CONTENTS

Summary

The Australian registered tanker Australian Achiever, of 127,575 tonnes summer deadweight, cleared the New Zealand port of Whangarei for the port of Brisbane at 2030 on 7 November 1992. The ship had part discharged and retained on board about 35,000 tonnes of crude oil.

At 2230, the exhaust gas uptake high temperature alarm sounded and the temperature reading was seen to be 10 degrees Celsius above the alarm setting. The engine was slowed to reduce the temperature and the waste-heat unit was inspected for hot spots. None were found and the engine speed was increased at 2345.

At 0115 on 8 November, when about 11 miles from the nearest land, the exhaust gas alarm sounded again and the main engine revolutions were reduced. A further inspection of the waste-heat unit revealed a small area glowing red at the forward, inboard corner. The main engine was stopped and the crew were alerted.

The fire within the waste-heat unit could not be fought directly and the main fire fighting effort concentrated on boundary cooling. After fire burnt a hole through the casing, several portable CO^2 extinguishers were discharged into the unit through the hole, without effect.

The ship's engineers initiated the proper established procedures and stopped the engine. Although the weather was favourable and the current tended to take the ship offshore, given the proximity of the land and the nature of the cargo, the Master requested that a tug be made available to tow the vessel back to Whangarei.

The fire in the waste-heat unit had reached such an intensity that areas of the generating section's steel tube banks, and a small section of the steel casing reached fusion temperature with resulting meltdown of the materials.

At daybreak, the crew prepared for the tow by hanging off the starboard anchor and ranging the anchor cable. A tug arrived at 0955 and the tow was connected at 1132. By 2100, the ship had been brought safely to harbour and it subsequently anchored in Bream Bay.

The fire was contained throughout 8 November and into 9 November by boundary cooling. It was extinguished by 1515 on 9 November, but it was considered prudent not to open up the unit until the area had cooled further. In all the fire burnt for some 39 hours.

Officers of New Zealand's Ministry of Transport, Maritime Transport Division, were appointed by the Inspector to undertake an initial investigation on behalf of the Australian Department of Transport and Communications.

Sources of information

Information was obtained from:

The New Zealand Ministry of Transport, Maritime Transport Division;
The Master and members of the crew of Australian Achiever;
ASP Ship Management;
MAN B&W, Copenhagen;

Time

Australian Achiever maintained New Zealand local time (UTC +13) while at Whangarei. The clocks were retarded one hour at 0100 hours local New Zealand time to zone time UTC + 12. For the purposes of this report all times are given in UTC +12 time zone.

Terminology

The fire occurred in the ship's waste-heat boiler, which is built into the main engine exhaust trunking. The waste-heat boiler is known by a variety of names. For the purposes of this report the waste-heat boiler will be referred to as the waste-heat unit, to prevent confusion with the auxiliary boilers, which are the main steam generating plant on board the ship.

AUSTRALIAN ACHIEVER

Australian Achiever was built in 1983, by Swan Hunter Ship Builders Ltd, at Newcastle on Tyne, in the north-east England, for BP Thames Tanker Co. Ltd (UK). It was handed over to BP Australia Ltd in July 1983 on a long-term charter. The vessel's name, formerly BP Achiever, was changed to Australian Achiever in 1991.

The ship is classed with Lloyd's Register as a 100 A1 oil tanker, equipped to operate with an unattended machinery space. It is also equipped with inert gas, crude oil washing and segregated ballast tanks, conforming to the International Convention for the Prevention of Pollution from Ships 1973, as amended by the Protocol of 1978.

Australian Achiever is 261.18m in length, with a beam of 39.6m and a depth of 23.1m. The ship has a deadweight of 127,575 tonnes at a summer draught of 17.316m and has 13 cargo tanks. It is powered by a five cylinder long-stroke diesel engine generating 11,953kW, driving a single shaft and propeller, capable of driving the ship at 13.5 knots when loaded.

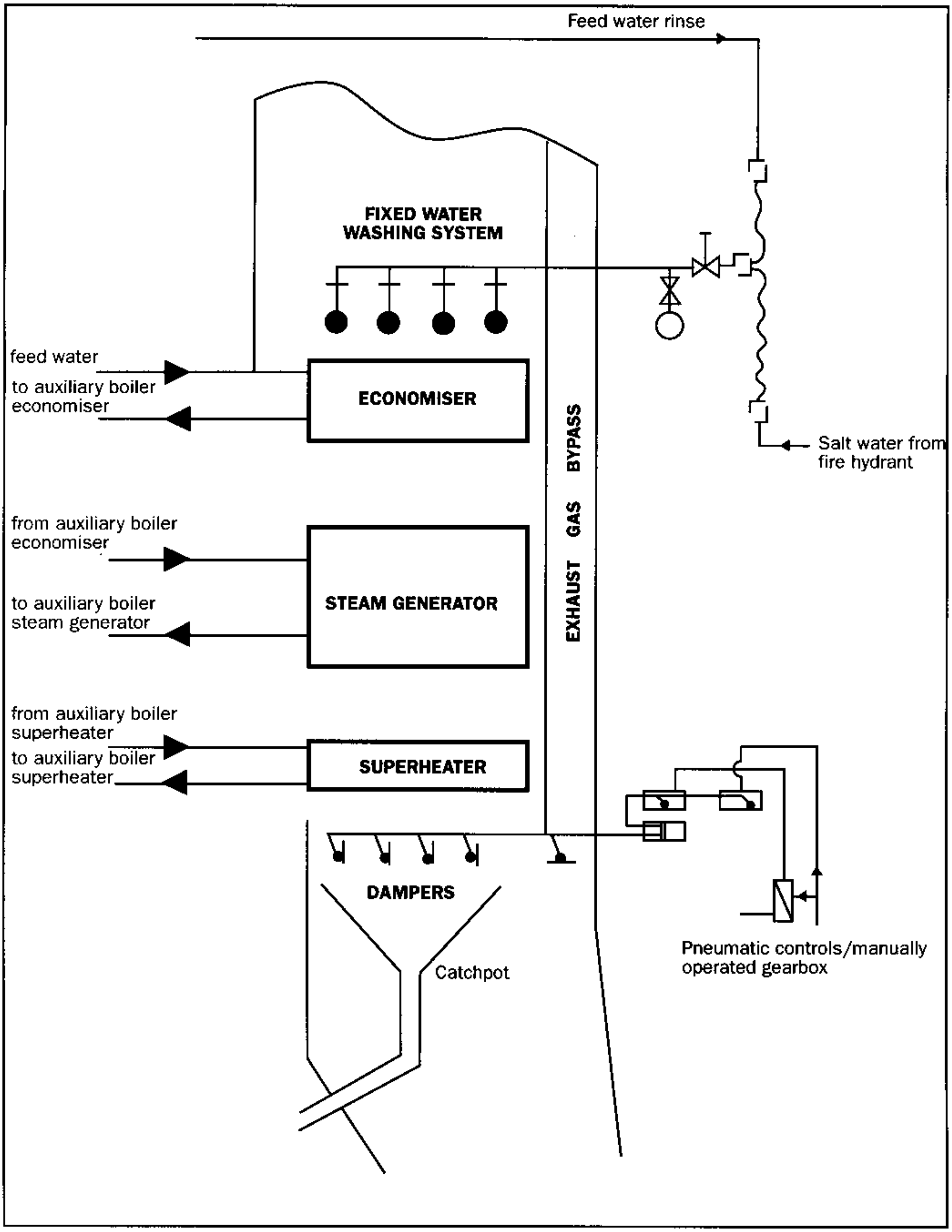
The ship's generators cargo and ballast pump prime movers are driven by steam generated by auxilliary boilers and the waste-heat unit.

To gain maximum efficiency from the main engine fuel, the engine exhaust gases are passed through a waste-heat unit. The engine exhaust gas cools as it rises through the unit, giving up its heat to the banks of tubes, and heating the water and steam within the tubes. The tubes have vertical fins to increase their surface area and maximise the efficiency of the heat exchange. The unit, a Green's Diesecon Steam Generator, is 4.257m in height, 4.53m long and 2.416m wide. It is on the starboard side of the engine room between frames 25 and 31.

Internally, the unit consisted of three separate sections of finned tube banks - the economiser, the steam generator and the superheater. Each bank, 3.352m in length and 1.948m in width, supplemented the equivalent units on the main auxiliary boiler by being a first stage heater for the water and steam within the system. The exhaust gas passed over the heating surfaces of the tube banks before passing to the atmosphere via the funnel. The waste-heat unit was fitted with an integral bypass that took the full flow of the exhaust gases. The elements of the unit acted as a silencer and to maintain this effect the bypass was fitted with baffles. Either the tubed sections or the bypass could be closed off by interlinked steel dampers, which were operated by pneumatic controls or alternatively by means of a manually operated gearbox.

The designed purpose of the pneumatic system was to automatically control the steam output, under varying engine load conditions, by setting the dampers to allow the requisite amount of exhaust gas to pass through the tube banks, to generate the required steam output.

The upper section of the waste-heat unit, the economiser, consisted of a bank of tubes arranged in a block of



Waste-Heat Unit Schematic Diagram

153 tubes 17 wide and nine high in a block about 0.737m in height. The unit was designed so that the engine exhaust gas passing through the economiser was about 190 degrees Celsius (C) on entry and at about 166 degrees C on exit. This section was designed to raise the feedwater temperature from 45 degrees Celsius to 173 degrees Celsius and circulate it back to the online auxiliary boiler steam drum via the boilers own separate economiser.

The economiser section of the waste-heat unit had been out of commission for about four to six years, because of leakage from a number of tubes affected by extensive wastage. The combined effects of "cold and corrosion" when the unit was in service, and "dew point" corrosion, during idle periods, had an adverse effect on the thickness of the tube walls.

The central bank of tubes was designated the steam generator and comprised a bank of 374 tubes, 17 wide and 22 high in a block about 1.93m in height. The generator section was designed for an exhaust gas inlet temperature of 312 degrees C and an exit temperature of 193 degrees C. Feedwater circulating through the generator section at a pressure of 7.5 bar, was returned to the online auxiliary boiler steam drum as a mixture of saturated steam and feedwater at a temperature of 173 degrees C.

The bottom bank, which was the superheater section, comprised of 30 tubes and was designed to receive saturated steam from the online auxiliary boiler steam drum at 7.5 bar pressure and at 173 degrees C, leaving the superheater bank at a superheat temperature of 250 degrees C at 7.28 bar pressure.

Engine exhaust gases contain carbon particles in the form of soot. In any waste-heat unit these are deposited on the tube surfaces during the passage of the exhaust gases through the tube banks, which initially reduces the efficiency of the heat transfer. However, under some operating conditions, if there are accumulated deposits of soot in the tube banks, there is a likelihood the soot might reach ignition temperature and result in a fire within the unit. It is recommended waste-heat units be cleaned of soot regularly.

The Australian Achiever waste-heat unit was originally designed to be water washed by a fixed system consisting of eight nozzles located above the economiser section. Water at a pressure of between 1.4 bar and 7 bar, was directed down over the tube banks to wash the tube surfaces clean and carry the soot away in the washing water to a collector tank. This system proved to be ineffective.

The waste-heat unit could not be washed while the engine was running. Given the length of voyages undertaken, typically 26 days, an Infraphone soot blower system was retrofitted, operated by air to clean the unit while the ship was under way. But this system also proved to be ineffective.

The only effective method of cleaning the unit was to water wash by hand. Access was gained to the waste-heat unit by a manhole above the economiser section. This was large enough to allow a man to enter and direct a water jet vertically down through the small gaps between the tubes and their associated fins. A manhole below the unit, let into the exhaust trunking directly below the interlocking dampers, gave access to the space immediately below the tube banks.

The water from the washing operation was prevented from running back down the exhaust trunking to the turbo blower by a "catch pot", a funnel arrangement beneath the unit, inside the exhaust trunking. This collected the water, which was drained to a collection tank. A salt water wash was followed by a distilled water wash to remove any residual salt deposits. The operation usually took about two hours.

As a general rule, the operation was undertaken where possible at every terminal load and discharge port, about every 26 days. In practice the cleanliness of the waste-heat unit was assessed on the temperature differential between the temperature of the gases entering the superheater unit and the exit temperature above the economiser unit. Differentials of 70 to 80 degrees C were taken to indicate satisfactory heat transfer and a relatively clean system. If the temperature differential dropped to 50 degrees C washing of the waste-heat unit was undertaken.

The owners issued instructions, which in relation to cleaning stated:

> *To maintain maximum efficiency and reduce the possibility of fire, it is essential that the heating surfaces of the W.H.B. are kept clean. The main causes of excessive soot deposits are cleaning of the Turbo-Blowers while in service, incorrect combustion of fuel, slow running and manoeuvring. As soon as possible after shut down, the heating surfaces should be examined, and, if deposits are found adhering to the finned element surfaces or there is any build up of debris, the unit should be washed. Heavy concentrations of deposits should be removed by local washing and a soot releasing agent of anhydrous sodium carbonate (NA2CO3 Soda Ash) should be used in conjunction with the water.*

The remainder of the instructions dealt with the preparation for washing and the operational procedures involving the fixed system, including rinsing the waste-heat unit with distilled water.

The makers, Senior Green Limited, issued more detailed instructions on the operation and cleaning of the waste-heat unit. The manual stated:

> *To maintain maximum efficiency it is essential that the heating surfaces of the Diesecon are kept clean. Under ideal conditions deposits are unlikely to adhere to the element heating surfaces but deposit build up may be caused in several ways resulting not only in reducing efficiency but the possibility of fire.*

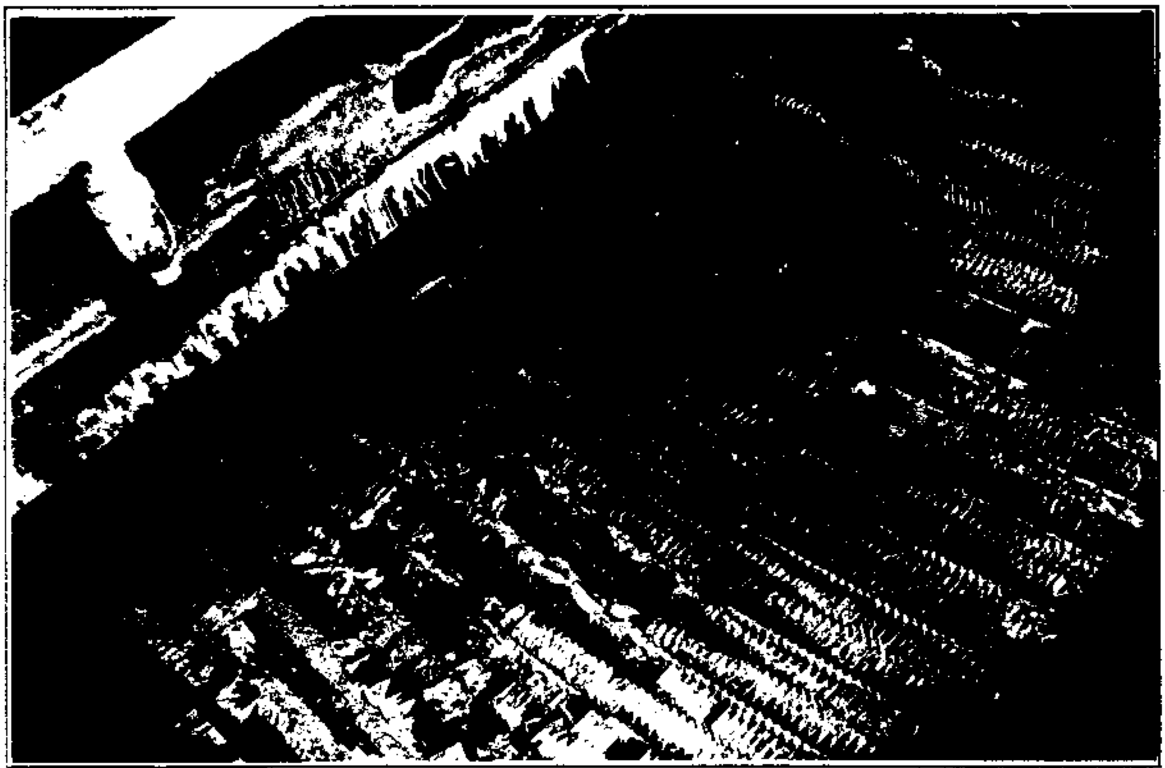
The Green's instructions contained also a section on how to deal with fires within the unit, particularly their prevention, detection and the emergency action to take. The instructions recommend that:

> *A ship procedure should be established for dealing with soot fires and training arranged to ensure that all aspects of the procedure can be carried out quickly and effectively.*

These instructions were augmented by a six page document "Information on Sootfires in Waste-heat Boilers and Economiser." This document states that:

> *Sootfires are minor in the initial stages and may burn for long periods without causing damage. However, if the water circulation to the heat exchanges is stopped, the combustion of soot can rapidly develop into an intense fire.*
>
> *Visual inspections and water washing are the only certain ways to keep tubes clean.*
>
> *SOOTFIRES CANNOT OCCUR IN A HEAT EXCHANGER WHICH IS FREE OF SOOT DEPOSITS.*
>
> *IF THE BOILER IS NOT BEING CIRCULATED WITH WATER, THE BURNING DEPOSITS CAN CAUSE TUBE DAMAGE.*

The tube banks were removed from the waste-heat unit in January 1993 after the fire.



Fined tubes in waste-heat unit-economiser also showing fixed water system nozzle (top left)

Australian Achiever 2 November - 9 November

Australian Achiever, with a crew of 29, arrived at Marsden Point, Whangarei on Monday 2 November 1992, with a cargo of 125,000 tonnes of crude oil. It was to part discharge 90,000 tonnes of oil and carry the remainder (35,000 tonnes) to Brisbane. The ship was boarded by officers from New Zealand's Ministry of Transport, Maritime Transport Division, and all certificates, including the qualifications of the officers and crew, were checked and found to be in order.

When the part cargo discharge to the Whangarei terminal was completed, Australian Achiever was moved to a lay-up location to carry out repairs to the aft bulkhead of the port oil fuel bunker tank. The engineers took the opportunity to overhaul two cylinders and renew the rings on the respective pistons. The waste-heat unit was water washed also.

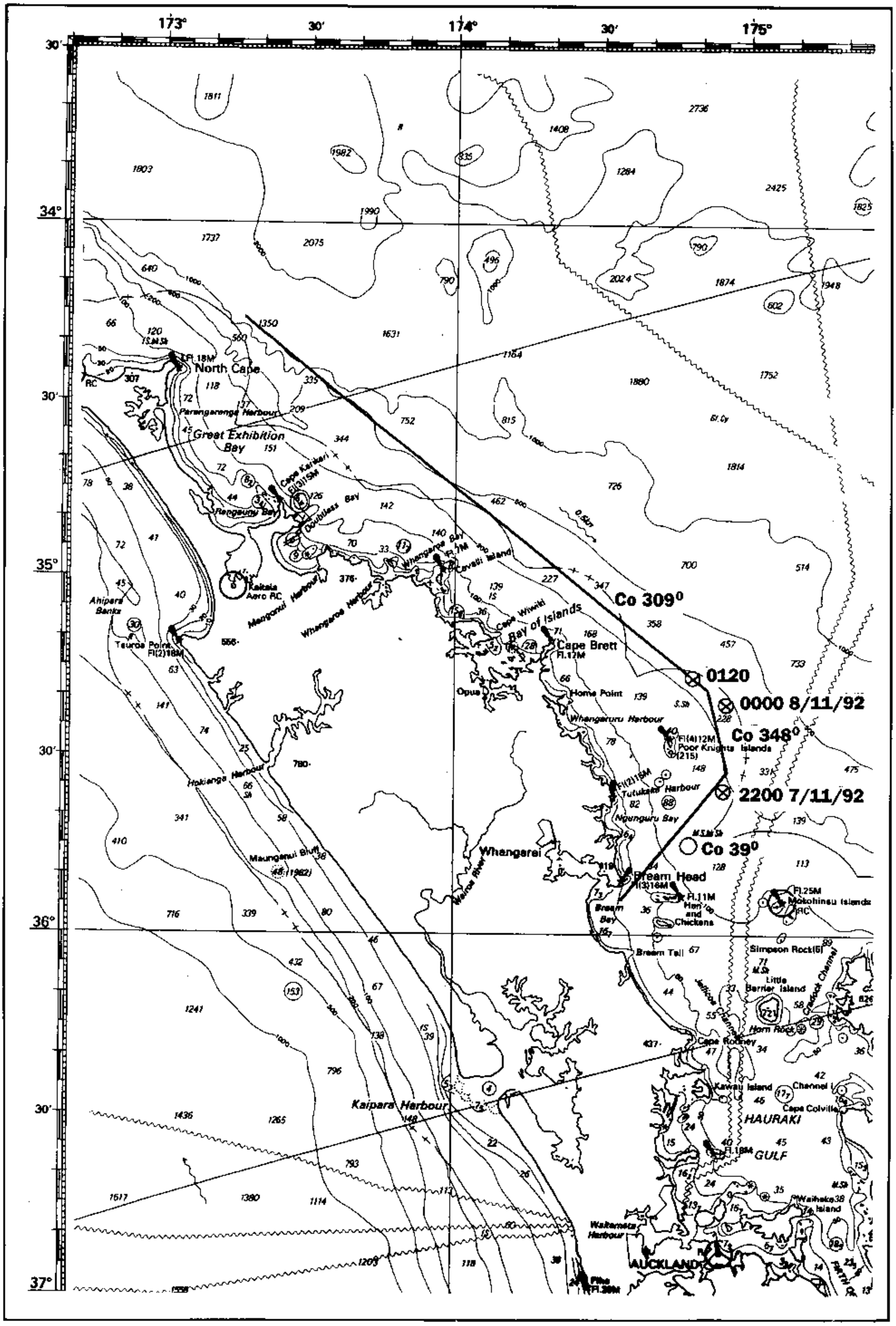
The Second Engineer supervised the washing of the waste-heat unit, he tested the unit for safe entry and issued the necessary entry permit. He instructed two engine room ratings on the cleaning operation and ensured that they were properly attired to carry out the task. Before the washing, he had inspected the inside of the exhaust casing above the waste-heat unit and found a relatively light coating of soot, nothing that would suggest the waste-heat boiler was unduly dirty.

One rating entered the unit above the economiser tubes and, standing on the top-most layer of tubes, used a normal fire hose and jet nozzle to direct a sea water jet under normal hydrant pressure, vertically down through the tubes to remove the soot. The soot removing agent of soda ash was not used in the washing process. When the waste water ran clear, the hose was connected to the feed water outlet and the whole unit was washed with distilled water to remove remaining salt deposits. After about two hours washing, during which a single hose was estimated to have delivered about 5 cubic metres of water, the waste-heat unit was assessed to be clean.

The man hole at the top of the economiser was secured.

Shortly after arrival at Whangarei on 2 November, water had been found leaking from one of the tube banks in the generating section of the waste-heat unit. Attempts to detect the leak were unsuccessful, therefore it was decided to carry on to Brisbane, running the waste-heat unit dry, with the exhaust gases passing to the funnel via the bypass duct in the waste-heat unit. Following water washing the interlinked dampers were set to their normal position for departure engine manoeuvers (i.e. "bypass" dampers open, tube bank dampers shut). It was intended to make the passage to Brisbane with the dampers in these positions.

The dampers were set to position by means of the alternative manually operated geared system, in lieu of the



Extract from Chart NZ 23
New Zealand North Island

pneumatic system, which had been out of service for about a month because of a defect in the control system.

The repairs to the fuel tanks were completed in the afternoon of 7 November and the vessel sailed that evening, at 1924.

The vessel cleared Whangarei Harbour and commenced passage at 2030 on 7 November, bound for Brisbane.

The Master set a course of 039 degrees true to pass about nine miles west of Poor Knights Island, before setting course to pass to the north of the North Island and then to Brisbane.

At 2220, the exhaust gas uptake "temperature high" alarm sounded and at 2230, the Chief Engineer reported to the bridge that the temperature reading was 10 degrees C above the alarm temperature of 380 degrees C. The engine speed was reduced to a propeller speed of 40 revs/min and the outside of the waste-heat unit casing was inspected for local hot spots, none were found. At 2345, with the temperature in the waste-heat unit reduced the main engine revolutions were increased to 60 revs/min.

One and a half hours later, at 0115 on 8 November, the exhaust gas uptake "temperature high" alarm sounded again and the main engine speed was again reduced to a propeller speed of 40 revs/min. An inspection of the waste-heat unit revealed a small area of the unit's casing glowing red hot at the forward, inboard bottom corner. The main engine was stopped and the Diesecon instructions in the event of a fire were followed. At 0120, the ship's position was fixed with Poor Knights Island bearing 199 degrees by 10.9 miles, and at 0125 the Master ordered the bridge and engine room watches to be doubled up.

At 0130, on the Chief Engineer's advice, the Master sounded the fire alarms and the crew was mustered at fire stations. At this time the turbo blower air intake was blocked off with canvass.

At 0135, the fire parties entered the engine room and by 0140 boundary cooling of the waste-heat unit had began. By 0148, six hoses were in operation, cooling the casing of the waste-heat unit. A message outlining the emergency was sent by the Master to Auckland Radio.

At 0200, the Master received a report from the Chief Mate, that the fire was inside the waste-heat unit, which had been isolated, and that soot inside the unit was on fire. The casing of the waste-heat unit was glowing in places and that eight hoses were used to cool the unit from all sides. The ship's managers were informed of the situation.

At 0215, the Master requested, through Auckland Radio, that tugs be sent to take the ship under tow to return to Whangarei and, shortly after, the Maritime Rescue Coordination Centre, Canberra, was informed.

As the fire developed, the intense heat burnt a hole in the forward inboard side of the waste-heat unit casing. At 0230, a number of small portable extinguishers CO_2 were discharged into the unit, through this hole, but without any apparent effect.

Because of the boundary cooling, water was accumulating in the ship's engine room bilge. It was necessary to discharge the water build up at such a rate that it was not practicable to pass it through the oily water separator. The bilge water was pumped direct to the sea and to No 5 port tank. Auckland Radio was informed that bilge water was to be pumped direct to the sea and that there was a possibility of pollution.

At 0330 on 8 November, the ship was in a position with Poor Knights Island light bearing 193 degrees by 11.4 miles. The Chief Engineer reported to the Master that the intensity of the fire had diminished and the fire was being controlled by a fine water spray directed on the waste-heat unit casing to cool the boundaries of the fire.

At daylight (0530), three oil slicks, the largest being 80m x 30m, could be seen close by the ship. These were not heavy slicks, but a light sheen caused by a small amount of oil carried over in the bilge water. These sheens disappeared without leading to any pollution problems.

At 0645, the crew began to prepare for the tow to Whangarei by hanging off the starboard anchor and breaking the cable to make a towage connection for the tug, which was expected at 1030.

The tug Reinga arrived at the ship at 0955. At 1132, the tug's towing wire was connected to the ship's anchor cable. At 1200, with Poor Knights Island light bearing 202 degrees by 8.8 miles, the Reinga commenced the tow to Bream Bay off Whangarei Harbour.

During this time boundary cooling around the waste-heat unit continued, using four hoses. At 1230, a section of the waste-heat unit (steam generator section) collapsed on the superheater section.

The boundary cooling resulted in water damage and destruction of electrical contacts, switches and motors, without which the effective operation of the ship was not possible. The ship's crew did not include a specialist electrician and the engineering staff were fully occupied with the fire and maintaining services within the ship. An electrician was, therefore, sent from the shore by helicopter, arriving at 1530, to assist with the ship's electrical problems.

At 1600 on 8 November, the engine room fire party was able to reduce boundary cooling to two hoses using light sprays over the outside of the casing.

By 2000, the tug, with Australian Achiever in tow, approached the fairway buoy off Whangarei Harbour. At 2053, the tow line was released and at 2104 Australian Achiever anchored south-east of the fairway buoy in Bream Bay.

Boundary cooling of the waste-heat unit continued through the night and into the next day.

At 1515 on 9 November, the fire was judged to have been extinguished. To avoid re-ignition, no attempt was made to open up the waste-heat unit for several hours.

When the waste-heat unit was opened up, it was found that the interlinked dampers, which should have isolated the tube banks, were partially open, leaving a 50mm gap through which the gas could pass. Also, the tube banks within the unit were severely damaged. There was a hole, about 500mm in diameter, in the lower inboard casing and a further hole in the casing at the point that the Infraphone piping entered. Severe damage had been caused to electrical motors and wiring in the vicinity of the unit by the salt water used in boundary cooling.

COMMENT

Concerns regarding soot fires in exhaust gas boilers and economisers seem to have been growing since about 1988. A number of manufacturers and technical organisations have issued reports drawing the attention of the shipping industry to an increase in the incidents of boiler damage, often as the result of soot fires.

The engine makers, MAN-B&W of Copenhagen, issued a service letter in April 1988, to all owners of vessels with its engines. The letter drew attention to the tendancy of soot fires in waste-heat boilers, outlined the factors and made recommendations for suitable counter measures.

No single cause was identified in the MAN-B&W letter, or in other reports, for the increase in the outbreak of fires. Rather, the increase in the risk seems to stem from a number of individual factors which, in combination, increase the risk of soot fires. These include:

1 A major shift, throughout the industry, to cheaper lower grade fuel oils, with greater carbon emissions

2 Long-stroke diesel engines, making more economic use of fuel, emit exhaust at lower temperatures, leaving heavier soot deposits

3 The presence of lubricating oil carry over or mist in the exhaust gases

4 Waste-heat units constructed to extract the maximum heat energy from the exhaust gases, with narrowly spaced finned tubes designed with a maximum surface area to effect heat transfer

5 Manoeuvring operations after time in harbour, when the tubes within the waste-heat unit are cool or cold.

These potential sources of risk were recognised by management and ship staff as being present in the operation of the Australian Achiever.

Fuel

Australian Achiever's engine is a B&W with a cylinder length of 2.18m. The engine was designed to run on heavy fuel oil of 380sec, although from time to time, where the 380sec fuel was not available, a higher grade of 180sec was used. The quality of the bunker fuel received by Australian Achiever and used during the voyage met with the specifications of the owner and engine builder. This was confirmed by a fuel analysis conducted on behalf of the operators. However, the heavy fuel oil used was of the type identified in the studies of fires in waste-heat units, which could, in conjunction with other factors, increase the risk of such fires.

Engine

Since the vessel was commissioned in 1983, a number of modifications had been undertaken on the engine to improve its operational reliability. This had been gained by sacrificing up to about 1300kW of power.

The modifications had been carried out by the owner on the recommendation of the engine builder. At normal modified operating power output of 10,665kW, the exhaust gas leaves the cylinders at between 370 degrees to 400 degrees C, the load/rpm/exhaust temperatures varying in accordance with the usual number of prevailing conditions such as wind and tide.

Operating the engines at these temperatures, the exhaust gas enters the waste-heat unit at close to the inlet design temperature of 320 degrees C. On passage from Ras Tanura, the inlet temperature varied from between 335 degrees C to 305 degrees C, and the exit temperature varied between 255 degrees and 238 degrees C. The average temperature differential throughout the voyage averaged 70.5 degrees C, and differential was never less than 60 degrees. At no time did the temperature above the econoniser section approach 380 degrees C, at which the exhaust uptake "temperature high" alarm was set.

Lubricating oil

At Whangarei, piston rings in two units had been renewed, and the lubricating oil to these two cylinders had been increased for the "bedding-in" period. This period, as recommended by the engine builder is 15 hours, which is the approximate time it takes for the new piston ring rubbing surfaces to "bed-in" to the cylinder walls. This increase in lubricating oil would have added to any lubricating oil carry-over or mist in the exhaust system.

All the reports relating to waste-heat unit fires stressed the need for ensuring that the units remained free from soot deposits. The MAN B&W service letter stated that "oil wetted soot" may ignite at temperatures as low as 150 degrees C.

Waste-heat unit

Protection against a soot fire depends on efficient cleaning of the water tubes within waste-heat units. Waste-heat units are purposely designed with narrowly spaced, finned tubes to extract the maximum heat from the exhaust gases.

The documents and waste-heat unit washing instructions provided to the Australian Achiever's staff referred almost exclusively to the fixed washing sprays, which were part of the integral design of the waste-heat unit. The fixed water spray system, fitted above the economiser section, was intended to clear the tubes of all sections of all soot deposits. The makers instructions indicate that this cleaning system could at times require supplementing by hand washing.

Both the maker's and owner's washing instructions referred to the use of soda ash in solution with the washing water when heavy concentrations of soot were present. However, it seems that soda ash had not been used in recent years, if at all on Australian Achiever. Those aboard knew of no way of introducing the solution either into the fixed system, which in any case was not working, or into the hand held hoses.

The owners had only issued instructions related to automatic washing. Both these and the maker's instructions were effectively nine years out of date and did not reflect the practical realities of operational life aboard ship. However, the procedures for manual washing and the criteria for when the washing needed to be done were known and understood by the senior engineers attached to the ship.

More recent designs of waste-heat units can be cleaned and even water washed with the engine "on load". Although contemporary industry advice is that some form of soot cleaning should be undertaken every six to eight hours, the unit, as originally fitted on board Australian Achiever, could only be used with the engine "off-load". The engine had therefore to be stopped and, because of the need to remove access plates on the unit and exhaust trunking for access and the washing process, the engine was effectively immobilised.

Although an infraphone soot blower was fitted retrospectively, it was found to be ineffective with this particular unit.

Since 1983, the waste-heat unit had to be washed manually, because the originally fitted fixed system was not able to effectively clear the tube surfaces of soot. Therefore, the unit was, as a general rule, water washed at every terminal load and discharge port where immobilisation of the ship was possible.

However, many ports will not permit ships to immobolise their engines when in an oil terminal. In Persian Gulf ports and a number of Australian and New Zealand ports, oil tankers are not permitted to immobilise their engines while alongside a loading or discharging berth, and vessels must be ready to move at a moments notice. Kwinana is one of the few ports that will allow a ship to immobilise its engines for repair. The only alternative in most cases is to stop the vessel at sea.

There was no record of the waste-heat unit having been washed in October at Ras Tanura in the Persian Gulf, the loading port for the Whangarei cargo of crude oil. The last occasion on which the Second Engineer could recall the waste-heat unit being washed was at Kwinana in September, when he recalled that the same two engine room ratings undertook the physical cleaning of the unit. It seems probable, therefore, that the unit had not been washed between early September and 4 November. However, the temperature differentials indicated no particular build up of soot and that the unit was working efficiently.

Manual washing of the waste-heat unit is a hot and unpleasant job. Under normal washing conditions, the tubes and trunking would retain a level of heat from the engine and the water jet on to the tubes would create unpleasant fumes and humidity. Further, because of the restricted spacing between the fins that are attached to the tubes, it is difficult to ensure that the washing is effective and that no build-up of soot deposits are lodged between the fins.

The ship staff confined its assessment of the effectiveness of the washing to the water quality draining to a small four tonne capacity tank. This tank, which acted as a weir to catch the soot from the washings, in turn drained to a 40 tonne capacity engine room holding tank. Therefore, provided the holding tank was reasonably empty, there should have been little limitation placed on the volume of water that could be used in washing.

The ability to gauge the effectiveness of the washing was limited. Given the compact nature of the tubes, the general design of the unit and the absence of an effective light source, it was not possible to see the surfaces being washed.

The makers, in their instructions, state that:

> *Inspection of the boiler heating surfaces whenever possible are essential. Use an inspection lamp to project light through the gas passages towards the viewer to ensure that the passages are clear and the deposit is not adhering to the element surfaces. If deposits are found they must be removed.*
>
> *... and a visual inspection should be made to ensure that all deposit has been removed.*

A number of inspection plates are fitted to the unit - one above the tube banks on the inboard side, one between the economiser and steam generator sections of the unit, one on each end at mid height and one below the unit in the exhaust trunking, allowing access to the catch-pot and the area below the interlinked dampers. The inspection plate between the economiser tube bank and the steam generator opened on to baffle plates with no view of the tubes. The plates at the forward and after end of the unit opened on to the tube ends.

Discussions with the ship's staff and an examination of the unit called into question the practicality of making a visual inspection of the unit in the manner described. Access to the unit to make such an inspection could only be made through the top manhole used by those washing the unit and the manhole below the unit in the exhaust trunking. The inspection door between the economiser and the steam generator did not provide easy access and it was difficult to access the exhaust trunk casing to look up.

Effective overall inspection of the unit under operational conditions, to ensure that the unit was clean, was not practical.

But, it should be acknowledged that the method of washing the waste-heat unit and assessing the soot build-up had proved generally effective over eight years of operation, although there was one small soot fire in the unit reported in 1984, and possibly one other. The lack of up-to-date instructions on manual washing is not considered to be a factor in this incident.

In the event, residual soot or soot partially washed downward and compacted, when brought to its ignition temperature caught fire.

Manoeuvring operations

Under normal operating procedures, the waste-heat unit remains on bypass during periods of manoeuvring and until such time as the engine has been worked up to and settled on its normal operating temperature.

Manoeuvring, which involves low engine loads, results in exhaust gases containing higher carbon concentrations. During the manoeuvring, shifting ship and sailing from Whangarei, unless the bypass dampers were partially open, it is unlikely that any significant amount of soot would have been deposited on the tube bank surfaces at those times.

Similarly, very little oil mist, particularly the extra oil introduced into the system as a result of the engine overhaul, should have entered the waste-heat unit if the dampers below the tube banks had been closed.

However, with the interlinked dampers isolating the tube banks open 50mm (either during each port manoeuvre or only when the ship sailed for Brisbane), both carbon deposits, oil mist and hot gases would have been fed into the tube banks.

Comment

Because of the leaking tube or tubes in the steam generator section of the waste-heat unit, it was decided that the waste-heat unit would be "run dry" for the voyage between Whangarei and Brisbane. This meant operating with the waste-heat bypass in operation, the tube banks isolated from the exhaust gases by the interlinked dampers, and the water to the generating tube bank isolated.

On the evidence available, the fuel that fed the fire in its initial stages was carbon, deposited in the forward inboard corner, at about mid-height of the steam generator tube bank. It is probable that a soot deposit remained after washing. The dampers, designed to direct the gases either through the tube banks or through the bypass, were not gas tight and a certain amount of leakage would normally be expected.

If, as seems probable, the dampers isolating the tube banks were open about 50mm, a significant volume of low velocity gas would have been directed over the tube surfaces, through which no water or steam was circulating, possibly adding further soot and oil mist. It should also be noted that there was no indicator at the manually operated gear box to indicate whether or not the dampers were closed or open.

The soot fire generated such intense temperatures inside the waste-heat unit that areas of the generating section tubing and a small section of steel reached fusion temperature with resulting melt-down of the materials.

The probable underlying causes of the fire can be attributed to a combination of factors including:

- The failure of the washing operation to remove all the soot, itself largely due to the design of the waste-heat unit

- The failure of the dampers to close beneath the tube banks allowing hot exhaust gases, initially gases emmited while manouuvring out of Whangarei Harbour

- The design of the unit.

Fire fighting

Ships do not carry appropriate equipment for fighting hydrogen-generating fires directly, and the only form of fire fighting available is the technique of boundary cooling, which prevents the spread of the fire and serves to lower the temperature inside the space so that sufficient heat is removed to extinguish the fire.

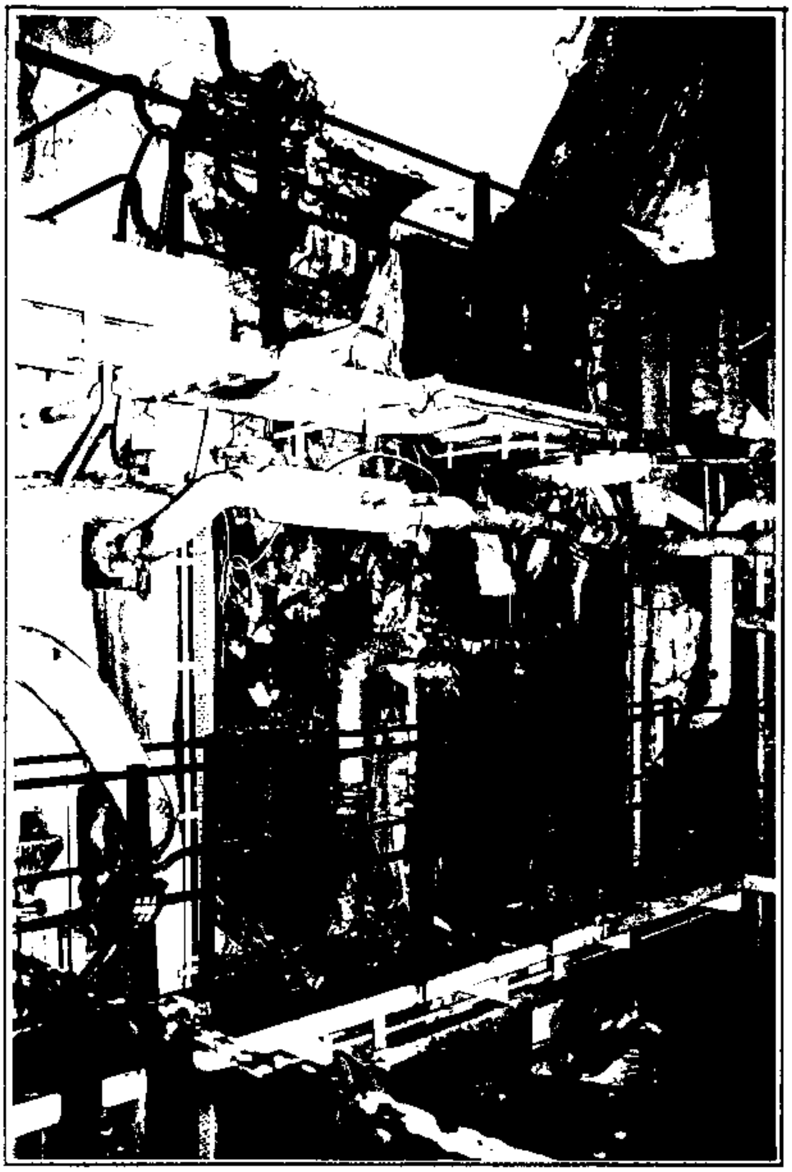
The Chief Engineer followed the Diesecon instructions with regard to stopping the engine, closing apertures and applying boundary cooling.

The crew employed the only method of combating the fire open to them. The fact that the fire lasted a matter of 39 hours, during which time some degree of boundary cooling was necessary, is no reflection on the effectiveness of their efforts. On the contrary it demonstrated good judgment and effective management of a prolonged operation.

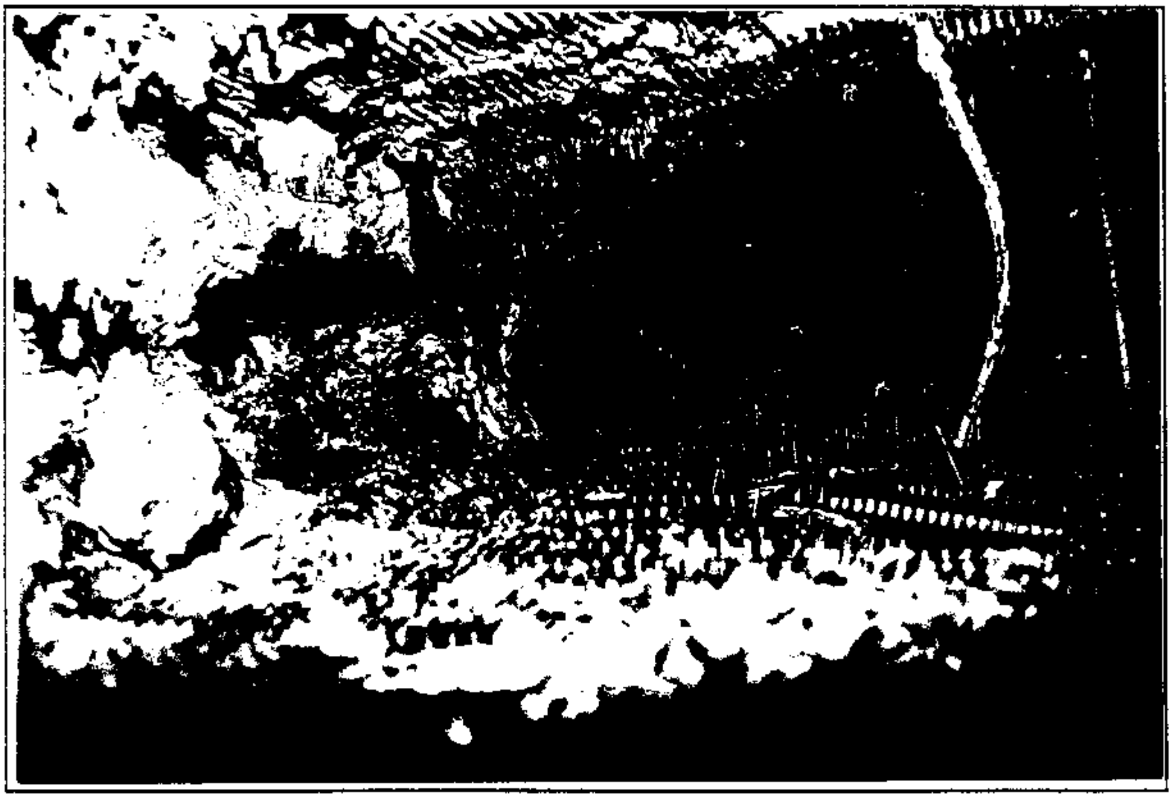
The fact that the fire was extinguished testifies to the effectiveness of the fire fighting and the organisation employed aboard. It is much to the credit of the Master, Chief Engineer and all on board that a more serious outcome did not eventuate.

A major problem was the accumulation of spent fire fighting water in the ship's engine room bilges. To prevent an unacceptable build-up of water to a level that could have affected machinery, it was necessary to pump some of the bilge water directly to the sea. The Master informed the New Zealand authorities of his action which, under the circumstances, the Inspector considers was unavoidable.

The Master took prompt action to inform the New Zealand authorities of the emergency and to ensure that tug assistance could be summoned.



Inboard side of Waste–Heat unit top and bottom manholes are visible



View in through lower door space between steam generator tube bank and superheater bank–showing tube meltdown

CONCLUSIONS

1 The fire occurred as a result of a combination of factors:

   (a) The washing process failed to remove all soot deposits

   (b) The dampers isolating the tube banks from the main stream of exhaust gas did not close properly, allowing hot low velocity gas to ignite the soot deposit

   (c) The lack of water circulating in the generating section may have contributed to the loss of the tubes, as there was no water to carry away the surface heat generated by the soot fire on the external surfaces of the tubes.

2 The original decision to isolate the waste-heat unit tube banks and run with the economiser dry was reasonable and not open to criticism

3 Design problems related to cleaning of waste-heat units have been known for some years, nevertheless, the unit had operated without a fire since about 1984. The importance of regular washing was well understood by the ship's staff and there was accepted criteria, based on inlet and exit exhaust gas temperatures, governing the necessity of washing the unit. But temperature differential would not indicate the presence of isolated areas of soot compaction.

4 There is no evidence that the failure to wash the unit at Ras Tanura resulted in excessive soot deposits. The only evidence is that sufficient soot remained or had compacted in one area after washing at Whagarei to cause a soot fire. However, the strong possibility that more soot than normal had accumulated can not be discounted.

5 Neither the maker's nor the owner's/operator's instructions reflected the reality of cleaning the waste-heat unit under operational conditions, but this deficiency is not considered to have contributed to the cause of the fire.

6 The actions taken by the Master to alert the New Zealand authorities and to place tug assistance on stand-by was timely and correct.

7 The actions taken by the Chief Engineer and the engine room staff in stopping the engine and blocking associated apertures was correct and in accordance with the makers instructions.

8 The fire fighting operation was efficient and effective, reflecting credit on the organisation of all the ship staff involved.

9 The Master's decision to pump the ship's bilges direct to the sea was a proper decision given the circumstances and priorities relating to Australian Achiever at that time.

ATTACHMENT

Particulars of ship

Name	Australian Achiever (ex BP Achiever)
Flag	Australian
Lloyd's No	7925730
Call Sign	VJEB
Type	Oil tanker
Owners	BP Australia Pty Ltd
Managers	ASP Ship Management
Classification society	Lloyd's Register (+100A1 oil tanker - +LMC - UMS &IGS - COW
Builders	Swan Hunter Ship Builders Ltd
Year Built	1983
Length	261.18m
Breadth	39.6m
Depth	23.1m
Summer draught	17.316m
Gross tonnage	66,031
Net Tonnage	41,316
Summer deadweight	127,575 tonnes
Engine	B&W
Engine power	11,953kW
Propeller	Single, fixed
Crew	29