to the watchkeeper, this valve was often left open. Once the watchkeeper started the pump on the aft propulsion motor room bilge he was actually pumping the bilges plus a large volume of sea water into the forward propulsion motor room via the overflow to tank 102. The bilge high-level alarm could not alert him to this as it had been cancelled but not accepted.

2.25 When the flooding was discovered the engineers advised the bridge that they had water entering the forward propulsion motor room but reportedly at no stage did they relay the extent of the water in the space. On the bridge they assumed that the water was at about the level of the floor plates and as the engineers soon reported that they had everything under control were not overly concerned. Although the engineers were confident they had the flooding under control they were still not sure of the source of the water, and under the circumstances may not have fully appreciated the potential effect on the ship's stability. In an emergency situation it is important that all staff communicate in the spirit of good crew resource management. It was not established if the engine room staff did relay the full extent of the problem to the bridge, but interviews with crew indicated a certain level of disunity between the deck and engine departments. Crew resource management encompassed all the ship's staff, not just those on the bridge. Effective crew resource management cannot happen in such a working environment.

Training

2.26 The watchkeeper completed his sea time and training portfolio aboard the *Arahura* where he received tuition and assistance from the engineers aboard the ship, some of whom had been on the ship virtually since it was built. Apart from benefiting from the experience and good work practices, a fault with such a system is the watchkeeper picks up on any bad work practices and short cuts that may have evolved over the years.

2.27 The engineer's training portfolio adequately covered the training necessary to become an engine room watchkeeper, if completed properly. The system of completing tasks and having them signed off by peers is reliant on the task being done properly, and being properly checked before being signed off. The portfolio completed by the watchkeeper included a number of tasks relevant to this accident, which had not been signed off, and others that had been signed off but with which he was not fully conversant.

2.28 As part of the watchkeeper's eligibility to sit the examination the MSA checked the training portfolio and in particular the "Duties at Sea Record". The declaration in this section of the watchkeeper's portfolio, which stated that he was competent to carry out the required tasks in the portfolio, was not signed and dated by the chief engineer nor was it signed by the watchkeeper, yet the watchkeeper was allowed to sit and pass the examination. The qualification the watchkeeper sought allowed him to be sole watchkeeper in charge of an engine room on a passenger ferry, and as such carried a significant level of responsibility. Checks after the incident revealed that the watchkeeper's incomplete training portfolio was probably an isolated occurrence. However, the fact that the watchkeeper was not fully conversant with some tasks that had been signed off shows it is imperative that candidates receive full training and familiarisation and applicable assignments are properly completed and signed before the declaration of competency is signed.

2.29 Under the safe ship management code, one of the requirements was that crew were to be given proper familiarisation with their duties. The fact that neither the watchkeeper nor other staff were aware of the status of the alarm channel 770 suggests 2 things: firstly that the alarm did not sound frequently, and secondly that the system for familiarisation for new staff was in need of review.

Watertight doors

2.30 Maritime Rule Part 23 required that the watertight doors be closed from berth to berth except for access and work in the immediate vicinity. The onboard management manual stated that outside enclosed waters the doors should remain shut except for the working of the ship. Section 35 of the *Arahura* engine room procedures manual stated that the doors could be left open once the ship was clear of enclosed waters. The 2 company manuals contradicted each other and neither complied with the maritime rule. Aboard the *Arahura* the engineers were adhering to the engine room procedures manual.

2.31 If the watertight doors had been left open the flooding would not have been confined virtually to one space, but would have reached the watertight doorsills and then flowed into the adjoining spaces. This would have had the effect of flooding more spaces and further compromised the stability of the ship, but would have limited the damage to machinery and electrical equipment. As the machinery spaces aboard the *Arahura* were designed to provide redundancy in the event of flooding, it was preferable to maintain that redundancy by having the doors closed and reduce the risk of capsize.

2.32 There were good arguments for and against having the watertight doors closed while the *Arahura* was at sea. The engine room runs for almost the entire length of the ship and is divided into watertight compartments by 10 watertight doors. During its voyage the *Arahura* spends the majority of its time in enclosed waters. If the doors were left open it is possible that collision, grounding or fire could render the closing systems inoperable, compromising the watertight integrity of the ship. The risk of this happening would by far outweigh the inconvenience to engine room staff in carrying out their daily tasks.

3. Findings

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

3.1 The forward propulsion motor room flooded via the overflow pipe for the bilge water collection tank during a machinery space bilge pumping operation that went wrong. The submersible high-capacity emergency fire and bilge pump being used was able to draw water direct from the sea through a sea suction valve that was partially open.

3.2 When the *Arahura* was built the sea suction valve had been incorrectly installed in a way that made it operate unconventionally and its status almost impossible to monitor remotely. Rather than correcting the fault the operator and crew accepted the incorrect installation of the valve, which was a latent failure that contributed to the flooding.

3.3 Before the bilge pumping operation was started sea water had gravitated through the partially open sea suction valve and through the tank valve that was often left open, filling the bilge water collection tank. The prudent shipboard practice of monitoring where liquids are being pumped from and to was an important defence that could have prevented the flooding, had it been followed.

3.4 The prudent practice of checking the cause of any engine room alarm rather than assuming its cause was an important defence that was not being followed and could have improved the watchkeeper's situational awareness and prevented the flooding.

3.5 The training regime undertaken by the watchkeeper would have been sufficient had it been properly completed and monitored by those responsible for doing so. The watchkeeper's familiarisation, training and experience with the engine room were not sufficient for him to be given sole charge of an engine room watch.

3.6 The operator's policy on manning the engine room during safety-critical sections of the voyage was being routinely violated by the crew, leaving the engine room undermanned at times which increased the risk to the operation.

3.7 The operator's policy of not having more experienced senior staff on duty in the engine room during safety-critical times of the voyage was not consistent with the principles of safe ship management and unnecessarily increased the risk to the operation.

3.8 The disunity between the deck and engine room staff on board the *Arahura* made effective crew resource management difficult and probably compromised the safe management of the flooding.

3.9 Although not contributory to the flooding, the disparity between the operator's 2 written instructions and the maritime rule governing the operation of watertight doors indicates a review of the operator's safe ship management systems may be required.

4. Safety Actions

4.1 The sea suction valve was reconfigured to operate correctly both manually and remotely.

4.2 The 770 spare alarm was added to the on-board training and familiarisation programmes.

4.3 The legend "Tank 102 high level" was added to the hard copy list of alarms.

4.4 The signs on the alarm monitors were enlarged.

4.5 All bilge high-level alarms were fitted with a 40-second delay before being activated.

4.6 The video monitoring system was upgraded to colour monitors on the main panel and another 5 cameras were to be fitted to improve coverage.

4.7 A low capacity Wilden pump was designated for pumping engine room bilges.

4.8 The MSA reviewed the system for checking documentation to determine the eligibility of candidates for maritime qualifications and compiled a notice to be issued to all future candidates for Marine Engineer Class 3 examinations stressing the importance of completing and signing off the training portfolio.

5. Preliminary Safety Recommendations

5.1 On 10 December 2001 the Commission recommended to the Managing Director of Tranz Rail Limited that he:

5.1.1 critically review the familiarisation and training programs for watchkeeping engineers to ensure that they fully cover all aspects of engine room watchkeeping (070/01)

5.1.2 critically review the experience and manning levels for engine room watches and stand by periods, and ensure an appropriate level of experience is present in the engine room at all times (071/01)

5.1.3 change the system for reporting fire alarms to ensure both the fire zone and the corresponding space are identified (072/01)

5.1.4 change the written procedures regarding the closing of watertight doors to reflect the intent of Maritime Rule Part 23 (073/01)

5.1.5 conduct a review of engine room watch keeping practices on board all company ships, and then issue instructions on the correct procedures to follow, particularly in relation to alarm monitoring (074/01)

5.1.6 modify the engine room alarm indicating system to ensure the watchkeeper can detect an alarm from anywhere in the engine room. (075/01)

5.2 On 7 January 2002, Tranz Rail's General Manager, Health, Safety & Environment, replied:

5.2.1 **Final Safety Recommendation 070/01**
Tranz Rail accept this recommendation. Completion is expected by 28 February 2002.

5.2.2 **Final Safety Recommendation 071/01**
Tranz Rail accept this recommendation. Completion is expected by 28 February 2002.

5.2.3 **Final Safety Recommendation 072/01**
Tranz Rail accept this recommendation. Completion is expected by 31 January 2002.

5.2.4 **Final Safety Recommendation 073/01**
Tranz Rail accept this recommendation. This was completed on 1 November 2001 with the re-issue of the Interisland Line Safety Manual. Please find attached as … evidence of the amended procedures.

5.2.5 **Final Safety Recommendation 074/01**
Tranz Rail accept this recommendation. Completion is expected by 31 January 2002.

5.2.6 **Final Safety Recommendation 075/01**
Tranz Rail are reviewing this recommendation. Further work will be undertaken to determine if this is necessary or whether the current alarm lights and siren are adequate. This will be completed by 28 February 2002.

Approved for publication 13 December 2001

Hon. W P Jeffries
Chief Commissioner