Inquiry 10-204: Bulk carrier *Hanjin Bombay*, grounding,
Mount Maunganui, 21 June 2010

TRANSPORT ACCIDENT INVESTIGATION COMMISSION
TE KOMIHANA TIROTIRO AITUA WAKA

Final Report

Marine inquiry 10-204
Bulk carrier *Hanjin Bombay*, grounding, Mount Maunganui, 21 June 2010

Approved for publication: March 2013

Transport Accident Investigation Commission

About the Transport Accident Investigation Commission

The Transport Accident Investigation Commission (Commission) is an independent Crown entity responsible for inquiring into maritime, aviation and rail accidents and incidents for New Zealand, and co-ordinating and co-operating with other accident investigation organisations overseas. The principal purpose of its inquiries is to determine the circumstances and causes of occurrences with a view to avoiding similar occurrences in the future. Its purpose is not to ascribe blame to any person or agency or to pursue (or to assist an agency to pursue) criminal, civil or regulatory action against a person or agency. The Commission carries out its purpose by informing members of the transport sector, both domestically and internationally, of the lessons that can be learnt from transport accidents and incidents.

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Important notes

Nature of the final report

This final report has not been prepared for the purpose of supporting any criminal, civil or regulatory action against any person or agency. The Transport Accident Investigation Commission Act 1990 makes this final report inadmissible as evidence in any proceedings with the exception of a Coroner's inquest.

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Citations and referencing

Information derived from interviews during the Commission's inquiry into the occurrence is not cited in this final report. Documents that would normally be accessible to industry participants only and not discoverable under the Official Information Act 1980 have been referenced as footnotes only. Other documents referred to during the Commission's inquiry that are publicly available are cited.

Photographs, diagrams, pictures

Unless otherwise specified, photographs, diagrams and pictures included in this final report are provided by, and owned by, the Commission.

The *Hanjin Bombay* re-entering Tauranga Harbour after the accident

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Abbreviations

°C	degree(s) Celsius
Commission	Transport Accident Investigation Commission
gyro	angular direction as read from a ship's gyro compass
ISM Code	International Management Code for the Safe Operation of Ships and for Pollution Prevention
m	metre(s)
mm	millimetre(s)
SOLAS	International Convention for the Safety of Life at Sea
STCW 1995	International Convention on Standards of Training, Certification and Watchkeeping for Seafarers, 1978 as amended in 1995
UTC	co-ordinated universal time

Glossary

abeam	direction at right angles to the length of a vessel
global positioning system receiver	receives signals from a space-based satellite navigation system that provides location and time information in all weather, anywhere on or near the Earth, where there is an unobstructed line of sight to 4 or more global positioning system satellites. It is maintained by the United States Government and is freely accessible to anyone with a global positioning system receiver
long-range information and tracking system	consists of the already installed (generally) ship-borne satellite communication equipment, communication service providers, application service providers, long-range information and tracking data centres, the long-range information and tracking data distribution plan and the international long-range information and tracking data exchange. Certain aspects of the performance of the long-range information and tracking system are reviewed or audited by the long-range information and tracking co-ordinator acting on behalf of the International Maritime Organization and its contracting governments
magnetic compass	a compass that contains a magnet that interacts with the Earth's magnetic field and aligns itself to point to the Earth's magnetic poles
marine very-high-frequency radio	a combined transmitter and receiver that only operates on standard, international frequencies known as channels. Channel 16 (156.8 megahertz) is the international calling and distress channel. Channel 9 can also be used in some places as a secondary call and distress channel. Transmission power ranges between 1 and 25 watts, giving a maximum range of up to about 60 nautical miles (111 kilometres) between aerials mounted on tall ships and hills, and 5 nautical miles (9 kilometres) between aerials mounted on small boats at sea level. Frequency modulation is used, with vertical polarisation, meaning that antennas have to be vertical in order to have good reception
radar	an object-detection system that uses radio waves to determine the range, altitude, direction and speed of objects. It can be used to detect aircraft, ships, spacecraft, guided missiles, motor vehicles, weather formations and terrain. The radar dish or antenna transmits pulses of radio waves or microwaves that bounce off any object in their path. The object returns a tiny part of the waves' energy to a dish or antenna, which is usually located at the same site as the transmitter
port and starboard	nautical terms that refer to the left and right sides, respectively, of a ship or aircraft as perceived by a person on board facing the bow (front). At night, the port side of a vessel is indicated with a red navigation light and the starboard side with a green one
significant wave height	the average height of the highest one-third waves in a wave spectrum
tidal stream	the periodic movement of water in a horizontal direction that is due ultimately to the same astronomical causes as the tide (whereas the tide is a movement in the vertical direction)
voyage data recorder	a data recording system designed for all vessels required to comply with the International Maritime Organization's International Convention for the Safety of Life at Sea (SOLAS) requirements (IMO Res.A.861(20)) in order to collect data from various sensors on board the vessels. It then digitises, compresses and stores this information in an externally mounted protective storage unit. The protective storage unit is a tamper-proof unit designed to withstand the extreme shock, impact, pressure and heat that could be associated with a marine incident (fire, explosion, collision, sinking, etc). A simplified voyage

data recorder as defined by the requirements of the International Maritime Organization's Performance Standard MSC.163(78) is a lower-cost, simplified-version voyage data recorder for small ships, with only basic ship data recorded

Data summary

Vehicle particulars

Name:	*Hanjin Bombay*
Type:	bulk carrier
Class:	SOLAS
Limits:	unlimited
Classification:	✠ KRS – Bulk Carrier 'ESP' (HC/E:Hold Nos.2,4 may be empty) ENV (IAFS, IOPP, ISPP, IAPP) CHA LI ✠ KRM1 – UMA
Length:	167 metres (m)
Breadth:	26.2 m
Gross tonnage:	16 252
Built:	Hanjin Heavy Industry Company, Ulsan, Korea 1994/1995
Propulsion:	one B&W 5L50MC/HHIC direct-reversing diesel engine producing 7450 brake-horse power at 120 revolutions per minute, driving a single fixed-pitch propeller
Service speed:	14.14 knots
Owner:	Kamco No. 4 Shipping Company S.A.
Operator:	Hanjin Shipping Company Limited
Port of registry:	Panama, Republic of Panama
Minimum crew:	13
Crew on board:	20

Date and time	21 June 2010 at about 2006
Location	Mount Maunganui
Damage	vessel's hull set in and penetrated in way of No.1 port-side water ballast double-bottom tank between frames 179 and 181 vessel's hull and internal framing damaged between frames 174 and 195

1. Executive summary

1.1 At about 1930 on 21 June 2010, the bulk carrier *Hanjin Bombay* left the wharf at Mount Maunganui loaded with a full cargo of logs for the port of Kunsan in Korea. The vessel was under the control of a Port of Tauranga harbour pilot, with the master in command.

1.2 The vessel was manoeuvred off the berth and turned in the channel using the main engine and 2 tugs. Once the vessel was heading outward the vessel's main engine was used to propel it seaward. The 2 tugs remained with the ship until it was about to enter the narrow entrance channel, at which point they were released to return to their berths, but remained in radio contact with the pilot.

1.3 As the *Hanjin Bombay* began to increase speed, a malfunctioning valve in the engine cooling system caused the engine cooling water to rise above normal temperature. The engine room crew did not alert the bridge to the problem, but instead began attempting to resolve the cooling-water issue.

1.4 Oblivious to the technical problem in the engine room, the bridge team took the *Hanjin Bombay* into the narrow entrance channel and continued to increase the engine speed to improve the steering performance.

1.5 The engine-cooling-water temperature continued to rise and reached the point where the engine safety control system automatically slowed the engine down, then shut it down completely to prevent it becoming permanently damaged.

1.6 The *Hanjin Bombay* was negotiating the turn from the Cutter Channel into No. 2 Reach when the engine shut down. The loss of propulsion reduced the steering performance of the vessel and the rudder was unable to arrest the turn before the ship left the Channel and grounded on the eastern shore of the channel.

1.7 The harbour pilot had radioed the tugs to return to the *Hanjin Bombay*, but they arrived at the vessel just after it had grounded. The *Hanjin Bombay* remained aground for about 2 hours until it refloated on a rising tide.

1.8 The vessel received a hole in one of its water-ballast tanks and indentations in the hull plating in the bow area. There was no pollution and the ship later re-entered the port, where it underwent temporary repairs before resuming its voyage. It later entered a dry-dock in China to effect permanent repairs.

1.9 The Commission made findings that the grounding could have been prevented if the automatic engine-shutdown condition had been overridden for long enough to stabilise the heading of the vessel, and/or if the tugs had been in attendance to help maintain directional control. Either option could have been achieved through better knowledge of the engine systems, better communication between the bridge and engine room crew, and if the bridge crew had informed the harbour pilot of the escalating engine problem.

1.10 Port of Tauranga Limited's risk assessment for its Port and Harbour Safety Management system did not fully address the risk of departing vessels experiencing failure of propulsion and manoeuvring systems at critical locations in the entrance channel.

1.11 The Commission made recommendations that the Director of Maritime New Zealand resolve the safety issue of adequate tug escorts for vessels in all New Zealand ports, and that he develop a national system that would allow port authority staff access to new and previous information on vessel and crew performance in the interests of preventing similar accidents and incidents in the immediate future.

1.12 The key lessons from the inquiry into this occurrence were:

- vessel crews must have a thorough knowledge of their vessels' operating systems if they are to deal effectively with abnormal situations

- the concept of crew resource management must extend to all operational areas on a vessel, and in particular must result in a common understanding of the voyage plan and good communication between bridge and engine room

- The level of tug assistance given to vessels when transiting narrow channels needs to be commensurate with the level of risk and should be decided on the basis of reducing the risk to as low as reasonably practicable

- shipboard operations must be conducted using an agreed common language that everyone can understand. Crew members lapsing into their native tongue during an emergency is a breakdown in communication that can seriously hinder any response to deal with the emergency.

2. Conduct of the inquiry

2.1. On 21 June 2010 at about 2130, the Transport Accident Investigation Commission (Commission) was notified by Maritime New Zealand that the *Hanjin Bombay* had earlier that evening run aground as it was leaving the port of Tauranga.

2.2. The accident fell into the category of a "serious casualty" as defined in the International Maritime Organization's casualty investigation code. The Commission opened an inquiry into the occurrence under section 13(1)(b) of the Transport Accident Investigation Commission Act 1990.

2.3. On 22 June 2010 the Commission notified the occurrence to the Flag State of the vessel, Panama. The Commission and the Panama Maritime Authority agreed that the Commission would investigate the occurrence and would produce a report on behalf of Panama.

2.4. On 23 June 2010 two investigators from the Commission travelled from Wellington to Tauranga to start the site investigation. On arrival the investigators were briefed by Maritime New Zealand investigators and members from the port management team.

2.5. During the next 2 days the investigators interviewed the vessel's crew, the harbour pilot and others who had been involved in the events leading up to the grounding. Pertinent documents were sourced from the vessel, including those relating to the International Safety Management System. Relevant data was also extracted from the *Hanjin Bombay*'s voyage data recorder by the investigators.

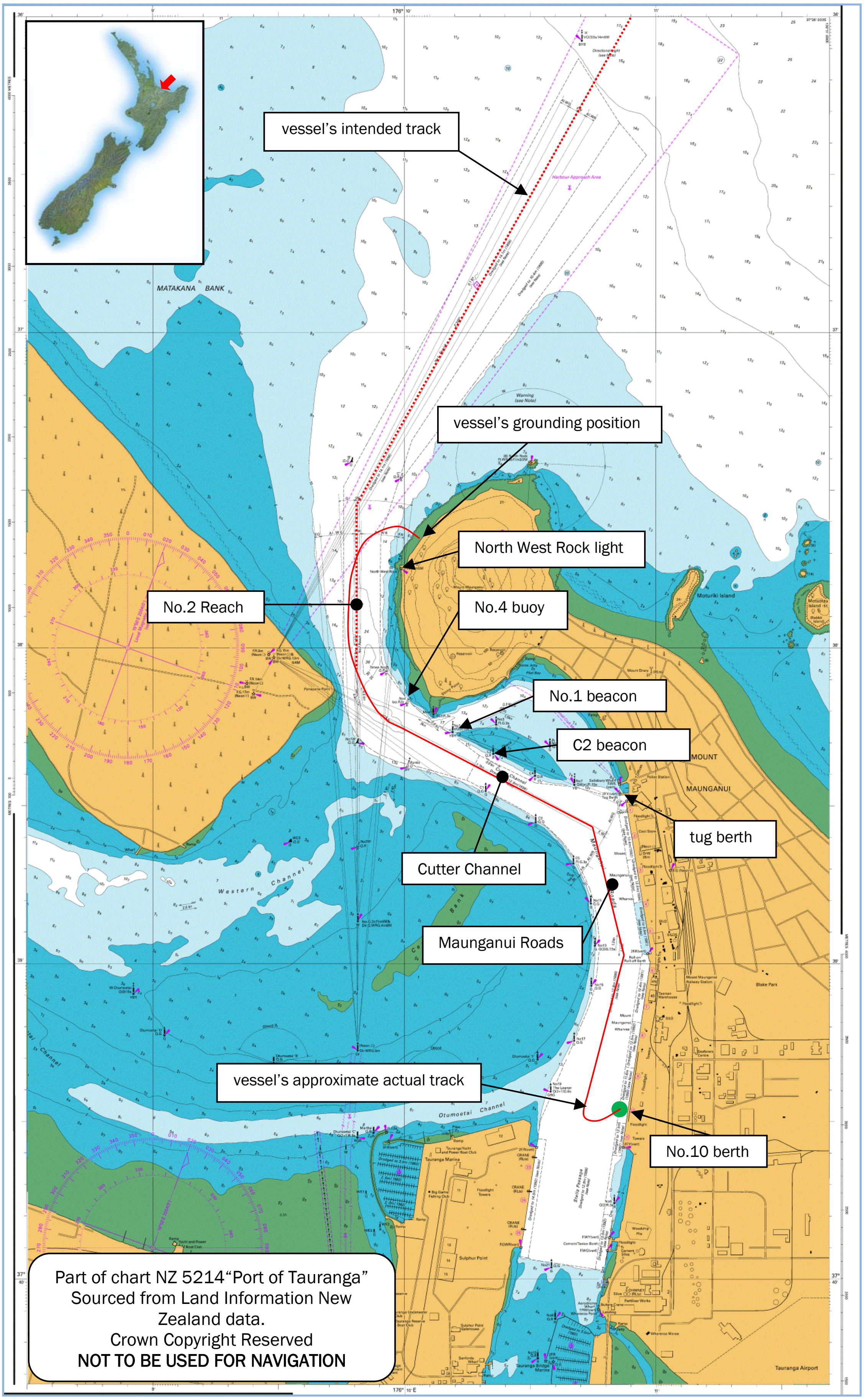
2.6. The investigators interviewed relevant staff from the port company and sourced various pertinent documents supporting the Port Safety Management System.

2.7. Following the first phase of the investigation, data was sourced from national and international agencies, equipment manufacturers, the vessel owners and the vessel's classification society.

2.8. On 12 December 2012 the Commission approved a draft final report for circulation to interested persons.

2.9. The draft final report was sent to 16 interested persons with a request that submissions be forwarded to the Commission no later than 1 February 2013. Written submissions were received from Port of Tauranga Limited, the Korean Maritime Safety Tribunal and Maritime New Zealand.

2.10. On 20 March 2013 the Commission approved the publication of the final report.



Part of chart NZ 5214"Port of Tauranga"
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Figure 1
Chart of the general area

3. Factual information

3.1 Narrative

3.1.1. On 15 June 2010 the bulk carrier *Hanjin Bombay* arrived at No. 10 berth in the port of Tauranga. The vessel discharged its import cargo then loaded a full cargo of export logs during the following 5 days.

3.1.2. Loading of the logs was completed at about 0930 on 21 June. The crew were then engaged in the lashing of the cargo, which was completed by about 1745 the same day. A harbour pilot boarded the vessel at about 1912 ready for a 1930 departure. The master arrived on the navigating bridge at about 1918, after completing departure formalities.

3.1.3. The following chronology of events has been developed mainly from data recorded on the vessel's voyage data recorder and other shipboard recording devices, and recordings of radio messages made by Port of Tauranga Limited, augmented with the recollections of those persons interviewed in connection with the grounding.

Events on the navigating bridge

3.1.4. At about 1920 the master ordered standby engines (noted in the vessel's log book as 1918). The pilot then went through Port of Tauranga Limited's passage plan with the master and explained the anticipated manoeuvres, speeds and courses.

3.1.5. At about 1925 a tug had been secured forward and another tug was secured aft. The pilot ordered all lines securing the vessel to the wharf to be let go, which was accomplished by about 1930. The pilot, with the aid of the tugs and the vessel's main engine, manoeuvred the *Hanjin Bombay* away from the berth and turned the vessel in the channel to head outwards.

3.1.6. Once the vessel was turned and heading outwards the pilot ordered the tugs to be let go and at about 1941 the pilot increased the speed of the main engine to half-ahead and conned the vessel through Maunganui Roads and into the Cutter Channel. The tugs provided a passive escort (without a line attached) for the *Hanjin Bombay* as it transited Maunganui Roads. At about 1949 the pilot was comfortable with the vessel's engine performance, so he stood down the tugs and increased the engine speed to full ahead. The tugs then returned to their berths located at Mount Maunganui, but were asked by the pilot to remain listening on very-high-frequency radio channel 12, the working channel for the port of Tauranga. At about 1951 the *Hanjin Bombay* entered the Cutter Channel (see Figure 2).

3.1.7. At about 1954 the *Hanjin Bombay* was abeam of C2 beacon and the pilot was preparing to turn the vessel out of the Cutter Channel into No.2 Reach. At 1955 a 'main engine automatic slowdown' alarm activated on the bridge engine alarm panel, which was signalling to the bridge team that the main engine revolutions were automatically reducing for some reason. The master did not bring this to the pilot's attention. Instead he telephoned the engine control room and, speaking in Korean, asked if he should reduce the revolutions per minute of the main engine. The master then said (in Korean), "It's not possible, it is now just turning – is it OK? – what is your situation?" The master then ended the call and did not say anything to the pilot.

3.1.8. About one minute later the telephone on the navigating bridge rang and was answered. By this time the vessel had already entered the turn into No.2 Reach. The next discernible words recorded were the pilot requesting the master to not slow the vessel down. He (the pilot) asked why the engine was slowing down – what was wrong. The master did not respond. Instead he was heard telling the officer on the forecastle head (in English) to stand by the anchors (ready to let go).

3.1.9. At about 1957 the vessel was approximately abeam of No.4 buoy. The pilot was unable to ascertain from the master what the problem was with the main engine, so he radioed the tugs to return and stand by to assist as soon as possible.

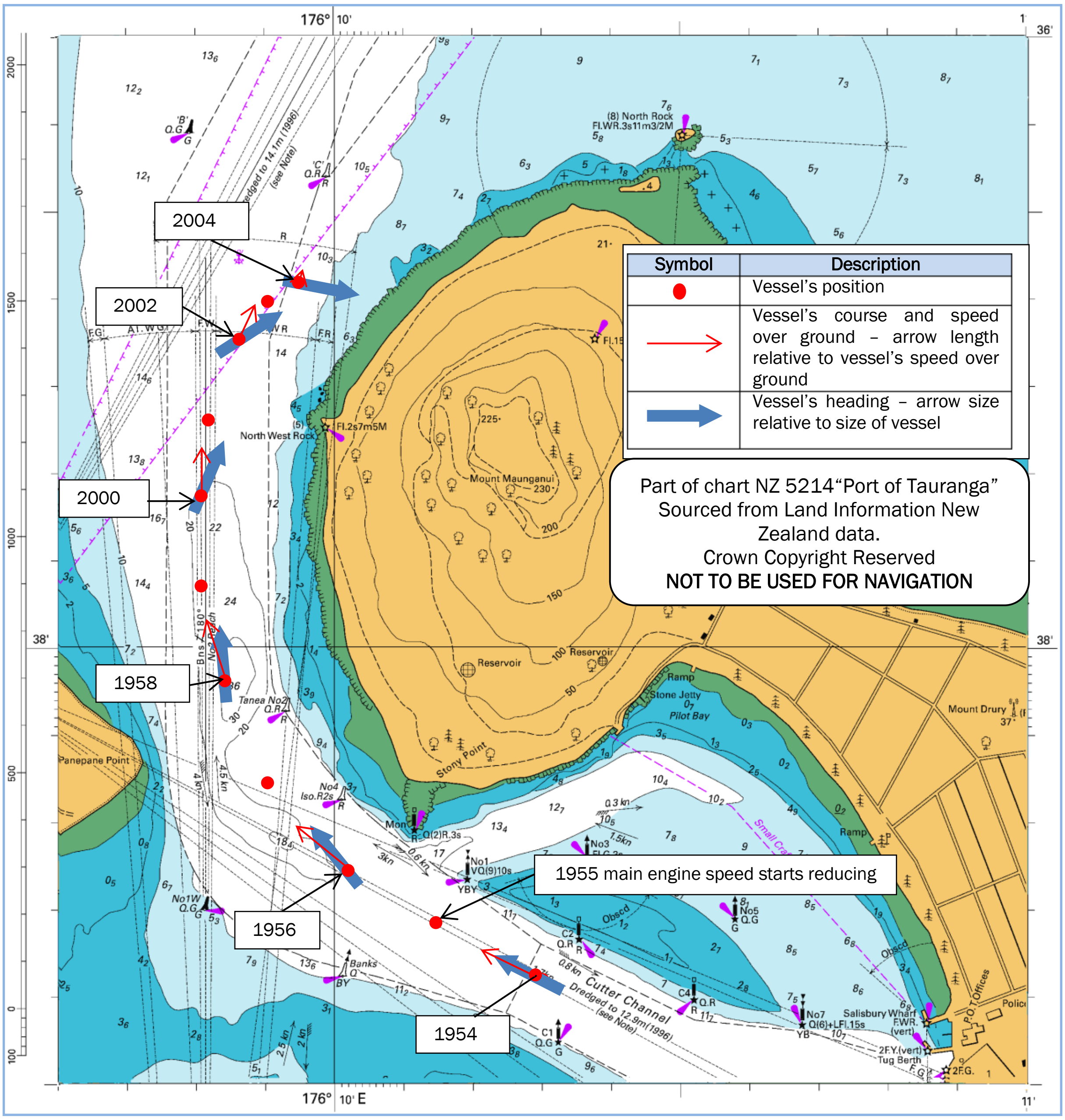


Figure 2
Chart of the entrance to Tauranga Harbour detailing the *Hanjin Bombay*'s track

3.1.11. The engine was still turning ahead on reduced revolutions, so the pilot ordered port helm to stop the vessel turning and steady the course to No.2 Reach. The *Hanjin Bombay* was reacting slowly to the helm, so the pilot requested the master to get the engine going as soon as he could, otherwise the vessel was going to run aground.

3.1.12. At about 1958 the 'main engine automatic shutdown' alarm activated on the bridge and engine room alarm panels, and the engine stopped. The pilot again requested the master to get the main engine on-line, and radioed the tugs to attend as quickly as possible.

3.1.13. At about 1959 the helmsman advised the pilot and master that the vessel was not responding to the helm. The master then telephoned the engine room and asked the chief engineer (in Korean) if he was able to start the main engine.

3.1.14. At about 2000 the *Hanjin Bombay* was approaching North West Rock light abeam to starboard. The vessel was in the main channel moving at about 2.6 knots on a heading of about 020 degrees gyro; however, with no main engine power the vessel's bow was swinging to starboard at an increasing rate. At that point the master at the request of the pilot ordered the officer on the forecastle head to drop the anchors.

3.1.15. About one minute later the pilot issued a broadcast on the radio that the *Hanjin Bombay* was running aground and requested the port radio operator to activate the port emergency response procedure. By about 2002 the vessel's head had swung to about 060 degrees gyro, so the pilot again requested the master to drop both anchors and asked what the status of the main engine was. The master advised the pilot that the port anchor had been let go.

3.1.16. At about 2004 the *Hanjin Bombay* ran aground on the Mount Maunganui side of the entrance channel, about 222 m north of North West Rock light.

3.1.17. As the vessel ran aground, the first officer on the forecastle head radioed the master to advise that he could hear air venting from the No. 1 port double-bottom water-ballast tank vent.

Events in the engine room

3.1.18. At about 1920 'standby engines' was rung from the navigating bridge on the engine room telegraph. At that time the engine room was manned by a total of five engineers, one more than the company minimum of 4. Present in the engine room and engine control room were the chief engineer, first engineer, second engineer, third engineer and engineer officer apprentice. The engineers completed the final preparations for departure, which included closing the steam valve to the main engine jacket-cooling-water pre-heater. The function of the pre-heater was to warm the engine in preparation for use.

3.1.19. At about 1937 the first engine movement was recorded in the engine room. The chief engineer was monitoring the temperature of the main engine jacket-cooling-water system. He noted that it steadily increased from the 60 degrees Celsius (°C) that had been maintained by the main engine pre-heater to about the normal operating temperature of 80°C.

3.1.20. Between 1945 and about 1950, as the *Hanjin Bombay* was proceeding through the Cutter Channel, the chief engineer noticed that the temperature of the main engine jacket-cooling-water system was rising above the 'normal' 80°C and had reached 82°C. The chief engineer told the first engineer to check the main engine jacket-cooling-water pumps and to vent any air out of the coolers.

3.1.21. At about 1949 the bridge team increased the main engine from 'half-ahead' to 'full-ahead'.

3.1.22. At about 1952 the chief engineer noticed that the temperature of the main engine jacket-cooling-water system was at 85°C. The second engineer had just returned to the engine control room, so the chief engineer told him to stay in the control room while he went to the main engine jacket-cooling-water coolers and checked the air vent himself. He checked the main engine jacket-cooling-water 3-way temperature control valve (3-way valve) and found that it did not appear to be opening as it should.

3.1.23. The chief engineer lowered the temperature set point on the controller unit for the 3-way valve, but this had no effect. The 3-way valve was spring-loaded to 'normally open'. Control air pressure acted on a diaphragm to push against the spring to close or partially close the valve depending on the cooling-water temperature. The chief engineer reduced the control air pressure to see if this would allow the valve to open – it did not.

3.1.24. The chief engineer returned to the engine control room to collect tools to free the 3-way valve. He returned to the 3-way valve, removed the pneumatic connection to it and hammered the side of the valve in an attempt to free it. He noticed the valve starting to move.

3.1.25. Meanwhile the cooling-water temperature had reached 90°C, which initiated the main engine automatic slowdown function. Shortly after this the cooling-water temperature reached 95°C, which initiated the main engine automatic shutdown function, and the main engine stopped.

3.1.26. The chief engineer had just succeeded in getting the 3-way valve to move when he heard the general engine room alarm sound and the sound of the main engine revolutions decreasing, so he went back to the engine control room to find out what the alarm was for. By the time he got to the control room the main engine had already stopped. He noted that the warning lights for main engine slowdown and shutdown were illuminated, so he cancelled the alarms and telephoned the master on the navigating bridge.

3.1.27. The chief engineer said that in his telephone call to the master he advised the master that "everything was under control and could the master try to restart the main engine". This did not work, so the chief engineer advised the master to put the "engine telegraph to the 'stop' position to reset the system and then restart". This did not work either. The chief engineer noted at this time that the temperature of the main engine jacket-cooling-water was registering 100°C.

3.1.28. The chief engineer went to the 3-way valve control unit to check that "everything was in order", then returned to the engine control room to telephone the master. However, by the time he returned to the engine control room the vessel had run aground.

Post-accident events

3.1.29. The 2 tugs arrived soon after the vessel ran aground. They were used near the vessel's stern to hold the vessel at right angles to the shoreline, against the force of the tidal current.

3.1.30. All other shipping movements were postponed while the port services dealt with the grounding. A second harbour pilot boarded the vessel, then the pilot vessel was used to check around the *Hanjin Bombay* for any signs of pollution.

3.1.31. The master ordered the crew to emergency stations. The crew made soundings of all tanks to check their integrity. It was eventually established that only the port double-bottom ballast tank had been breached.

3.1.32. Low water was at 2130. As the tide rose again the bow began to float. The tugs were repositioned to hold the vessel against the incoming tide and to assist in pulling the vessel off.

3.1.33. By about 2215 the *Hanjin Bombay* was floating along its whole length. The pilots manoeuvred the vessel back into the channel, using the incoming tide to push the stern southwards and the bow heading out to sea. The vessel was then taken to anchor off the port for further assessment. The following day, 22 June, the vessel was brought back into the port under its own power with assistance from the harbour tugs.

3.2 Inspection and testing

3.2.1 After berthing, the operator and classification society arranged for an underwater inspection of the hull. The classification society surveyor specified that a temporary plate be welded over a penetration in the hull. The penetration was approximately 1050 millimetres (mm) long by about 135 mm wide into the No. 1 port double-bottom water-ballast tank. After this repair had been completed the *Hanjin Bombay* sailed for Korea on 28 June 2012, where it discharged its cargo then entered a dry-dock in China for permanent repairs. Those repairs consisted of new steelwork inserted in the hull to repair several major indentations in the hull ranging between 10 mm and 80 mm in depth, and the replacement of the internal structure of parts of No. 2 side girder, transverse web and floor plate. The vessel left the dry-dock on 2 August for its next voyage.

3.2.2 While the *Hanjin Bombay* was in Mount Maunganui the 3-way valve was dismantled under the guidance of the Commission's investigator. The investigator also checked the relevant settings and use of the cooling-water system, as well as the operation of the main engine control system, to establish why the engine had shut down.

3.2.3 Nothing obvious could be found that would have caused the 3-way valve to malfunction. The full results of the 3-way-valve inspection can be found in Appendix 1.

3.3 Recorders

3.3.1 The *Hanjin Bombay* was equipped with a simplified voyage data recorder, which is a device that collects data from various sensors on-board a vessel. The system digitises and stores the information in a protective tamper-proof storage unit. The stored data in the unit is volatile, which means it is overwritten by new data after a period of time. The data can, however, be manually saved to the equipment's non-volatile memory, then later downloaded for analysis.

3.3.2 After the incident the master of the *Hanjin Bombay* saved the data for the previous 12 hours. This data was later downloaded by the Commission investigators. The data was uncorrupted and proved useful for determining the timing and sequence of events, as well as the conversations on the bridge.

3.4 Vessel information

3.4.1 The *Hanjin* Bombay was a bulk carrier built in Korea in 1994/1995, owned by Kamco No.4 Shipping Company S.A. of Panama, and operated by Hanjin Shipping Company Limited of Korea. The vessel was registered in Panama and had valid certificates issued by the Korean Register of Shipping on behalf of the Panamanian Government.

3.4.1 The *Hanjin Bombay* had an overall length of 167 m and a breadth of 26.2 m. It had a summer draught (fully loaded) of 9.88 m, giving a total displacement of 33 509.9 tonnes. At the time of the accident the mean draught was 9.86 m and the vessel was carrying about 26 268 tonnes of logs.

3.4.2 The *Hanjin Bombay* was powered by a single B&W 5L50MC/HHIC direct-reversing diesel engine developing 7450 brake-horsepower (5555 kilowatts), driving a single fixed-pitch propeller, giving a loaded service speed of 14.14 knots. It had a semi-balanced rudder fitted directly behind the propeller. The vessel was not fitted with a bow thruster.

3.4.3 The *Hanjin Bombay* was fitted with the typical suite of navigational equipment.

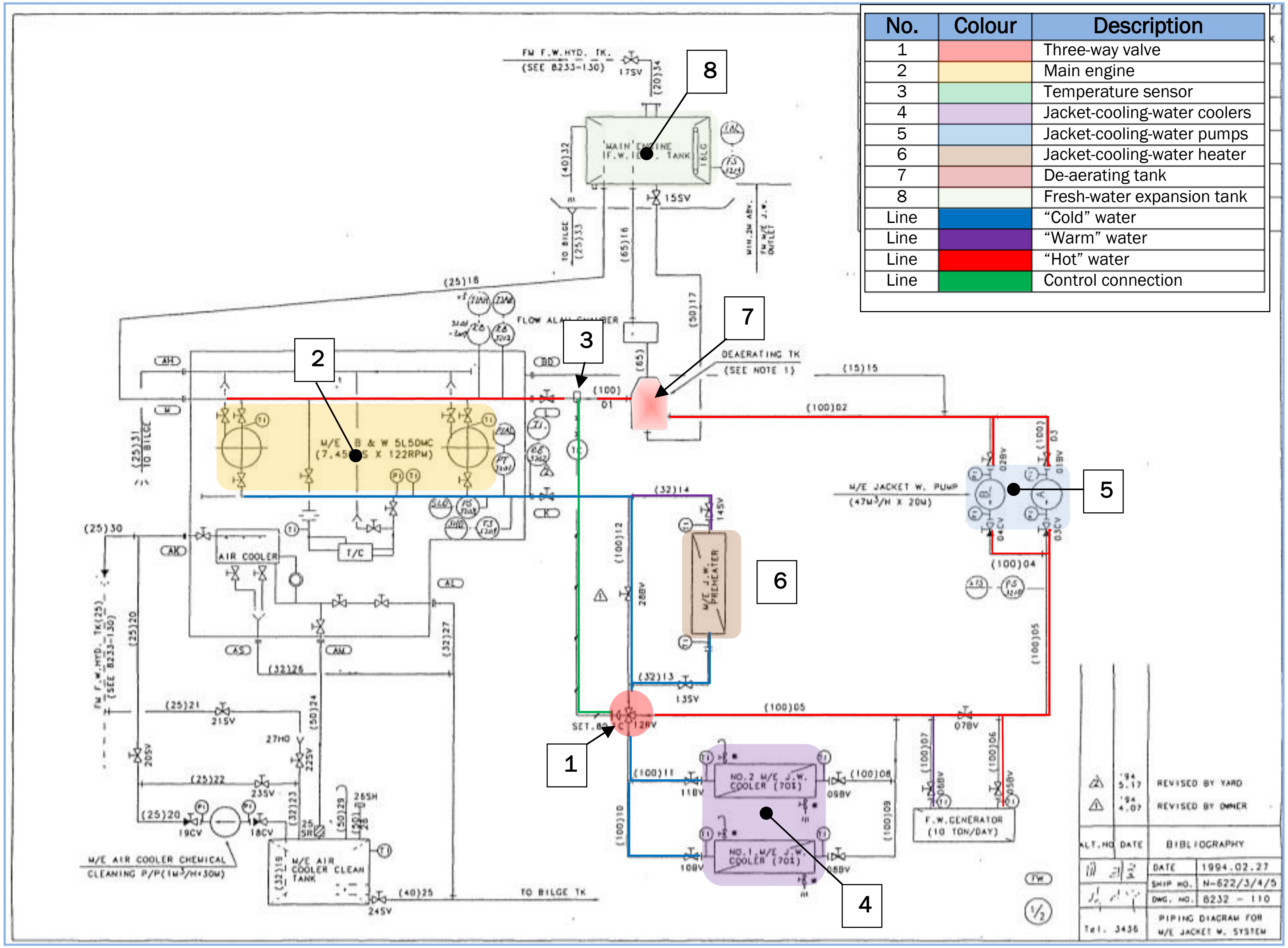
3.5 Operation of the engine-cooling water system

3.5.1 The main engine on the *Hanjin Bombay* was a water-cooled diesel engine. The main engine was kept at its optimum operating temperature using a closed-loop fresh-water cooling system (see Figure 3).

3.5.2 The fresh water could be passed through heat exchangers (water coolers) to remove heat that it picked up as it circulated through the engine. These water coolers used, in this case, sea water to remove the heat from the fresh water. The amount of fresh water from the closed-loop system that was diverted through the water coolers was controlled by the 3-way valve. Simplistically speaking, the hotter the fresh water became, the more of it would be diverted through the water coolers, to cool it.

3.5.3 With reference to Figure 3, the 3-way valve was in turn controlled by a temperature sensor (3) located in the return line of the cooling water from the main engine (2). The water was pumped around the system by the main engine jacket-cooling-water pumps (5) and could, through the operation of the 3-way valve, be sent through the main engine jacket water coolers (4). Also located in the system after the 3-way valve and before the main engine was the jacket-cooling-water heater (6), which when the main engine was running was isolated from the system. In the event of the system getting air or gas into it from either a leak or the water boiling, the de-aerating tank (7) would allow this to escape through the main engine fresh-water expansion tank (8).

3.5.4 When the vessel was ready to depart the engineers would isolate the jacket-cooling-water heater. The temperature sensor would send a signal through a pneumatic control unit to the 3-way valve. The valve would automatically open and close to regulate the cooling water temperature. When the engine was not running the 3-way valve would typically be closed. When the engine was running, the 3-way valve would open to varying degrees to regulate the



No.	Colour	Description
1	🟥	Three-way valve
2	🟨	Main engine
3	🟩	Temperature sensor
4	🟪	Jacket-cooling-water coolers
5	🟦	Jacket-cooling-water pumps
6	🟫	Jacket-cooling-water heater
7	🟥	De-aerating tank
8	⬜	Fresh-water expansion tank
Line	🟦	"Cold" water
Line	🟪	"Warm" water
Line	🟥	"Hot" water
Line	🟩	Control connection

Figure 3
Main-engine-cooling water system diagram

flow of the fresh water through the water coolers to keep the fresh water at the optimum pre-set temperature.

3.5.5 If the temperature rose above the pre-set value, the engine control system would sound an alarm to alert the engineers to the situation to allow them to take remedial action, and would automatically slow down the engine. The alarm also sounded on the navigation bridge to warn the bridge team that there was a problem and that the engine was automatically slowing down. If the temperature within the engine continued to climb and reached another pre-set value, the engine control system would automatically shut down the main engine, usually by shutting off the fuel to the engine (see Appendix 1 for details of the alarm settings). An alarm would alert both the engine room and bridge teams to this automatic engine-shutdown condition.

3.5.6 If the main engine cooling water reached a temperature at which it boiled, large amounts of vapour or gas would be produced that would overwhelm the de-aerating system; the engine would "gas up" and vapour would have to be bled off before normal cooling could be resumed.

3.5.7 The chief engineer said later that the settings had been set by the manufacturer to the company-recommended settings and that he had not altered them since he had been on board the vessel.

3.6 Main engine manoeuvring system

3.6.1 The main engine on the *Hanjin Bombay* could be controlled either directly from the side of the main engine or electro-pneumatically from the control room or navigating bridge. The main engine side control would usually only be used if the other systems failed.

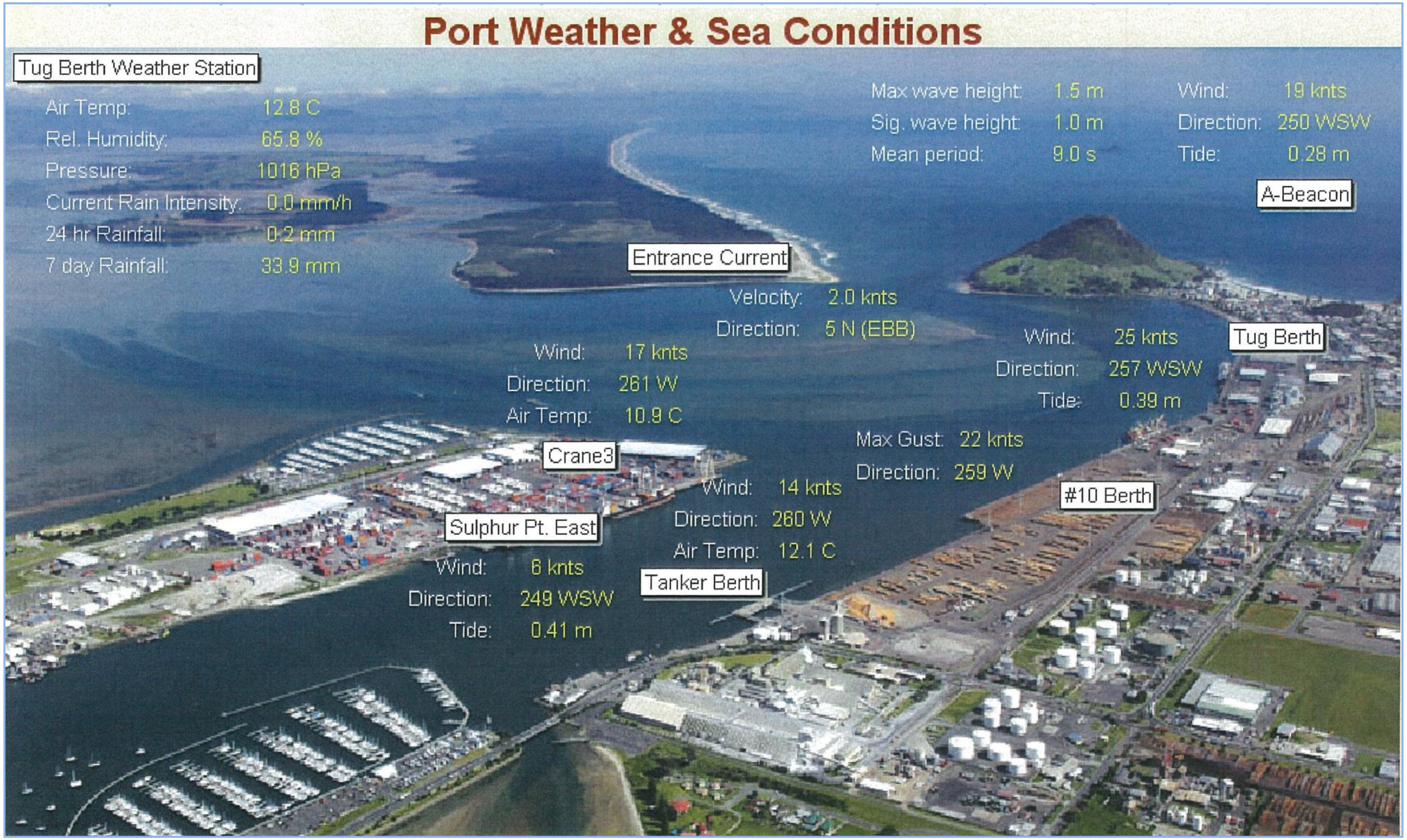
3.6.2 The main engine could only be controlled from one of the control stations at a time. This was usually the bridge when the vessel was being manoevred under pilotage.

3.6.3 The direction and speed of the main engine were controlled from the navigating bridge by a single telegraph transmitter with reversing, starting, stopping and speed regulation controlled through a micro-computer unit. The equipment also incorporated safety devices, including an engine safety system and a manual emergency shutdown system using electro-pneumatic signals.

3.6.4 The engine safety system would automatically slow down the main engine (for 10 instances) and if the fault was not corrected shut down the main engine (for 5 instances). The automatic slowdown could be overridden for all 10 instances and for 4 of the 5 shutdown instances. This was done by pushing a button on either the control room panel or the navigating bridge panel. An automatic engine slowdown or shutdown due to high cooling-water temperature was one of the instances that could be overridden. The engine safety system was designed to protect the engine from damage. The override feature was provided in case the automatic slowdown or loss of an engine was going to result in more serious damage and compromise the safety of the vessel and crew.

3.7 Environmental conditions

3.7.1 Port of Tauranga Limited had numerous meteorological sensors around the port, which were used to produce a picture of the conditions within the port and out to "A" beacon. The prevailing conditions at the time of the accident are shown in Figure 4, which for "A" beacon are wind from a west-south-westerly direction with a speed of about 19 knots, a significant wave height of 1 m and a tidal height of 0.28 m. The tidal stream in the entrance channel was running at about 2 knots in a northerly direction (ebbing).



Port Weather & Sea Conditions

Tug Berth Weather Station
Air Temp: 12.8 C
Rel. Humidity: 65.8 %
Pressure: 1016 hPa
Current Rain Intensity: 0.0 mm/h
24 hr Rainfall: 0.2 mm
7 day Rainfall: 33.9 mm

Max wave height: 1.5 m
Sig. wave height: 1.0 m
Mean period: 9.0 s

A-Beacon
Wind: 19 knts
Direction: 250 WSW
Tide: 0.28 m

Entrance Current
Velocity: 2.0 knts
Direction: 5 N (EBB)

Crane3
Wind: 17 knts
Direction: 261 W
Air Temp: 10.9 C

Tug Berth
Wind: 25 knts
Direction: 257 WSW
Tide: 0.39 m

#10 Berth
Max Gust: 22 knts
Direction: 259 W

Tanker Berth
Wind: 14 knts
Direction: 260 W
Air Temp: 12.1 C

Sulphur Pt. East
Wind: 6 knts
Direction: 249 WSW
Tide: 0.41 m

Figure 4
Climatic conditions for the port of Tauranga at the time of the grounding

3.7.2 The predicted tides for Tauranga from the New Zealand Nautical Almanac (Government of New Zealand, 2009) were:

	Date	High Water	Low Water	High Water	Low Water
Tauranga	21/06/2010	0203 1.9 m	0816 0.2 m	1440 1.8 m	2040 0.3 m

3.7.3 From data supplied by Port of Tauranga Limited, low water occurred at "A" Beacon at about 2100 and at the tug berth and Sulphur Point at about 2130. The tidal stream in the entrance channel became slack at about 2215, then commenced to flood.

3.8 Personnel information

The *Hanjin Bombay*

3.8.1 The master of the *Hanjin Bombay* was a South Korean national and held a Panamanian master's certificate of competency issued on 11 December 2008 under the provisions of the International Convention on Standards of Training, Certification and Watchkeeping for Seafarers, 1978 as amended in 1995 (STCW 1995). This was a certificate of equivalent competency to his Korean certificate. He had joined the *Hanjin Bombay* on 22 September 2009 as master.

3.8.2 The third officer of the *Hanjin Bombay* was an Indonesian national and held a Panamanian certificate of competency as a navigational watchkeeping officer issued under the provisions of STCW 1995. This was a certificate of equivalent competency to his Indonesian certificate. He had joined the vessel on 25 December 2009 as third officer.

3.8.3 The helmsman of the *Hanjin Bombay* was an Indonesian national and had signed on to the vessel as quartermaster on 4 May 2010.

3.8.4 The chief engineer of the *Hanjin Bombay* was a Korean national and held a Panamanian chief engineer's certificate of competency issued on 11 December 2008 under the provisions of STCW 1995. This was a certificate of equivalent competency to his Korean certificate. He had joined the *Hanjin Bombay* on 4 September 2009 as chief engineer.

Port of Tauranga Limited

3.8.5 The pilot on board the *Hanjin Bombay* was a New Zealand national and held a New Zealand certificate of competency as a master issued under the provisions of STCW 1995. He had been a pilot in Tauranga for about 18 months and was licensed as a Grade "B" pilot. As a Grade "B" pilot he was limited to piloting vessels up to a length of 210 m overall and up to a draught of 11.7 m.

3.9 Organisational and management information

3.9.1 In 1993 the International Maritime Organization adopted the International Management Code for the Safe Operation of Ships and for Pollution Prevention (ISM Code); and in 1998 the ISM Code became mandatory. The ISM Code established safety management objectives and required a safety management system to be established by the operating company. The procedures required by the ISM Code were to be documented and compiled in a safety management manual, a copy of which was to be kept on board.

3.9.2 Under the ISM Code the operating company is required to designate a working language for use on the vessel so that the crew can communicate effectively at work. The chosen working language on board the *Hanjin Bombay* was English.

3.9.3 On 18 May 2009 Hanjin Ship Management Company Limited, the operator of the *Hanjin Bombay,* was audited by the Korean Register under the authority of the Government of the Republic of Panama and was found to comply with the requirements of the ISM Code. The operator was issued with a document of compliance. The first annual verification was due to take place between 15 April and 15 October 2010.

3.9.4 The *Hanjin Bombay* had been similarly audited and the vessel's safety management system had been found to comply with the requirements of the ISM Code. The vessel had been issued with a safety management certificate on 10 August 2009, which remained valid, subject to periodic verifications, until 30 May 2011.

3.9.5 Port State Control is the inspection of foreign vessels in national ports to verify that the condition of the vessels and their equipment complies with the requirements of international regulations and that the vessels are manned and operated in compliance with those regulations. The primary responsibility for vessel standards rests with the Flag State – but Port State Control provides a "safety net" to catch substandard vessels.

3.9.6 Maritime New Zealand, as the regulator and as New Zealand's International Maritime Organization representative, inspects 90% of all eligible foreign vessels during their time spent in New Zealand ports (under section 54 of the Maritime Transport Act 1994).

3.9.7 On 14 June, about one week before the grounding, the *Hanjin Bombay* was inspected by a Maritime New Zealand Port State Control officer at Marsden Point. One deficiency with mooring arrangements was recorded, which was to be assessed by the classification society on the vessel's return to Korea. Under the Asia Pacific Memorandum of Understanding on the Port State Control Targeting Scheme, the *Hanjin Bombay* had a target factor of 20, which was considered medium risk, where 0-9 was low risk, 10-29 was medium risk and 30+ was high risk. The *Hanjin Bombay* had never been detained for any deficiencies under Port State Control.

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3.9.8 The procedures for piloting vessels into and out of the port of Tauranga by pilots were contained in Port of Tauranga Limited's Piloting Procedures booklet. They comprised, amongst others, the following:

> This manual contains information relating to piloting at the Port of Tauranga. Procedures are listed and information made available through attachments to allow pilots to make measured and informed decisions. This should not, however, be taken to mean that this document deals comprehensively with all of the concerns which will need to be addressed. It is not the intention of this document to take decision-making away from a pilot.

3.9.9 The New Zealand Port and Harbour Marine Safety Code was published in August 2004. Its objective was to provide for the safe management of vessels in ports and harbours, including preventing serious harm to people and protecting the environment and property.

3.9.10 The Code was developed following a number of serious accidents involving large vessels in the approaches to and within New Zealand harbours in 2002-03. Investigations revealed a need for more rigour and consistency in the standard of safety management of New Zealand ports and harbours.

3.9.11 The Code was prepared by Maritime New Zealand in consultation with industry stakeholders. The Code identified the duties and powers under existing legislation of those involved in port and harbour safety. The Code was voluntary and recommended that regional councils, as the principal local regulators of navigational safety, undertake risk assessments and develop safety management systems for the harbours in their regions. Maritime New Zealand provided advice to councils on these tasks and approved the completed assessments and safety management plans.

3.9.12 The Code was supported by a series of guidelines to good practice, of which one was the Guidelines for Port & Harbour Risk Assessment and Safety Management Systems in New Zealand. Bay of Plenty Regional Council and Port of Tauranga Limited jointly employed an outside marine consultancy firm specialising in marine risk assessment, risk management and vessel traffic surveys to conduct the navigational risk assessment in accordance with the requirements of the Code.

3.9.13 The results of the navigational risk assessment were presented to Bay of Plenty Regional Council and Port of Tauranga Limited in June 2007. The assessment identified 73 hazards at the overview level, which were ranked according to risk. Of these 73 hazards, 18 referred to groundings. Of the 18 grounding hazards, 3 referred to the possibility of a grounding in the entrance channel or No. 2 Reach. All 3 references were concerned with vessels entering the port rather than departing. Total loss of propulsion was not considered.

3.9.14 New risk-control recommendations for 2 of the grounding scenarios suggested introducing requirements to meet specified vessels with tugs at an agreed location.

3.10 Previous and subsequent occurrences

The *Caribic*

3.10.1 On 7 May 2000 the refrigerated cargo carrier *Caribic* was departing the port of Tauranga when it ran aground between Mount Maunganui and Tanea No.2 Buoy (Transport Accident Investigation Commission, 2000).

3.10.2 In the findings of the report the Commission found that:

- the resources available on the navigating bridge of the *Caribic* at the time of the accident did not allow the principles of good crew resource management to function properly
- the *Caribic* had a known tendency to initially react slowly to applied rudder before establishing a fast rate of turn. That tendency was not noted on the pilot information card nor was it adequately conveyed to the pilot
- the turn had been initiated by the application of 10 degrees of starboard rudder and became greater than the pilot had estimated. He took corrective action, but the application of counter helm in small increments, given the slow initial reaction time of the vessel, was not sufficient to avoid the grounding
- the slow reaction of the *Caribic* to counter rudder once swinging to starboard, together with the faulty movement of the rudder indicator, led the pilot to believe that the steering gear was not moving the rudder to port. The possibility of an intermittent malfunction of the steering gear that was not evident in subsequent testing could not be discounted.

The *Schelde Trader*

3.10.3 This occurrence was not investigated by the Commission, but Port of Tauranga Limited provided information from its investigation into the occurrence.

3.10.4 On 28 October 2011 the general cargo vessel *Schelde Trader* was departing the port of Tauranga. As the vessel was negotiating the bend from the Cutter Channel into No.2 Reach the oil mist detector in the crankcase of the main engine activated, which triggered an automatic engine shutdown.

3.10.5 The *Schelde Trader* was executing a turn to starboard at the time of the automatic engine shutdown. With the main engine and propeller stopped there was not enough water flow over the rudder to stop the vessel's swing to starboard, despite the rudder being put hard over to port.

3.10.6 The pilot and the master of the *Schelde Trader* ordered the port anchor to be dropped but there was a delay in dropping the anchor. The vessel grounded before the anchor was dropped, approximately 100 m to the north of the position where the *Hanjin Bombay* grounded.

4. Analysis

4.1 General

4.1.1 The *Hanjin Bombay* was about 15 years old at the time of the grounding. It was classed as a medium-risk vessel as far as the Port State Control system was concerned, primarily because of the deficiencies attributed to the vessel, although none of those deficiencies was serious enough for it to be detained. The safety management systems for the operating company and the vessel were current, and the vessel was crewed in accordance with the international and national standards of the day.

4.1.2 Vessels' machinery installations and their control systems are complex, and regardless of how well maintained they are there will always remain the possibility that some part fails for some reason. Vessels like the *Hanjin Bombay* are designed fundamentally for long sea voyages, with only a small percentage of their time spent manoeuvring around ports and enclosed waters. Consequently they often have only one main propulsion engine, for economy. Such vessels rely on harbour tugs to provide redundancy while assisting them into and out of ports. Harbour pilots provide a link between the vessels and the tugs and other port services.

4.1.3 It is important that the safety systems for a vessel and for a port company are aligned in their recognition of the risks involved when the vessel enters and leaves the port or harbour. The respective safety systems must be robust and communication between vessel and port needs to be good before a pilotage passage plan is agreed. This is because every vessel is different and handles differently.

4.1.4 The following analysis discusses what caused the *Hanjin Bombay*'s main engine to stop; the technical reasons why it ran aground; the robustness of the safety system for the port, particularly regarding risk; and communication issues within the bridge team and between the bridge team and the engine room.

4.2 Why the engine stopped

4.2.1 It is clear from the engine alarm data and the observations of the chief engineer that the engine automatically slowed down then automatically shut down due to rising cooling-water temperature. The engine protection system automatically shut down the engine, as it was designed to do in order to protect the engine from serious damage. The reason for the rising cooling-water temperature could not be conclusively established because when the 3-way valve was later dismantled, it was found to be in good condition.

4.2.2 Four possibilities have been considered. The first is that the temperature sensor may have been faulty, but this was unlikely because the engineers observed the temperature steadily rising on the monitor in the engine room. It was not performing erratically.

4.2.3 The second possibility was that the 3-way valve controller may not have been receiving the signal from the temperature sensor. This too is unlikely because when the cooling water temperature increases the control system decreases the control air pressure to the control diaphragm, which would normally allow the spring to open the valve to the coolers. When the chief engineer removed the control air connection from the valve this should have overridden the automatic control unit and allowed the spring to open the valve, but it didn't.

4.2.4 The third possibility is that the spring that normally opened the valve was faulty, but it was found in good condition with no signs of corrosion.

4.2.5 The fourth possibility is that the valve stem became temporarily jammed with debris such as detritus. Evidence of detritus was not found jammed around the valve spindle, but detritus was found in the cooling water system (see figures A1-2 and A1-3). The chief engineer succeeded in starting to move the valve by hammering on the valve casing. This would indicate that something was jamming the valve. By the time the valve was dismantled for inspection, it had been operating to cool the main engine when it was used to re-float the vessel, to take the vessel out to the anchorage and then to re-enter the port again. Any debris lodged around the valve spindle would not necessarily have remained there, which could explain why the valve spindle was found in a clean condition when the valve was dismantled for inspection.

4.2.6 The Commission therefore considers that the most likely reason for the overheating of the cooling-water system was a malfunction of the 3-way valve, and that the most likely reason for this was that it could not operate due to debris in the cooling water becoming lodged around the valve spindle.

4.3 Loss of control

4.3.1 The *Hanjin Bombay* was heavily loaded with logs when it departed No.10 berth. A heavily laden vessel is generally slower to respond to changes in speed and direction than an empty vessel. It will take longer to gain speed under engine power, and will take longer to slow down when engine power is reduced. Larger rudder angles will be needed to begin the vessel turning, and again when trying to slow or stop the rate of turn.

4.3.2 Once the *Hanjin Bombay* had been turned and lined up with the channel, the need for tug assistance was reduced, provided the vessel propulsion and steering systems remained operative. Vessels with fine underwater lines (container and passenger vessels) will generally be more directionally stable than others. Bulk carriers like the *Hanjin Bombay* are generally wider, with a more box-shaped underwater profile. These types of vessel are not generally so directionally stable. This means that more control is required to keep them going in a straight line.

4.3.3 The rudder is aerofoil shaped. When it is turned the water flowing past it creates ‘lift’ on one side, like an aeroplane wing. That lift pushes the stern of the vessel sideways and the stern rotates around the pivot point, which is near the bow of the vessel when it is moving ahead. In this way the vessel is steered. The faster the water flowing past the rudder, the more lift is produced and the better the vessel steers. The water flowing past the rudder is governed by 2 things: the speed of the vessel through the water; and the additional flow created by the propeller. At higher water speeds the speed of the vessel through the water plays a greater role. When a vessel is accelerating the propeller wash has a greater effect until the speed of the vessel builds up. Momentarily increasing engine speed will therefore give the pilot more steering control. Decreasing the engine speed will result in less control for the pilot.

4.3.4 If the body of water through which the vessel is moving is also moving, the pilot will need to take this into account, particularly when navigating narrow channels. The speed of the vessel through the water will need to be proportionally higher, otherwise the current can have too much influence on the vessel’s path.

4.3.5 At the time of the *Hanjin Bombay*’s departure the tide was still ebbing at 2 knots in the channel, which means the vessel was running with a 2-knot current. In order for the pilot to better control the planned track of the vessel as it entered the narrow channel, he needed to have a reasonably high water speed, and he was attempting to achieve this by building up the speed rapidly with the successive ‘half’ then ‘full’ engine speeds.

4.3.6 Figure 5 shows the progress of the *Hanjin Bombay* as the events unfolded. When the chief engineer first noted that the cooling-water temperature had risen above normal (82°C), the tugs were still in attendance. By the time the temperature had risen to 85°C the tugs were returning to their berth, less than half a nautical mile away. A precautionary phone call to the bridge at that time could have allowed the tugs to be back in attendance. It also could have delayed the ‘full-ahead’ engine movement from the bridge, which would have slowed the rise in cooling-water temperature and given the engineers more time to resolve the issue before the engine shut down.

4.3.7 As it was, the pilot was not told of the engine auto-slowdown event and he went ahead and initiated the turn into No. 2 Reach oblivious to the fact that the engine had slowed down. He soon noticed the unresponsiveness of the vessel to his helm orders and began questioning the captain on why the engine had slowed down. The reason for the poor response to the rudder movements was the reduced propeller wash past the rudder. Depending on the speed through the water that the vessel had reached, it is feasible that the propeller at ‘dead-slow ahead' revolutions was disrupting the water flow past the rudder being created by the vessel's speed through the water.

4.3.8 When the engine shut down altogether, the vessel was still turning to starboard. Without any propeller wash past the rudder, there was not enough lift generated by it to arrest the turn. To exacerbate the situation, once the bow began to leave the channel and out of the influence of the following current, the current pushing on the stern of the vessel would have accentuated the swing to starboard. Without the engine or the use of tugs, the grounding at that point was probably inevitable.

4.3.9 There was a way that the use of the main engine could have been prolonged. The automatic slowdown and subsequent shutdown of the main engine were features of the engine safety system, designed to prevent damage to the main engine from overheating. Both events could have been overridden by the master on the bridge if the circumstances had permitted, simply by pushing the override button on the engine control console. This button was flashing at the time, which was a cue to the master that the override function was available to him.

4.3.10 An override feature is installed to allow the master to weigh up his options to achieve the least unfavourable outcome in such a situation. Overriding an engine safety system could have caused overheating damage to the main engine, but overriding it for just long enough to enable the pilot to steady the course of the vessel in the channel could have prevented the grounding. The tugs at that point were close to arriving and could have been used to keep control of the vessel until the main engine was available again. With the 3-way valve beginning to function again, restoring main engine power could have occurred very soon after it had been lost.

4.3.11 It was unclear whether the master understood the function of the override button. When the auto-slowdown alarm activated, he asked the chief engineer on the phone whether he should reduce the engine speed. This would suggest that he was not aware that this was already happening automatically. Overriding a safety system is not a decision to be taken lightly. The master should be fully conversant with the system and the ramifications of using it. However, the consequences of a vessel running aground can be serious. Apart from the disruption to service and the cost of repair, the potential for environmental damage must be considered, as should the disruption to port services.

4.3.12 Alternatively, had the entire bridge team been in the loop and an early assumption been made that no engine power was going to be available, it is possible that the immediate deployment of both anchors would have alleviated the force of the grounding, or even prevented it (but that is purely speculation).

4.3.13 The short time it took for control of the *Hanjin Bombay* to be lost highlights the risks of mechanical failure for port operations. It also highlights the importance of good communication between all parties whose actions can affect the progress of a vessel. These matters are discussed more fully in the following sections.

Findings:

The automatic main engine slowdown and shutdown events were caused by high cooling-water temperature, which was most likely caused by a malfunction of a 3-way valve used to regulate the temperature of the cooling water.

The *Hanjin Bombay*'s main engine automatically shut down after the vessel was established in a turn into No.2 Reach, which left the vessel with insufficient steering control to overcome the momentum of the turn and prevent it leaving the channel and grounding.

The facility was available both on the bridge and in the engine control room to override the automatic main engine shutdown, which might have resulted in damage to the main engine but probably would have prevented the vessel running aground.

Better communication about the developing situation within the bridge team and between the bridge and engine room could have prevented the *Hanjin Bombay* grounding through the better use of engines, tugs and anchors.

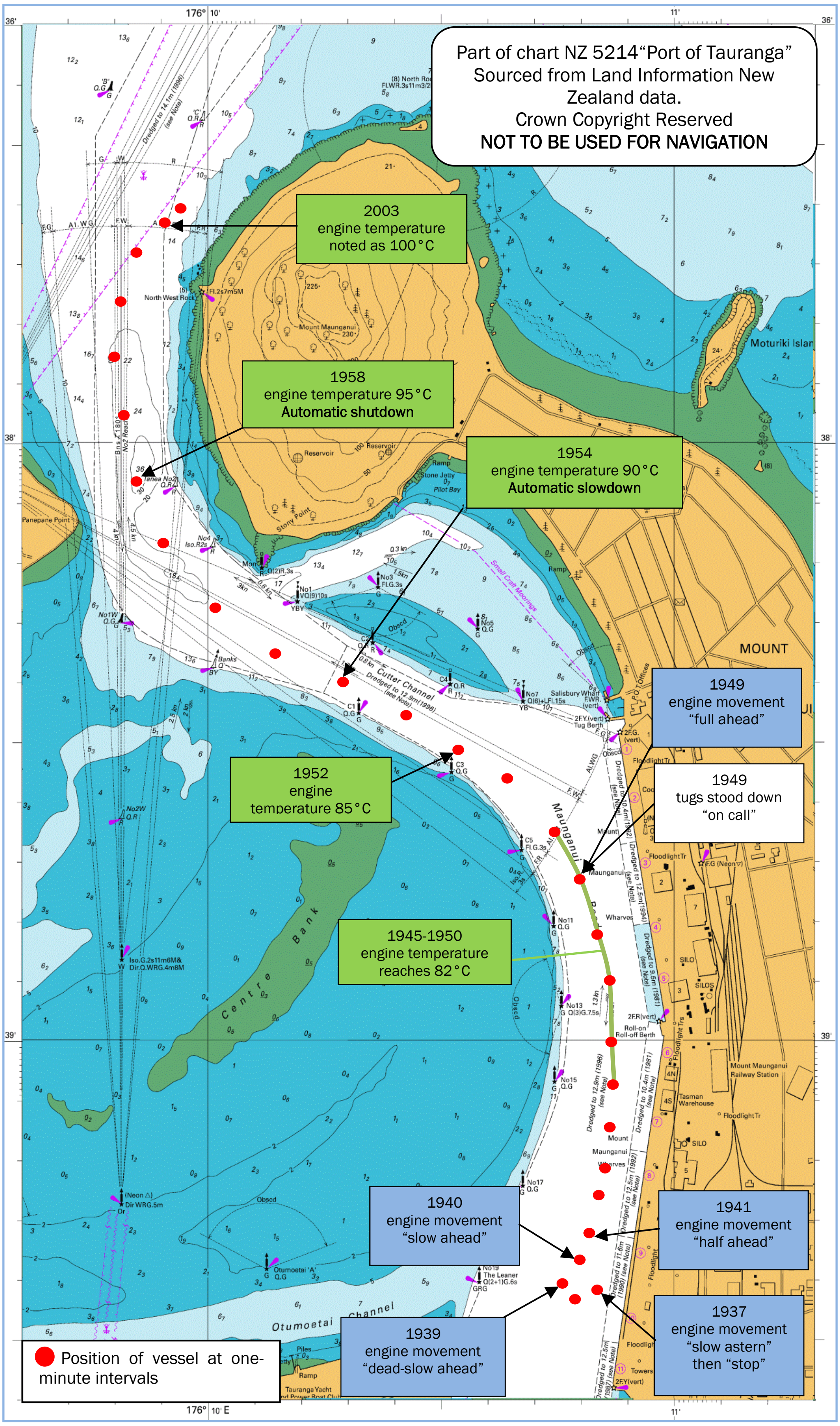

Figure 5
Diagram showing engine movments and temperatures against time

4.4 Crew resource management

4.4.1 Crew resource management is the term used to describe the co-ordination of all skills and resources available to a vessel's crew to achieve the established goal of optimum safety and efficiency[1].

4.4.2 The use of crew resource management helps to eliminate the potential for one-person errors to result in an accident, and it aids the flow of information between anyone whose actions can affect the progress of the vessel. This is not just limited to bridge personnel, but includes the engine room and other deck crew, tugs and shore-based information services.

4.4.3 When used effectively, crew resource management ensures that all the vessel's crew: share a common view of the intended passage; maintain situational awareness; anticipate dangerous situations; acquire all relevant information and act upon it in a timely manner; avoid an error chain being formed; and avoid preoccupation with minor problems.

4.4.4 When crew resource management is working effectively, the pilot joining the vessel is incorporated into the navigating bridge team and an exchange of relevant information takes place. This is usually in the form of a pre-departure briefing on the pilotage passage plan. It is industry best practice that the entire bridge team take part in this briefing so that they all understand the plan. This did not happen on the *Hanjin Bombay*. The exchange was between the master and pilot only. This fact was reflected in the performance of the bridge team as events unfolded. The officer of the watch had virtually no involvement in managing the situation as it escalated. The master was acting alone, even to the exclusion of involving the pilot. His discussions with the chief engineer were in Korean, which no-one else on the bridge understood. The pilot asked the master for information several times, but did not get any response other than to be told when one of the anchors had been let go just before the vessel ran aground.

4.4.5 Under the ISM Code the working language of the ship had been declared as English. The use of a common working language is critical to the safe operation of a vessel. This is especially important when dealing with emergencies. On this occasion the master's discussions with the chief engineer being in the Korean language meant that the pilot and other bridge team members could not understand the problem they were dealing with. This was then exacerbated by the master's failure to then inform the bridge team what that problem was.

4.4.6 Vessels are totally reliant on the engineering systems for the safe transit of enclosed waters. It is important that engine room crew are fully aware of the situation during pilotage operations and vice versa, but so often this does not happen. Engine control rooms are usually located down in the engine room where the crew cannot see where the vessel is and what is happening to it. Naturally then, engine room crew can become 'immersed' in their own environment, focused solely on the performance of the machinery, and unaware of the overall situation.

4.4.7 Fitting duplicate chart plotter screens in engine control rooms is one initiative that can help engine room crew maintain awareness of the vessel's location. This knowledge can help engine room crew to balance their response to resolve technical problems with the need to communicate with the bridge. Using this accident as an example, the chief engineer was aware that he had an escalating cooling-water problem. He had 4 other engineers at his disposal, yet none was dedicated to bridge communications. Had he been aware, at a glance, where the vessel was in the channel, he could have surmised that it was not a good time to have main engine problems, warned the bridge team early enough for them to alter their plan, and prevented the grounding. There would even have been some benefit in someone from the engine room taking part in the passage plan briefing on the bridge.

4.4.8 Even after the captain and chief engineer started conversing in the Korean language on the phone, the master did not provide the pilot, who was controlling the vessel, with sufficient information for him to respond accordingly.

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[1] Captain Kari Larjo, Scandinavian Airline Service (SAS) Flight Academy AB, 1993, SAS-BRM – Student's workbook – Edition 6.

4.4.9 The standard of crew resource management on board the *Hanjin Bombay* fell well short of best industry practice. Crew resource management training is an important part of training required under STCW 1995. This inquiry did not look as far back as the training standards for the individual crew members involved in this accident, so it could not be determined whether the issue lay with just these individuals or whether there is a wider systemic training issue. However, the operating company does have a responsibility to ensure that the vessel is run safely, which includes ensuring that navigational practices and techniques as a minimum comply with the International Maritime Organization and Flag State standards. This is a requirement of any safety management system. The safe vessel management system for the operating company and the *Hanjin Bombay* clearly did not achieve those standards on this occasion.

Findings:

The standard of crew resource management on board the *Hanjin Bombay* fell well short of international industry best practice.

A better standard of crew resource management could have prevented the grounding in spite of the main engine cooling-water problem.

Navigation practices (including crew resource management) are a critical shipboard function that any safety management system should closely monitor to ensure that best industry practice is achieved.

The safety management system for the *Hanjin Bombay* and its operating company did not succeed in ensuring that good crew resource management was a standard feature of on-board operations.

The master not using English, the official working language of the ship, when engaging with the chief engineer as the emergency unfolded was a serious breach of emergency management protocols that left the pilot and other bridge team members unaware of the issue they were dealing with. This breach contributed to the *Hanjin Bombay* grounding.

4.5 Port risk assessment – tug escort

4.5.1 Port of Tauranga Limited's risk assessment identified 73 potential hazards, of which 18 were grounding events, and of these 18 three were grounding events in the entrance channel outside No. 2 Reach. Surprisingly, these 3 hazards referred to inbound vessels only, in spite of there having been 2 groundings of vessels during outbound passages, one (the *Schelde Trader*) under similar circumstances to this grounding and in almost the same location.

4.5.2 Since this grounding Port of Tauranga Limited has reviewed its operating procedures around the use of tug escorts. See Section 6 for full details. The review lists a number of factors for pilots to consider when deciding if a tug escort is to be used. However, transposing the *Hanjin Bombay*'s departure into the revised model, the pilot would not have been likely to use a tug escort for any longer than he did on this occasion. Referring to the criteria used in the model, the *Hanjin Bombay* was less than 25 years old, had a standard single-propeller/single-rudder configuration and had no history of mechanical failure; and no maintenance had been conducted on the machinery in port prior to departure – yet it encountered a mechanical problem on the outward journey that ultimately led to the grounding.

4.5.3 Earlier in this report we referred to the complexity of vessel machinery installations and their control systems. Using risk assessment methodology the likelihood of a malfunction of some sort is high, even with well maintained vessels. The data for reported occurrences of mechanical failure during pilotage in New Zealand alone shows this to be the case. Information supplied by Maritime New Zealand showed that in the 30 months from 24 January

2010 there had been 30 reported instances of machinery or equipment failure on vessels in the pilotage waters of New Zealand ports.

4.5.4 For a vessel like the *Hanjin Bombay* that has only one propulsion system, the risk of losing control of the vessel caused by a single-point failure is higher than that for other vessels that have greater levels of redundancy built in to their propulsion and power-management systems. This grounding was a relatively low-consequence event, although from the vessel operator's perspective there was some considerable expense in terms of repair costs and disruptions to service. From the port company's perspective there was the disruption to shipping services for one tidal window of operation.

4.5.5 The eastern side of No. 2 Reach is a rocky shoreline, and this seems to be the shoreline where ships are going to ground if propulsion is lost when making the turn into No. 2 Reach. The consequences of any future grounding in this area have the potential to be much worse. Port of Tauranga Limited would be advised to reconsider its long-term strategy for the use of escort tugs if the risk is to be reduced to as low as reasonably practicable. The Commission recommends that the port company address this safety issue and that Maritime New Zealand consider this issue when approving or auditing Port and Harbour Safety Management systems.

4.5.6 Port of Tauranga Limited has developed within its safety management system a 'history' database for vessels that have experienced technical malfunctions during Port of Tauranga transits. The system has merit. Such a system would have even more benefit if it was adopted on a national basis. Many vessels transit several New Zealand ports during a round trip. Information on problems experienced in one port should be passed on to other ports so that the risks can be appropriately mitigated there. Such a database need not be restricted to mechanical issues. A standard of crew resource management is another piece of useful information for a pilot planning for a vessel arrival or departure. Minor technical defects and human performance issues are often lead indicators of deeper systemic safety issues on board a vessel. Maritime New Zealand could use such a database to help focus its resources for best effect from a Port State Control perspective. A recommendation has been made to the Director of Maritime New Zealand to consider this safety issue.

Findings:

The grounding could have been prevented if the tugs had still been in attendance in a passive or active escort role.

Port of Tauranga Limited's risk assessment for its Ports and Harbours Safety Management System did not fully address the risk of departing vessels experiencing failure of propulsion and manoeuvring systems at critical locations in the entrance channel.

If the issues of mechanically unreliable vessels and substandard crew resource management on vessels operating in New Zealand ports are to be addressed, this will need to be done at a national level rather than individual ports dealing with the issues as they arise.

5. Findings

5.1. The automatic main engine slowdown and shutdown events were caused by high cooling-water temperature, which was most likely caused by the malfunction of a 3-way valve used to regulate the temperature of the cooling water.

5.2. The *Hanjin Bombay*'s main engine automatically shut down after the vessel was established in a turn into No.2 Reach, which left the vessel with insufficient steering control to overcome the momentum of the turn and prevent it leaving the channel and grounding.

5.3. The facility was available both on the bridge and in the engine control room to override the automatic main engine shutdown, which might have resulted in damage to the main engine but probably would have prevented the vessel running aground.

5.4. Better communication about the developing situation within the bridge team and between the bridge and engine room could have prevented the *Hanjin Bombay* grounding through the better use of engines, tugs and anchors.

5.5. The standard of crew resource management on board the *Hanjin Bombay* fell well short of international industry best practice.

5.6. A better standard of crew resource management could have prevented the grounding in spite of the main engine cooling-water problem.

5.7. Navigation practices (including crew resource management) are a critical shipboard function that any safety management system should closely monitor to ensure that best industry practice is achieved.

5.8. The safety management system for the *Hanjin Bombay* and its operating company did not succeed in ensuring that good crew resource management was a standard feature of on-board operations.

5.9. The master not using English, the official working language of the ship, when engaging with the chief engineer as the emergency unfolded was a serious breach of emergency management protocols that left the pilot and other bridge team members unaware of the issue they were dealing with. This breach contributed to the *Hanjin Bombay* grounding.

5.10. The grounding could have been prevented if the tugs had still been in attendance in a passive or active escort role.

5.11. Port of Tauranga Limited's risk assessment for its Ports and Harbours Safety Management system did not fully address the risk of departing vessels experiencing failure of propulsion and manoeuvring systems at critical locations in the entrance channel.

5.12. If the issues of mechanically unreliable vessels and substandard crew resource management on vessels operating in New Zealand ports are to be addressed, this will need to be done at a national level rather than individual ports dealing with the issues as they arise.

6. Safety actions

General

6.1. The Commission classifies safety actions by 2 types:

(a) safety actions taken by the regulator or an operator to address safety issues identified by the Commission during an inquiry that would otherwise result in the Commission issuing a recommendation

(b) safety actions taken by the regulator or an operator to address other safety issues that would not normally result in the Commission issuing a recommendation.

Safety actions addressing safety issues identified during an inquiry

6.2. Since the accident Port of Tauranga Limited has reviewed its Pilot's Standard Operating Procedures and a section has been inserted that covers the objectives, considerations and general information on escort towing as shown below:

Tug Escorting Objectives

- To reduce the risk of pollution in the port of Tauranga approaches due to groundings or collisions caused by technical or human failures on board a vessel.
- To apply steering and braking forces to a disabled vessel using escorting tugs to limit the impact of collision or grounding.
- Provide tug assistance to vessels with limited manoeuvrability.

Tug Escort Considerations

Factors to be considered in determining a tug escort requirement may include but [are] not limited to:

- Vessel history (e.g. previous piloting experience, advised engineering deficiencies, first time port call, etc)
- Age of vessel (e.g. a vessel more than 25 years old)
- Manoeuvrability characteristics (e.g. twin-screw/single rudder, directional stability, etc.)
- Vessel length, draft and under-keel clearance (e.g. deep draft coal vessel)
- Visibility (e.g. reduced or chance of reduced visibility during pilotage)
- Wind (e.g. high sided vessel)
- Tide and current

The pilot should check the Harbour Management System for a vessel's history remarks during passage planning.

Following a pilotage, the pilot should update the vessel's history remarks if required.

Vessel Speed when Escorting

A vessel being escorted should proceed at a speed appropriate to the prevailing operational circumstances and the tug's capabilities.

The pilot should consider:

- The ability of the tugs to overtake the escorted vessel in an emergency.
- The requirement for the safe handling of the tugs around the escorted vessel.
- The vessel's speed through the water determines the escort tug's effectiveness and not speed over ground.

Tug Availability and Tug Standby

Tugs are on standby at the tug berth 30 minutes prior to a vessel movement.

Pilots should consider the tugs' response time from the standby position to the time when the tugs could be effective. Tug line securing time should also be considered.

Pilots should also consider other shipping movements and tug escort requirements when passage planning.

- Inbound Vessels

Prior to, or when passing ‘A’ Beacon, the pilot will pass the instruction via [very high frequency] VHF CH 12 for the tugs’ rendezvous position if required, e.g. “Tugs standby at Tanea”.

- Outbound Vessels

The pilot will ask the tugs to continue standby with an instruction “to monitor VHF Channel 12 until clear” and/or to “follow the vessel to a nominated position”.

Tug Escorting Modes

During passage planning or as determined by the Pilot/Master exchange, the pilot may determine if a passive (no line) or an active (secure line) tug escort(s) precaution is required.

- Passive Escorting

  No line secured and the tug(s) escorts the vessel as required by the pilot.

  Tugs are placed in a standby position for immediate use in the event of an emergency onboard the escorted vessel and where the escort tug is required to provide assistance.

- Active Escorting

  The tug’s line is secured to the vessel centre-lead aft or as required by the pilot.

  A tug used for active escorting may be used to:

  - Take the way off a vessel
  - Turn a vessel
  - Counter a steering sheer

When using tugs for active escorting, the tugs’ characteristics must be taken into consideration.

Further guidance can be found in “Tug Use in Port” by Captain Henk Hensen, FNI. The Nautical Institute. Second Edition. Chapter 9.

Vessel Maintenance Declaration

Due to the increased risk of vessel breakdown after Main-engine and/or Critical Auxiliary System maintenance vessels are required to complete a Vessel Maintenance Declaration prior to work being undertaken. The purpose of these declarations is to allow planning to be undertaken early by the Pilot before he/she boards the vessel.

Vessel Maintenance Declarations will be emailed to the CSC. Pilots shall undertake a risk assessment with regard to the work carried out. Risk mitigating measures must be considered and carried out as required. These measures may include

- Re-grading vessel i.e. making it an “A” departure
- Ensuring anchors are immediately ready for letting go and anchor parties fully briefed and on standby
- Piloting the vessel at the end of multiple vessel movements to ensure tugs can be available if required
- Engaging active or passive tug escorting

6.3. Since the accident Port of Tauranga Limited has begun to use the Ship Model Simulator at Port Ash in Australia for pilot training. Port Ash is a manned model simulator. This means that scaled models are used in a scaled pond to simulate life-sized vessels and their manoeuvring characteristics. A particular strength of this type of simulation is the ability to execute anchoring manoeuvres. This means that Port of Tauranga Limited’s pilots have the opportunity to practise emergency anchoring procedures and experience how vessels will react in these situations. Port Ash focuses on the use of anchors in much of its training and pilots come away from these courses with a heightened understanding and awareness of anchor use.

7. Recommendations

General

7.1. The Commission may issue, or give notice of, recommendations to any person or organisation that it considers the most appropriate to address the identified safety issues, depending on whether these safety issues are applicable to a single operator only or to the wider transport sector. In this case, recommendations have been issued to the Director of Maritime New Zealand, with notice of these recommendations given to [insert organisations].

7.2. In the interests of transport safety it is important that these recommendations are implemented without delay to help prevent similar accidents or incidents occurring in the future.

Recommendations

7.3. On 22 March 2013 the Commission made the following recommendations to the Director of Maritime New Zealand:

7.4. The number of defects that are causing incidents and accidents in New Zealand pilotage waters is of concern. It is an indication that New Zealand port and harbour authorities cannot totally rely on the International Safety Management system to ensure that vessels transiting New Zealand ports are operated safely and efficiently. Minor technical defects and human performance issues are often lead indicators of deeper systemic safety issues on board a vessel. If the issues of mechanically unreliable vessels and substandard crew resource management on vessels operating into New Zealand ports are to be addressed, this will need to be done at a national level rather than individual ports dealing with the issues as they arise.

The Commission recommends that the Director of Maritime New Zealand consult port and harbour authorities and the New Zealand Maritime Pilots Association to develop a formal system for port and harbour authority employees to report vessel defects and crew performance issues. The purpose of the system should be to make information immediately available to maritime employees who can use the information to improve the safety of pilotage operations at subsequent ports. The purpose of the system should not be to replace the mandatory reporting of accidents and incidents, but instead to disseminate that information in a timely fashion to prevent similar accidents and incidents in the immediate future. (004/13)

On 23 April 2013, the Chief Executive of Maritime New Zealand replied:

> *Maritime New Zealand has previously commented on the distribution of incident and accident notifications, and also on the monthly summaries, which are now posted on the Maritime New Zealand public website. TAIC was perhaps envisaging an arrangement whereby a pilot in one port who has a concern about a ship or becomes aware of an incident can immediately pass that information on to pilots and MNZ personnel at the next port of call so that appropriate action can be taken. Martime New Zealand understands that this is what already happens routinely and considers there is no need to formalise it. Maritime New Zealand's previous comment on this recommendations is set out below, and is reiterated in light of the above recommendation:*
>
> *MNZ has online report system in place – this facilitates the notification of information including vessel defects and crew performance issues. Te recent shift to a regional structure and the development of an intelligence and planning team has resulted in a more timely response to any information received. Furthermore, notifications received by MNZ are forwarded to the appropriate harbourmaster for their information as well as a monthly summary of all notifications. It is intended that these monthly summaries will in future be posted on MNZ's website making them more readily availably to Pilots,* ***[this is now the case]*** *Harbourmasters, Port Companies and any oter interested parties. Information sharing may also be supplemented by other available resources such as APCIS and Lloyds.*

7.5. Vessels' machinery installations and their control systems are complex, and regardless of how well maintained they are there will always remain the possibility that some part fails for some reason. For a vessel like the *Hanjin Bombay* that has only one propulsion system, the risk of losing control of the vessel caused by a single-point failure is higher than that for other vessels that have greater levels of redundancy built in to their propulsion and power-management systems. These types of vessel rely heavily on tug services when operating in confined pilotage waters.

Port of Tauranga Limited's Port and Harbour Safety system policy on the level of tug service did not adequately manage the risk of single-point failures leading to the loss of control of a vessel. This is a safety issue that could also be relevant to other New Zealand ports.

The Maritime Transport Act 1994 currently restricts the Director's powers to audit port operators. However, the Commission notes that the Marine Legislation Bill currently before Parliament will introduce a new Part 3A to the Maritime Transport Act, which will provide clear authority for the Director to take action in relation to port operations.

The Commission recommends that, once the Marine Legislation Bill has been enacted and the new Part 3A of the Maritime Transport Act is in force, the Director address this safety issue with all port authorities, including Port of Tauranga Limited, when approving and auditing Port and Harbour Safety Management Systems. (005/13)

On 23 April 2013, the Chief Executive of Maritime New Zealand replied:

> *MNZ already does raise such matters with all port and harbourmasters when approving and auditing port and harbour safety management systems (SMS's) under the voluntary New Zealand Port and Harbour Marine Safety Code (the Code). Maritime New Zealand will continue to do this.*
>
> *The Code places responsibility on individual port companies and councils for preparing risk assessments and reviewing them on a regular basis, and for mitigating any risks identified in accordance with recognised risk management frameworks.*
>
> *The amendments to the Maritime Transport Act will include provisions for the Minister to make rules prescribing standards for port and harbour safety and for the Director to impose conditions on the use and operation of any commercial port. These are intended to be reserve powers for use where there are significant safety, or environmental, issues.*

8. Key lessons

8.1. Vessel crews must have a thorough knowledge of their vessels' operating systems if they are to deal effectively with abnormal situations.

8.2. The concept of crew resource management must extend to all operational areas on a vessel, and in particular must result in a common understanding of the voyage plan and good communication between bridge and engine room.

8.3. The level of tug assistance given to vessels when transiting narrow channels needs to be commensurate with the level of risk and should be decided on the basis of reducing the risk to as low as reasonably practicable.

8.4. Shipboard operations must be conducted using an agreed common language that everyone can understand. Crew members lapsing into their native tongue during an emergency is a breakdown in communication that can seriously hinder any response to deal with the emergency.

9. Citations

Government of New Zealand. (2009). *New Zealand Nautical Almanac 2009-10.* Wellington: Land Information New Zealand.

Transport Accident Investigation Commission. (2000). *00-204, refrigerated cargo carrier* Caribic*, grounding, Tauranga, 7 May 2000.* Wellington: Transport Accident Investigation Commission.

Appendix 1: Details of the examination and tests carried out on the equipment and systems on-board the *Hanjin Bombay*

A.1.1. The 3-way control valve for the main engine jacket-cooling fresh water was removed from the system and taken to the vessel's on-board workshop for disassembly and inspection. The results of that inspection are shown below. Numbers in the text refer to the part numbers highlighted in Figure A1-1: Diagram of 3-way control valve for main engine jacket-cooling fresh water.

- The lower bend (2) was removed and the stainless valve trim was found to be in good condition.
- There was no evidence of wear in the lower bushes (13b) or any signs of binding.
- There was no sign of wear in the lower valve spindle (7) or scale build-up present.
- The upper valve spindle (7) was initially sighted through the cooler bypass inlet (B), where a small amount of scale build-up on one side of the spindle was evident; this did not affect the operation of the valve.
- The valve seat (8) for the cooler inlet (C) was examined and found to be in good condition; the valve was then lowered by hand into the cooler bypass position and the bypass valve seat (9) examined and found to be in good condition. The valve head (7) was also examined and found to be in good condition.
- The play at the end of the valve spindle (7) was checked with a dial test indicator and a reading of about 1 mm was obtained.
- The return spring (19) was sighted and found to be in good condition with no signs of corrosion.
- The diaphragm (25) was opened for inspection, and the rubber was found to be in good condition with no signs of air leakage.

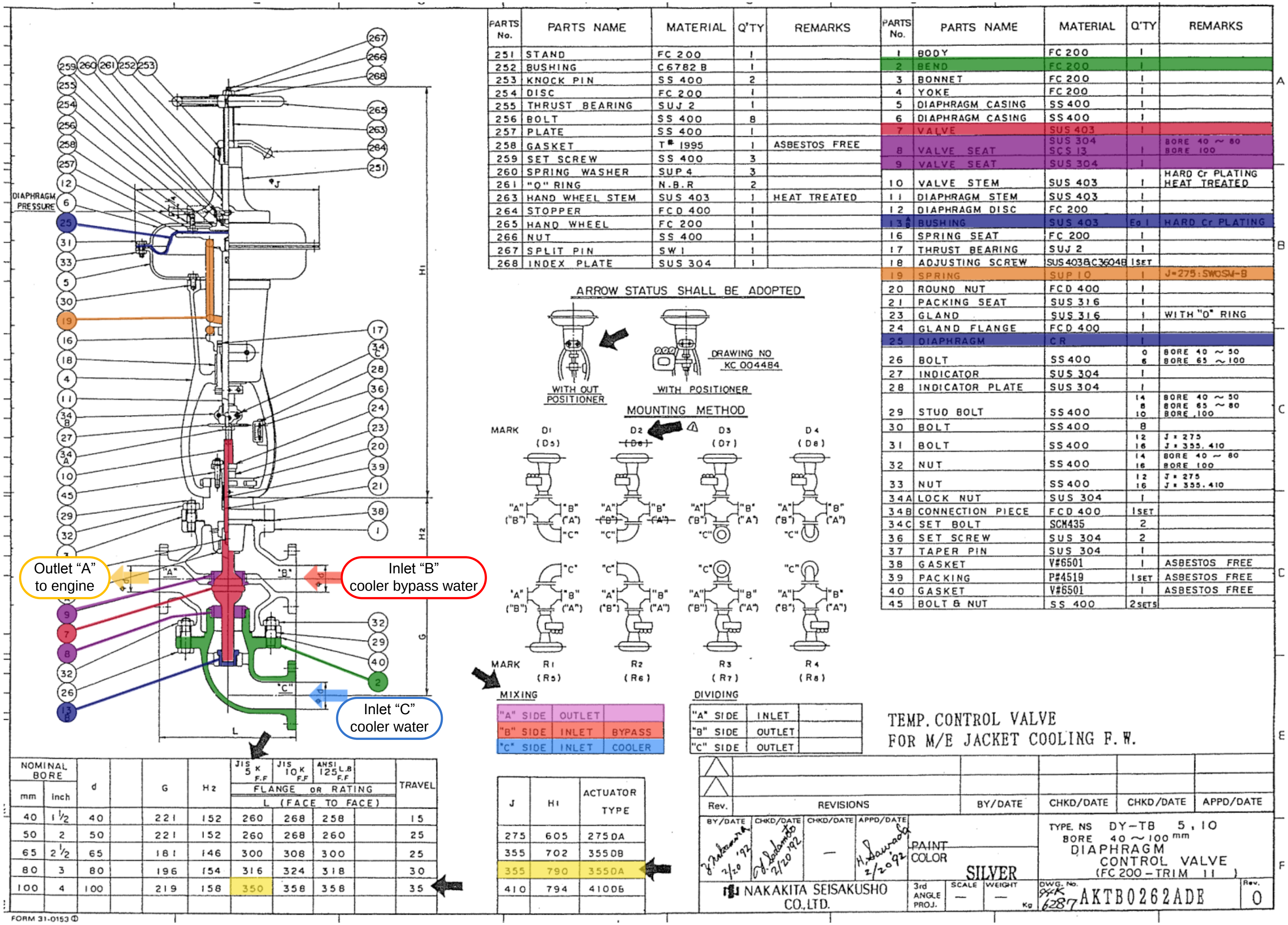
A.1.2. The 3-way valve was then reassembled using manufacturer-supplied spares where appropriate, and the operation of the 3-way valve tested under simulated conditions.

A.1.3. The automatic controller for the 3-way valve was examined, and the alarm limits checked.

- The high-temperature alarm for the jacket-cooling water was set at 90°C.
- The temperature for the automatic slowdown of the main engine was set at 90°C.
- The temperature for the automatic shutdown of the main engine was set at 95°C.
- The manufacturer's standard temperature setting for the 3-way valve to commence operating was 80°C.

A.1.4. The 3-way valve supply and return pneumatic pressures were checked during simulated operation cycles. With the valve indicator showing fully open in the bypass condition, the supply pressure was 1.4 kilograms per square centimetre (137.3 kilopascals) and the output pressure was 1.4 kilograms per square centimetre (137.3 kilopascals). With the valve indicator showing fully open in the cooler position, the supply pressure was 1.4 kilograms per square centimetre (137.3 kilopascals) and the output pressure was 0.13 kilograms per square centimetre (12.749 kilopascals).

A.1.5. The filter regulator for the automatic controller complete with the air supply pressure gauge was checked and a new pressure gauge was fitted. The pressure gauge at the time of the incident was showing 1.4 kilograms force per square centimetre (137.3 kilopascals). The new pressure gauge showed a reading of 0.9 bar (90 kilopascals) and the air supply pressure was increased to 1.4 bar (140 kilopascals).



PARTS No.	PARTS NAME	MATERIAL	Q'TY	REMARKS
251	STAND	FC 200	1	
252	BUSHING	C 6782 B	1	
253	KNOCK PIN	SS 400	2	
254	DISC	FC 200	1	
255	THRUST BEARING	SUJ 2	1	
256	BOLT	SS 400	8	
257	PLATE	SS 400	1	
258	GASKET	T# 1995	1	ASBESTOS FREE
259	SET SCREW	SS 400	3	
260	SPRING WASHER	SUP 4	3	
261	"O" RING	N.B.R	2	
263	HAND WHEEL STEM	SUS 403	1	HEAT TREATED
264	STOPPER	FCD 400	1	
265	HAND WHEEL	FC 200	1	
266	NUT	SS 400	1	
267	SPLIT PIN	SW 1	1	
268	INDEX PLATE	SUS 304	1	

PARTS No.	PARTS NAME	MATERIAL	Q'TY	REMARKS
1	BODY	FC 200	1	
2	BEND	FC 200	1	
3	BONNET	FC 200	1	
4	YOKE	FC 200	1	
5	DIAPHRAGM CASING	SS 400	1	
6	DIAPHRAGM CASING	SS 400	1	
7	VALVE	SUS 403	1	
8	VALVE SEAT	SUS 304 SCS 13	1	BORE 40 ~ 80 BORE 100
9	VALVE SEAT	SUS 304	1	
10	VALVE STEM	SUS 403	1	HARD Cr PLATING HEAT TREATED
11	DIAPHRAGM STEM	SUS 403	1	
12	DIAPHRAGM DISC	FC 200	1	
13 A B	BUSHING	SUS 403	Ea 1	HARD Cr PLATING
16	SPRING SEAT	FC 200	1	
17	THRUST BEARING	SUJ 2	1	
18	ADJUSTING SCREW	SUS 403 & C3604B	1 SET	
19	SPRING	SUP 10	1	J=275:SWOSM-B
20	ROUND NUT	FCD 400	1	
21	PACKING SEAT	SUS 316	1	
23	GLAND	SUS 316	1	WITH "O" RING
24	GLAND FLANGE	FCD 400	1	
25	DIAPHRAGM	CR	1	
26	BOLT	SS 400	0 6	BORE 40 ~ 50 BORE 65 ~ 100
27	INDICATOR	SUS 304	1	
28	INDICATOR PLATE	SUS 304	1	
29	STUD BOLT	SS 400	14 8 10	BORE 40 ~ 50 BORE 65 ~ 80 BORE 100
30	BOLT	SS 400	8	
31	BOLT	SS 400	12 16	J = 275 J = 355, 410
32	NUT	SS 400	14 16	BORE 40 ~ 80 BORE 100
33	NUT	SS 400	12 16	J = 275 J = 355, 410
34A	LOCK NUT	SUS 304	1	
34B	CONNECTION PIECE	FCD 400	1 SET	
34C	SET BOLT	SCM435	2	
36	SET SCREW	SUS 304	2	
37	TAPER PIN	SUS 304	1	
38	GASKET	V#6501	1	ASBESTOS FREE
39	PACKING	P#4519	1 SET	ASBESTOS FREE
40	GASKET	V#6501	1	ASBESTOS FREE
45	BOLT & NUT	SS 400	2 SETS	

MIXING

"A" SIDE	OUTLET	
"B" SIDE	INLET	BYPASS
"C" SIDE	INLET	COOLER

DIVIDING

"A" SIDE	INLET	
"B" SIDE	OUTLET	
"C" SIDE	OUTLET	

NOMINAL BORE		d		G	H2	JIS 5K F.F	JIS 10K F.F	ANSI 125 L.B F.F		TRAVEL
						FLANGE OR RATING				
mm	inch					L (FACE TO FACE)				
40	1 1/2	40		221	152	260	268	258		15
50	2	50		221	152	260	268	260		25
65	2 1/2	65		181	146	300	308	300		25
80	3	80		196	154	316	324	318		30
100	4	100		219	158	350	358	358		35

FORM 31-0153 ①

J	H1	ACTUATOR TYPE
275	605	275DA
355	702	355DB
355	790	355DA
410	794	410DB

TEMP. CONTROL VALVE
FOR M/E JACKET COOLING F. W.

Rev.	REVISIONS	BY/DATE	CHKD/DATE	CHKD/DATE	APPD/DATE
△					
△					

BY/DATE	CHKD/DATE	CHKD/DATE	APPD/DATE
Y. Nakamura 2/20 '92	Y. Sadamoto 2/20 '92	—	H. Sawada 2/20 '92

PAINT COLOR SILVER

TYPE. NS DY-TB 5, 10
BORE 40 ~ 100 mm
DIAPHRAGM
CONTROL VALVE
(FC 200 - TRIM 11)

NAKAKITA SEISAKUSHO
CO., LTD.

3rd ANGLE PROJ.
SCALE —
WEIGHT — Kg
DWG. No. 94K 6287 AKTB0262ADE
Rev. 0

Figure A1-1
Diagram of 3-way control valve for main engine jacket-cooling fresh water

Figure A1-2
View into 3-way valve through bypass inlet showing detritus build-up and “clean” valve stem

Figure A1-3
Photograph of spring showing condition on disassembly

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