

SECTION 8. MATERIEL STATE OF THE SHIP

DEFECTS

Urgent Defects (URDEFS)

8.1 On departure on 5 May 98 all but one urgent defect had been rectified [T66, E279] and relatively few other defects remained outstanding [E280]. The one outstanding priority 2 URDEF on the AVCAT cargo system (45/97) was to be rectified at the next Assisted Maintenance Period (AMP). The recent AMP 12 was considered to be one of the best [T19 and T798] although there was some disappointment at the low take on of work. Recovery from the poorly regarded 1996 refit [E370, E285] seemed all but complete.

Fuel leaks

8.2 Fuel leakage had been a perennial problem that caused concern on a number of occasions [E369 and E188A para 27]. In the period between a refit which took place in 1996 and before AMP 10 which was carried out from 24 November - 21 December 1996 [E373], CMDR Lodomirski, then CO WESTRALIA, raised a minute to the Ordering Authority Western Australia (OAWA) attaching a list of defects. The list included numerous fuel leaks.[E137]

8.3 LCDR Crouch joined the ship as the Marine Engineer Officer (MEO) in November 1996. He became aware of the extent of the fuel and oil leaks in January 1997 when WESTRALIA sailed south to participate in the Bullimore rescue [E188 para 18]. In evidence he described the fuel leaks as follows:

...There were a number of lube oil leaks, just coming from joints, flanges, but there were also a number of fuel leaks coming from underneath, or around the injector pumps and from the connecting blocks. In order to get at these leaks in a lot of cases we have to remove injector pumps or connector blocks and it was made extremely difficult by having to manipulate solid lines.[T2844]

8.4 The concern was sufficient for COMFLOT, CDRE Cox, to interview the Engineer, LCDR Crouch in about September 1997 to explore the wisdom of proceeding to sea at that time.[T3445, T2841] The judgement was made that the leaks were no worse than usual and that they would be reduced by routine maintenance. The situation is probably described quite well by POMT Nikiforus (who served in the ship from May 95 to May 96 and January 98 to 4 May 98) in his statement.[T2860]

At times, fuel lines leaked although not seriously as far as I am aware. It was not unusual to have minor diesel fuel leaks. As soon as these leaks were identified, however, every effort was made by the Engineering Department to repair them quickly. I had never seen diesel leaking from the fuel lines become atomised.

8.5 The last engineering sea check was conducted during the period 30 September - 2 October 97 with an assessment given as Standard Achieved Minus. The report of this check [E232] indicated the following points:

There were a large number of fuel and oil leaks in the Main Engines and Diesel Alternators [in excess of 100 individual leaks]. Despite this, the main spaces were presented with minimal fuel/oil accumulation and were considered safe to operate, provided that the level of cleanliness achieved was maintained. The report concluded that the ship required time alongside with no external activities to rectify many of the fuel leaks.

8.6 Repairing leaks in the fuel system was often a time consuming task because of the difficulty encountered in removing and refitting the rigid supply and return lines from the fuel rails to the cylinder fuel pumps. The idea of replacing these lines with flexible ones was directed at making rectification of leaks in other parts of the system quicker and easier, rather than replacing an intrinsically poor component. Fuel leaks were recognised as dangerous and wasteful. Ironically it was the attempt to improve safety that led to the fire.[T3353-3554, T2844, T1664, T2229]

8.7 The new flexible fuel hoses are discussed in Section 9 of this report and the conclusion is drawn that they were defective.

Fuel system

8.8 The fuel back pressure system was worked on during AMP 12 by the contractor. The ITT pressure regulating valve on the fuel return line is designed to maintain a back pressure of 5-6 bar. This valve, controlled by air signals, was said to have been overhauled during AMP 12 as work instruction A1167. When the engine was tested after the valve had been refitted, with the fuel flow direction in accordance with the markings on the valve, there was erratic movement of the controller on the valve.[T2734] The valve was removed and turned round. Mr Morland of ADI gave an opinion that ‘. . . one of the controllers was a little bit still erratic, but it actually did the job that it was required to, yes.’[T2735]

8.9 The Board heard evidence of possible over-pressurisation of the fuel return system and some pressure gauges. It was suggested that rapid closing of the ITT pressure regulating valves may have augmented the fuel pulse pressure and contributed to the failure of the flexible fuel hoses.[T4081] The ITT valves were removed for examination and testing in the presence of RAN and ADI representatives.[E480]

8.10 This examination showed that the valve plugs (poppets) had broken away from the valve stems. When aligned correctly this allowed fuel to flow without any back pressure. When the valves were turned round and incorrectly aligned it appears that the valves partially restricted the fuel flow and created sufficient back pressure to allow the engine to operate. In this condition the valves could not close and any effect on the pressures in the fuel system would have been minimal. As Dr Goodwin stated ‘The chosen solution simply hid the problem’.[E481]

8.11 Evidence before the Board suggests that WESTRALIA had difficulty in achieving full power when the shaft generator was on line.[T1620, T1688] As the fuel oil pressure in the return line was low, the injection pump galleries may not fill at each injection stroke. ‘Under these conditions, the engine might fail to run or might fail to achieve full power.’(Goodwin)[E481]

8.12 The examination could not determine with absolute certainty whether or not the valve became detached before or after it had been refitted, although the expert from Western Process Controls considered that the valves had been broken ‘for some

considerable time'.[E480] Grease and dirt around the spindle suggested that the valve had not in fact been opened up recently.

8.13 The TM200, signed by LCDR Crouch required, amongst other things, for ADI to:

- a. inspect stripped units on receipt of opening report;
- b. to witness workshop trials.

8.14 The ADI work order (WO976006) to the sub-contractor omitted these requirements.[E145] The required inspections were not completed. Although the work order was signed by Mr Morland, the ship had refused to sign for the work based on the unsatisfactory engine trials.[E480]

Recommendation

8.15 Correct installation and operation of the fuel back pressure system should be confirmed before further use.

8.16 WESTRALIA's sister ship BAYLEAF had an MMS fire in November 1997 [E21]. The Board obtained an executive summary of the RFA's report on that fire. That report, which included a copy of Crossley service bulletin 51 issue 2 (first issued in 1978), expressed concern 'that the fuel isolating cocks fitted to the fuel rails appeared to be of a design not suited to this particular engine'.[E267]

8.17 Service bulletin 51 identifies which of a variety of cocks are suitable for the Pielstick PC2.2V engines dependant on the engine serial number. For WESTRALIA's engines (serial numbers 18104 and 18105), the originally fitted Auxim cocks should have been replaced by Orseal cocks. The Orseal cocks were prone to leakage and should have then been replaced by a ball valve (PC16677). Although the bulletin is less than clear, it appears that WESTRALIA should now be fitted with modified Auxim cocks (PC 20005) which are identical in appearance and interchangeable with the superceded cock PC 7559. The Bulletin does acknowledge that a Schneider type cock can be fitted to WESTRALIA's engines and that these cocks have a more positive shut off.

8.18 The BAYLEAF report does not specify which cocks were fitted but alerts to thread incompatibilities if the wrong cock is used. The Board instigated an audit of the actual cocks currently fitted and the results are in Board document MR090.[E472] The audit found that a mixture of cocks are fitted, including those deemed unsuitable by the service bulletin. In addition, many of the cocks had missing or damaged locking plates. Although these cocks had no part to play in this fire, they appear to pose a major danger. The engineering staffs on both BAYLEAF and WESTRALIA were apparently unaware of the existence of Bulletin 51.

Recommendation

8.19 Appropriate fuel isolating cocks should be fitted to the fuel rails.

Main engine controls

8.20 The ship has suffered a number of main engine control problems [e.g. T20-21, T62A-63, T1465, T1612, T1656] but none is relevant to the events of 5 May 1998.

Ships communications - external

8.21 When the power was isolated from the main switchboard and the emergency source of electrical power started, normal radio communications were lost. Evidence was given that the emergency power to the radios was through the emergency switchboard and there was no transitory battery supply. After the fire started, power 'spikes' made the radio sets in the communications centre inoperative. The communications centre then had to be abandoned because smoke was being drawn in through the air conditioning duct [T3473].

8.22 Notification of the emergency was undertaken by mobile telephone. Other critical messages throughout the emergency were passed in the same way or by means of either hand held VHF radio or the bridge VHF sets on channel 69.

8.23 A portable 'Raven' radio was initially set up adjacent to the flight deck but no reception was achieved. The set was moved to the bridge top and communications established.[T3473]

Recommendation

<p>8.24 The emergency power supply to essential radio communications equipment should be reviewed.</p>

Communications - internal

8.25 The ships fitted communications systems performed well given the severity of the fire and the damage to power supplies. Although functional, there were many complaints about the sound quality of the sound powered circuits [T1629, T1599, T1691].

8.26 Hand held radio communications have been discussed in Section 7.

Recommendation

<p>8.27 The ship's sound powered circuits should be checked for proper operation.</p>
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Main machinery space gas tight integrity

8.28 WESTRALIA's MMS is separated from the accommodation by steel bulkheads and decks rated 'A60' for fire resistance. Under SOLAS rules, the bulkheads and decks between the MMS and the accommodation area are required to be suitably stiffened and able to prevent the passage of smoke or fire of a standard fire test for one hour. 'A60' bulkheads are insulated with approved non-combustible materials such that the average temperature of the unexposed side will not rise more than 139°C above the

original temperature, nor will the temperature at any point, including any joint, rise more than 180°C above the original temperature within the 60 minute period.

8.29 The forward bulkhead between the MMS and the pumproom was of steel but was not required to be insulated, and was rated as 'A0'. There was no time criteria relating to the rise in temperature through this bulkhead.

8.30 To maintain integrity, any doors or penetrations of 'A' class bulkheads or deckheads are required to meet the same standards as their respective time ratings. The MCR deck was subjected to very high temperatures from the fire in the MMS. Although there was some evidence that the deck became hot, it did not exceed 165°C and reached a temperature in the range of 130°C to 150°C.[E457] The indications are that the heat transfer through 'A60' boundaries was minimal.

8.31 The 'A60' bulkheads restricted the passage of heat [T1921, T3004], however the gas tightness of the MMS is poor [T1555]. Access doors do not have sealing strips but rely on metal to metal contact [T526-7, T461, T567]. Ventilation flaps are thin and easily distorted. Other doors forming part of the gas boundary have large gaps generally at the bottom. These deficiencies degraded the effectiveness of the CO₂ drench and the containment of smoke. Compliance with SOLAS and Lloyds standards is at best, doubtful. The exhaust and supply flaps for the MMS were well maintained. There is a possibility that one supply flap on the port side did not shut when first activated. If this was the case, then the cause is poor design rather than a lack of maintenance. The door between the MMS and the tiller flat was held open by lashings. It could not be closed during the emergency of 05 May 98, and this further reduced the effectiveness of the isolation of the MMS.

Recommendation

8.32 The gas tight integrity of the MMS should be brought up to the required standards.

Penetrations into MCR

8.33 The flames from the fire on the SME were impinging on a bulkhead adjacent to the engine on the outboard side and the steel plates that form the deck of the MCR and switchboard compartment. There is evidence that upon hitting the starboard bulkhead and the MCR deck the flames rolled forward, aft and to the port side.[T1857-1858]

8.34 There were various electrical cables on the bulkhead directly above the engines that were burnt during the fire [E246 photos P&Q]. Smoke and toxic gases being given off by the burning insulation would have added to the quantity of gases being generated in the MMS. The glands around the electrical cables and pipes passing through the deck did not prevent smoke from entering the MCR [T2835]. The cables were quickly burnt in the fire which then affected the shutting down of machinery, communications to the bridge and the MMS evacuation siren [T1625, T2835].

Conclusions

8.35 The penetrations in the MCR deck for the passage of electrical cables and pipes had not been properly sealed.

8.36 The electrical cable runs above the engines are poorly located.

Recommendations

8.37 All cable and pipe penetrations between the MMS and the MCR should be sealed to prevent smoke entry.

8.38 The electrical cables above the engines should be either relocated or covered with a fire resistant material.

Fixed CO₂ firefighting system

The system

8.39 SOLAS 74/78 requires that the MMS of a ship be protected, in the event of fire, by a fixed CO₂ fire extinguishing system. The required volume of CO₂ is calculated on the basis of a MMS volume of 5793 cubic metres, which includes the free air in the main engine air start cylinders.[E116] To reduce the atmosphere in the MMS to one that will not support combustion, the total CO₂ release must equal 35 per cent of the total space. This would reduce available O₂ to 14 per cent by volume, which is below the level that can support combustion.

8.40 Based on 0.56 kilogram to a cubic metre, the MMS required 81 x 45 kilogram cylinders of CO₂ to meet this standard. The ship was in fact equipped with 82 cylinders that are stored in the CO₂ bottle store on 1 deck. The requirement is that 85 per cent of the CO₂ be released into the MMS within two minutes.

8.41 The FCR, from where the CO₂ smothering system can be activated remotely, is situated on the port side aft on 01 deck. The door opens out onto the quarterdeck. Inside the space are the controls for the CO₂ release, the forced ventilation shut-offs and the remote closing valves for the ship's fuel tanks. The space also contained the shore power connection for the ship's electrical system.

8.42 There are two sets of CO₂ discharge valves in separate boxes, one for the MMS and one for the aft pump room. The system is designed so that if either box is opened a siren will sound in the MMS or the aft pump room.

8.43 The CO₂ is released by a sequential pulling of levers to prime the control system. The first is to build up pressure to the 'pilot cylinders' and automatically activate valves in the CO₂ room. The second is to activate the release mechanism for either 82x45 kilogram to be dumped into the MMS or 23x45 kilogram cylinders into the aft pump room. Each space has a separate control box for the release of the CO₂.

8.44 Instructions are fixed to the outside of door rather than the inside. The cylinder that should be operated first is labeled '2' and the cylinder that should be operated second is labeled '1'. [E256] The EOW, who activated the system on 5 May and was familiar with its operation, acknowledged that he had one unsuccessful attempt before checking the instructions and trying again [T1723].

8.45 Not all the CO₂ cylinders discharged. The evidence is that 'two banks' failed to discharge. [T29, T60, T61, T1631] The actual number of cylinders that failed to

discharge is not known with certainty. Subsequent testing of the system suggests that 53 cylinders probably discharged initially, or 64 per cent of the available CO₂.

8.46 The initial release of 53 cylinders of CO₂ if it had all discharged to the MMS, would theoretically have reduced the oxygen level to just over 16 per cent. This would be sufficient to support continued combustion, but at a poor rate of burning. The delay in the discharge of the remaining cylinders may have allowed the fire to draw in more air from outside the MMS. The second release of CO₂ would also have reduced the oxygen level. CO₂, being heavier than air, would have had a greater effect at the bottom plates.

8.47 Testing of the CO₂ release system demonstrated that the system failed to activate correctly because of inadequate tensioning of the actuating wires. In one test the actuation wire to the inboard bank of cylinders jumped off the guide pulley and jammed before the ram reached the full extent of its travel.[E453] In other trials, the operating ram reached the end of its travel before actuation of the cylinders was achieved. Many leaks were also discovered. The mist observed by WO Bottomley and others [T28] was caused by some leaks on the flexible piping system between the cylinders and the rigid steel piping to the MMS and pump room.

Conclusion

8.48 The Board concludes that the CO₂ system was not well maintained and failed to operate correctly because of incorrect tensioning of the actuating wires.

Recommendations

8.49 All RAN fixed firefighting systems should be checked to ensure:

- **operating instructions can be clearly seen by the person operating the controls**
- **all valves and levers are clearly labelled and logically numbered**

8.50 WESTRALIA's CO₂ system should be thoroughly overhauled before being set to work again.

Ships firemain

8.51 The absence of firemain pressure gauges outside the MCR is a serious shortcoming. Evidence was given that after the fire started the only way of establishing the pressure was for WO Bottomley to re-enter the MCR in OCCABA to read the gauge. Knowledge that the pressure was sufficient was vital before committing hose teams to fight the fire. Direct monitoring of the pressure from HQ1 or the section base may have given the command the confidence to use more hoses and attack the fire on an additional front.[E3]

Recommendation

8.52 Firemain pressure gauges should be fitted in HQ1 and the Damage Control section bases

Exhaust leakage

8.53 Leakage from the engine exhausts seems to be another regular problem for the ship [T593, T664, T706]. Besides the health risks the exhaust gases and smoke from new lagging fitted following repairs have repeatedly triggered the fire alarm system.[T3206-7, T390-1, T442] The standard practice has been to isolate the alarms in the MMS zones for a period when proceeding to sea. On occasions, alarms in other zones have been triggered by exhaust gas. Work was completed during AMP 12 to fix exhaust leakage and this may have been successful. Different fire sensors may be better at avoiding false alarms and this should be investigated. This is addressed more fully later in this section.

Indicator cocks

8.54 The indicator cocks and lines in WESTRALIA are unlagged. These fittings are hot, in close proximity to the fuel lines and, being directly connected to the cylinders, reach temperatures close to that of the engine exhaust. Ignition of leaking fuel by a hot indicator cock was observed in the BAYLEAF fire and, as discussed elsewhere in this report, an indicator cock is the likely source of ignition for WESTRALIA's fire. According to Mr Gillespie of Rolls Royce [E185] the engines were originally fitted with lagging and shielding to reduce the outside surface temperature to less than 220°C. Although he does not specifically mention lagging of the indicator cocks, there is a strong inference that they should be lagged. Further investigation is required.

Recommendation

8.55 Investigations should establish whether the indicator cocks should be lagged and or shielded. If appropriate, insulation and shielding should be fitted.

Future of the injection pump suction and spill pipework

8.56 As discussed in other parts of this report the new flexible hoses were unsuitable. The options for reinstating the system appear to be either to refit the original rigid system with its known problems and dangers or to procure and fit the purpose designed modification from the manufacturer. The new arrangement has apparently not been fitted to any PC 2.2V engines and would be a prototype if fitted to WESTRALIA. The fuel lines can be either flexible or steel. The Board has obtained some basic price and availability information and has passed it to the Class Logistics Office.[E451] As discussed in Section 9, the magnitude of the spill pulse pressures is not known with any certainty, there are doubts about whether any flexible hose is suitable for this application.

Recommendation

8.57 In the absence of information about the actual magnitude of the spill pulse pressures and a lack of clarity about whether any flexible hose can withstand this operating environment, a new piping arrangement, using the rigid steel option, should be procured from the engine manufacturer and fitted.

Drawings and Technical Documentation

8.58 The technical documentation available to the ship is generally poor. Although the Board has not researched this issue in any depth, the quality of drawings and information (e.g. The Main Engine fuel system), and the detailed understanding by the crew of their ship has been disappointing. Of particular concern has been the rudimentary knowledge of emergency systems including the CO₂ drench. CMDR Stapley's submission [E355] points to improvements in the ship's technical documentation since the ship was acquired but suggests that WESTRALIA is not up to the standard of other RAN vessels.

Recommendation

8.59 Although the remaining life of the ship is short and the provision of a satisfactory set of ships drawings and documentation is unlikely to be achievable, priority should be given to providing accurate information on the ships emergency arrangements.

Maintenance Funding

8.60 Claims have been made by some personnel that WESTRALIA maintenance is underfunded and that she is the 'poor relation' compared to SUCCESS.[T103, T539, T675, T1382] There is no objective evidence to support such claims. In fact, some observers who know the ship well commented that when she sailed on 5 May 98, she had never been in such good condition [e.g. WO Bottomley T249 and PO Nikiforus E186, T2860]. According to the CO [T3212] 'the level of funding is as good if not better than most of the other ships'.

8.61 CMDR Coverdale noted in evidence that during AMP 11 the budget of \$1 million was overspent by \$630 000.[T3284.4]

Conclusion

8.62 The ship's maintenance history does not support the proposition that there was any policy to reduce or deprive WESTRALIA of funding. In 1996 the ship spent six months undertaking an extensive refit. The ship undertook AMP 10 early in 1997. AMP 11 involved a significant over-spend of the budget allocation.

CLASSIFICATION REQUIREMENTS AND INTERNATIONAL STANDARDS

Lloyd's Certificates

8.63 WESTRALIA is classed as a 'tanker under survey' by Lloyds Register of Shipping. Class certificates are carried covering the provisions of:

- the International Load Line Convention 1966;
- the Safety of Life at Sea Convention 1974; and
- the 1978 Protocol, as it relates to construction and machinery.

SOLAS

8.64 The SOLAS Convention sets minimum international standards relating to aspects of ship safety including construction, machinery, electrical installations, fire protection, fire detection and fire extinction for vessels on international voyages. The International Loadline Convention relates to the watertight integrity of ships and the depth to which they may load in safety. The SOLAS convention was extensively amended in 1981 and 1983 and these later amendments do not apply to WESTRALIA. As a minimum standard, the ship is required to meet the provisions of the two conventions, as well as the relevant Lloyds Rules and Regulations for the Classification of Ships.

8.65 SOLAS 74/78 covers extensive safety requirements of the ship's subdivision and stability, machinery and electrical installations. It also covers fire safety measures for ships carrying Convention certificates.

Surveys

8.66 Under the provisions of SOLAS, merchant ships are subject to a five-year cycle of survey to ensure compliance with various international safety and pollution prevention conventions. The survey cycle consists of an initial 'Special' survey, 'Annual' surveys (essentially visual inspections to ensure that standards are maintained) and, midway through the cycle, an 'Intermediate' survey when a more thorough examination of the ship is conducted. In the case of older ships, particularly tankers, the rigour of examination is increased at 16 years, thereafter every five years such a ship is subject to an 'Enhanced Special' survey. In July 1996 WESTRALIA underwent an 'Enhanced Special Survey' while in Newcastle. The survey included extensive testing of the hull thickness and condition.

8.67 The items for survey include requirements contained in Chapter II of SOLAS 74, as amended by the 1978 Protocol, for⁵:

- Emergency Source of Electrical Power (Ch.II-1, Reg 26)
- Precautions against Shock, Fire and other Hazards of Electrical Origin (Ch.II-1, Reg 27)
- Steering Gear (Ch.II-1, Reg 29 as amended by 1978 Protocol)
- Fire-Extinguishing Systems and Equipment (Ch.II-2, Reg 52)
- Means of Escape (Ch.II-2, Reg 53 & 59)
- Special Arrangement in Machinery Spaces (Ch.II-2, Reg 54)

International Standard for Emergency Source of Electrical Power

8.68 The requirement for an emergency source of electrical power is satisfied by the fitting of a generator located above the uppermost continuous deck and outside the machinery casing. Under SOLAS 74/78,

The power available shall be sufficient to supply all those services which are, in the opinion of the Administration, necessary for the safety of all on board in an emergency, . . . The services must include emergency lighting, the general alarm system and navigation lights.

⁵ International Convention for the Safety of Life at Sea, 1974, London, 1975 (Reprint 1982)

8.69 WESTRALIA's emergency power system exceeded these requirements. In fact they accorded with more stringent Lloyd's requirements and the 1982/83 amendments, which require, inter alia, the generator to:

- a. start automatically in the event of the failure of the main generators;
- b. supply power to the navigation equipment;
- c. supply power to one of the steering motors.

8.70 When the main switchboard room was isolated at the outbreak of the fire, the emergency generator started automatically and connected to the emergency switchboard. It was reported that this occurred within 15 seconds, well within the maximum time provided by the Convention. Initially there were power 'spikes' probably caused by circuits that ran through the MMS shorting out. After a short period, [E16A & E16B], a constant supply was available to the bridge navigation equipment and the emergency lighting.

8.71 Following the fire it was established, on behalf of the Board, that the wiring from emergency switchboard to the navigation equipment on the bridge was in good condition. This was consistent with the maintenance of power to the navigation equipment on 5 May.

8.72 It was also confirmed that the electrical continuity and insulation of the 440 volt supply cables between the emergency switchboard and one of the steering motors was in good condition. This cabling was routed outside the MMS. However, the control circuits to allow change over from main to emergency steering pass through the MMS. Steering from the bridge could have been lost as the 230V control cabling passed through the MMS and was damaged. However, the 440V supply would have provided power to allow the vessel to be steered from the tiller flat.

8.73 The emergency supply apparently did not conform to Lloyds Rules Chapter 6, section 2.3.3 which requires the emergency source of electrical power:

. . . to be such as to ensure that a fire or other casualty in the space containing the main source of electrical power . . . will not interfere with the supply, control and distribution of electrical power.

8.74 The absence of up to date wiring diagrams and drawings made a full analysis of the materiel state of the emergency switchboard and cabling unachievable during the course of the Board of Inquiry.

International Standard for Means of Escape

8.75 For escape from machinery spaces SOLAS 74/78, Regulation 53, requires:

In machinery spaces, two means of escape, one of which may be a watertight door, shall be provided from each engine room, shaft tunnel and boiler room. In machinery spaces, where no watertight door is available, the two sets of steel ladders as widely separated as possible leading to doors in the casing similarly separated and from which access is provided to the embarkation deck.

8.76 Escape routes from spaces, including the MMS, are items of survey under Lloyd's Rules (Pt.6. Ch.4, Section 19.4.3). Lloyd's provisions, though similar, exceed the SOLAS 74/78 requirements. For ships similar to WESTRALIA:

Two sets of steel ladders as widely separated as possible leading to doors in the upper part of the space similarly separated and from which access is provided to the open deck. In general, one of the ladders is to provide continuous fire shelter from the lower part of the space to a safe position outside of the space. However, the shelter may not be required if, due to the special arrangement or dimensions of the machinery space, a safe route from the lower part of this space is provided. This shelter is to be of steel, insulated where necessary and provided with a self closing steel door at the lower end. If access is provided at other levels each level is to be provided with a steel self closing door.

8.77 In WESTRALIA there are two emergency exits from the MMS. One is the forward bulkhead at the 'middle' plates level. This escape is an exposed steel ladder with an access to the main switchboard room and thence to the hydraulics room on 1 deck. At the after end of the MMS, there is a ladder from the bottom plates level on the starboard side, between frames 14 and 15. This ladder extends only to the middle plate level. Any person trying to escape by this route is then forced to move forward to the normal after access ladder leading to the top plates. The route then goes aft to the steering flat, from where there is a vertical steel ladder to the fridge flat.

8.78 The Board is concerned that such an arrangement has been approved by Lloyd's. Of equal concern is that such an escape route has been accepted by successive crews in WESTRALIA and has not been identified by any audit of the space by other Navy staff.

8.79 Mr Ridland, Area Manager for Australasia of Lloyds Register of Shipping was asked questions relating to the emergency escapes from the MMS. It was pointed out to him that there was no vertical ladder between the bottom plates and the middle plates at the after end of the MMS. He was asked if that conformed to Lloyds Rules or SOLAS [T4062]. Solicitors acting for Lloyd's provided the following response in a facsimile responding to questions asked of Mr Ridland, which he had taken on notice.

The two means of escape from the engine room are checked at annual survey.[E415]

Conclusion

8.80 The Board notes the failure of Lloyd's to answer the questions and in the absence of further advice, the Board considers that the arrangements for means of escape from the MMS is not in the spirit of the Convention requirements and is dangerous.

Recommendation

8.81 The Board recommends that enclosed escape arrangements be fitted at both ends of the MMS as a matter of urgency.

ENHANCEMENTS

8.82 In the course of the Inquiry, the Board identified a number of ship enhancements that would improve safety. These are discussed in the following paragraphs.

Configuration of MMS Ladders

8.83 The ladder system in the MMS consists of the following:

- Port and starboard central ladders from the bottom plates to the top plates,
- Forward escape ladder from the middle plates to the electrical switch room,
- After escape ladders, bottom to middle and top plate to fridge flat,
- Port and starboard ladders from the top plates to the junior and senior change rooms.

8.84 Due to the design of the ship, the central ladders (the main escape route) are the quickest and sometimes only means of egress from the MMS.

8.85 The construction of the ship above the main engines makes it highly likely that, with a large engine fire, flame will impinge on the MCR deck. Evidence given to the Board details the flame and heat hitting the deck of the MCR rolled outwards and rendered the forward escape ladder from the bottom plates to the switch room unusable almost immediately [T1857, 1858].

8.86 The fire modelling analysis that was carried out indicates the temperatures that could be expected around these ladder areas. Figure 8 indicates that one minute after the fire started, the calculated temperature near the forward escape ladder was in excess of 1200°C.

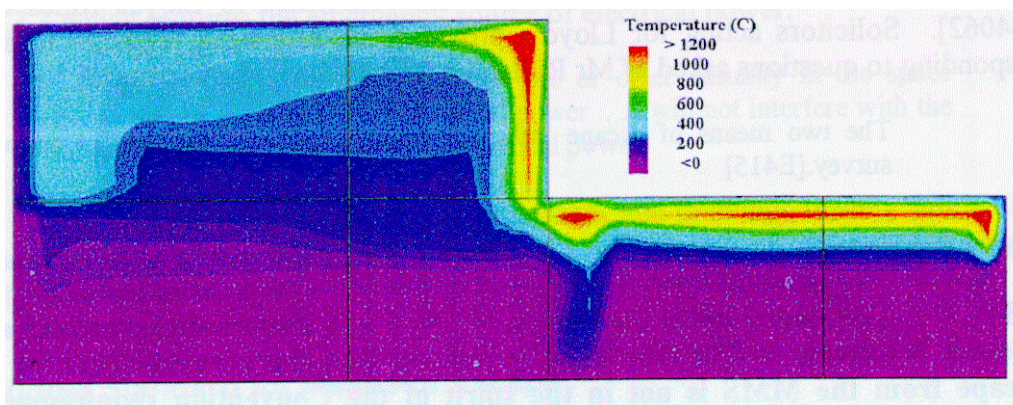


Figure 8. The predicted temperature distribution of the fire incident after 1 minute. The figure shows an aft to forward section through the origin of the fire. The bottom of the picture corresponds to the top of the starboard engine. (Fig 11 of DSTO report)

8.87 The funnel, directly aft of the MCR, created a chimney effect which drew the flame, heat and smoke to this point. The only escape route from the middle plates, other than the forward escape ladder, are those ladders located centrally just aft of the MCR and within the 'chimney'.

8.88 Personnel evacuating the MMS had to proceed from the middle plates to the top plates via the port or starboard central ladder. However the starboard ladder was near where the fire was hitting the bulkhead and was engulfed in flame [T1807]. The flames and heat also rolled aft from under the MCR deck near the port ladder and made egress extremely hazardous.[T1244] Figure 9 indicates the calculated temperature around the top of the port ladder.

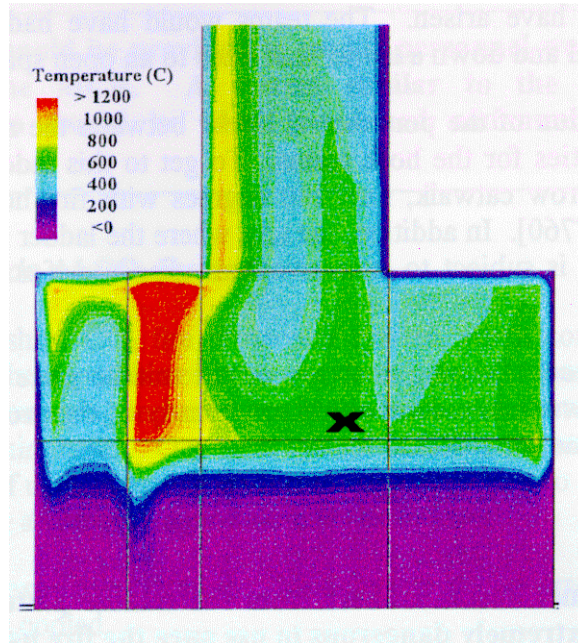


Figure 9. Temperatures distribution 1 minute into the event for a cut across the compartment aft of the MCR looking aft. High temperatures of the order of 400°C are predicted to exist at the top of the port ladder (marked with an X). (Fig 12 DSTO report)

8.89 A report of a fire in the RFA BAYLEAF, WESTRALIA's sister ship, also detailed problems with ladders from the MMS [E21].

8.90 The narrow configuration of the ladders and their location within the MMS made access for the hose teams onto the different levels extremely difficult. During firefighting operations, the number one on the hose teams had to tuck the water wall under his/her arm and descend approximately four metres down a narrow ladder backwards. This activity was undertaken in intense heat with zero visibility and personnel were dressed in OCCABA and protective clothing. The other hose team members also had to descend the ladders in a similar manner and avoid tripping over the hose [T702].

8.91 This procedure, although practiced during training on a regular basis, is difficult, energy sapping and dangerous. On the day of the fire the hose teams were required to undertake this procedure to gain access to the top and then the middle plates. When relieved the hose teams then had to negotiate the ladders again to exit the area. A number of the personnel commented how difficult it was to use the ladders [T702, T762].

8.92 The ladder that created the most difficulty for personnel was the ladder from the fridge flat to the top plate [T627]. To get to the ladder from the fridge flat is not any easy task. On entering the MMS the teams had to veer approximately 90 degrees to the right and then to the left to mount the top of the ladder. This had to be undertaken while trying to bend and twist charged lines of hose [T707, T708].

8.93 The ladder concludes in a relatively confined area, which also leads to hoses becoming tangled and getting caught up on objects [T630, T759, T702]. The narrow steep ladder and sharp corners made this route difficult as a way of removing the bodies after the fire was out [T702].

8.94 If a wider and less steep ladder had been fitted to the landing on the fridge flat and went directly from aft to forward (down the centre line of the ship) the majority of the problems would not have arisen. The teams would have had access to the MMS by moving straight ahead and down a ladder that leads to an open space on the top plate.

8.95 The location of the port central ladder between the middle and top plate also caused some difficulties for the hose teams. To get to this ladder the hose team had to progress down a narrow catwalk, turn 180 degrees with fire hoses, and then descend a steep ladder [T629, T760]. In addition, the area where the ladder meets with the top plates, just aft of the MCR, is subject to excessive heat exposure if a fire involves the engines [E457].

8.96 A ladder commencing centrally on the middle plate and finishing on the top plate inline with the workshop door would solve many of the problems that restrict access between the middle and top plates.

Conclusions

8.97 The normal access ladders from the middle plates to the top plates are exposed, and were extremely dangerous to use once the fire had started.

8.98 The ladder from the fridge flat to the top plates and the port ladder between the middle and top plates are difficult for hose teams to use.

Recommendations

8.99 A wide and less steep ladder should be fitted from the fridge flat landing to the top plate running centrally from aft to forward.

8.100 A wide ladder should be installed on the port side between the middle and top plates concluding in line with the workshop door.

8.101 The existing central port ladder and the ladder from the fridge flat to the top plate should be removed.

Main Machinery Space Communications

8.102 WESTRALIA's MMS is a large cavernous compartment with three distinct levels. The Machinery Control Room (MCR) which controls the operation of the machinery within the MMS, is a self contained compartment at the forward end of the MMS at the 'top plate' level. There is not an effective system of communications between the MCR and any part of the MMS. In his evidence PO Hollis, who discovered the fuel leak on the port main engine, notes that he had to 'race back to the MCR to inform the engineering OOW'. [T1804.4]

Conclusion

8.103 The Board is of the view that the lack of MMS to MCR communications is unacceptable.

Recommendation

8.104 A system should be provided to enable personnel working in the MMS to communicate with the MCR. A system similar to the 'Flight Deck Loop' communication system would be ideal (combined communications and hearing protection system)

Replacement/Upgrade of CO₂ System

8.105 Whilst the ships CO₂ fire protection system, when correctly maintained and operated, will provide the appropriate fire protection to the MMS and after pump space. It is considered that new emerging technologies in fire protection systems may provide better options for Navy's requirements. One such system is 'Water Mist'. Water Mist systems work on the principle of using a low or high pressure water mist to extinguish, suppress or control the fire by using a combination of methods as follows :

- a. Heat extraction from the fire as water is converted into vapour and the fuel is cooled.
- b. Reduced oxygen levels as the water vapour displaces oxygen near the fire.
- c. Direct impingement wetting and cooling of combustibles
- d. Enveloping the protected area to cool gases and adjacent combustibles, as well as to pre-wet the adjacent combustibles while blocking the heat transfer of radiant heat to them.
- e. Dilution of flammable vapours by the entrainment of water to such an extent that the resultant mixture of vapours will not burn.

8.106 These systems have the considerable advantage of supporting life.

8.107 The Board is aware that DSTO has been examining water mist and other fire protection systems.

Recommendation

8.108 Whilst WESTRALIA's CO₂ fire protection system might be considered satisfactory, consideration should be given to other fire protection systems such as water mists, which could be fitted in lieu, particularly if these are safer and more adequately meet Navy's requirements.

Incident Recording Devices

8.109 To enable an accurate reconstruction of the events surrounding any incident to be made, it is important that appropriate recording devices are installed in command positions in ships and submarines. WESTRALIA's bridge had a small commercial portable tape recorder with a single microphone. The tape recording was critical in establishing certain evidence objectively. However, the sound quality of the tape was so poor that the tape required enhancement using sophisticated equipment and even then a great deal of the material was inaudible. The tape also ran for only 30 minutes after the commencement of the incident and, understandably in all the circumstances, it was not replaced when it ran out.

8.110 The aviation industry has been using data recording devices for many years and such devices have been invaluable in enhancing aviation safety. At least two shipping companies, P & O and Silja Line, have adopted recording technology to record critical data from equipment such as the radar, GPS and engine control. There is also provision for recording bridge conversations. The systems are not only used for accident analysis, but also training and planning.

8.111 Apart from emergency incidents, this equipment can record exercises with the results being analysed to provide feedback on the conduct of such exercises. This type of equipment should be of good quality and not a cheap ad hoc arrangement like the bridge tape recorder, used in WESTRALIA.

Conclusion

8.112 Suitable data recorders strategically placed in command positions such as the bridge, MCR and HQ1 can play an important role in enhancing safety at sea.

Recommendation

<p>8.113 Data recording equipment should be fitted in command positions of all HMA ships and submarines.</p>

System for Opening the Funnel Flaps

8.114 The standard operating procedure for a CO₂ drench states that the supply air fans and natural ventilation points must be closed [E112]. This procedure is necessary to seal the MMS and prevent oxygen getting to the fire. While sealing the MMS is a relatively simple task the problem arises after the fire is out and the area needs to be cleared of heat, smoke and CO₂.

8.115 The funnel door on the starboard side is the highest access point to the MMS. The door could have provided an alternative to the funnel flaps, but in this case, the door was on the windward side, facing a 15 knot breeze. If the ship had been head to wind (at anchor) or drifting, the funnel door may have greatly assisted the ventilation of the MMS – although this cannot be guaranteed.

8.116 Pulling the operating cables on 04 deck retracts the retaining devices and the flaps close under their own weight. To open the exhaust flaps personnel have to enter the funnel, climb a small ladder in darkness and exit through a small trap door at the top and

then physically lift the heavy covers. During the fire on 5 May such a task would have been virtually impossible. The funnel casing and ladder would have been extremely hot, filled with smoke and there would have been minimal visibility. In addition the personnel would have had to climb a ladder, with BA on, and get through a small trap door. Such an operation could only be considered extremely hazardous and unlikely to succeed during a fire.

Conclusion

8.117 Once shut there is no means of opening the funnel flaps without entering the funnel space.

Recommendations

8.118 A system should be installed that allows the MMS ventilation exhaust flaps to be opened remotely.

Fire Detection System

8.119 The existing fire detection system comprises smoke, heat and flame detectors and manual call points located in service, accommodation and MMS areas connected to a central indicator panel on the Bridge; a sub-indicator panel is located on 02 deck. The detectors are grouped together into zones such that if any detector in a group is activated then the alarm signal for the group is raised on the fire indicator panel. Four alarm zones (Zones 7 to 10) cover the MMS and support area [E430].

8.120 Smoke detectors are used throughout the MMS, with the inclusion of two flame detectors, one over the engines and one adjacent to the generators. The Fire Detection Manual indicates the smoke detectors to be of an ionisation type, while the flame detectors respond to the modulated radiation emitted by flaming hydrocarbon fuel. There is a manual call point in the MCR overlooking the MMS [E430].

8.121 Evidence given suggests that for a period (length not clear, but several hours at least) following the start up of the engines, the MMS detection zones have to be isolated to prevent continual false alarms being generated by haze from the engines [T429, T446, T1186]. Since the flame sensors are on the same alarm zone as the smoke detectors, which cause the false alarms, this has resulted in the flame sensors also being isolated. Were they on a separate zone they could have remained in operation during isolation of the smoke sensors and given a degree of protection – alternatively, heat detectors could have been used for one zone, along with the flame detector, in place of smoke detectors [E430].

8.122 There are number of modern systems which could provide an increased level of protection for the area. These include:

- VESDA- (Very Early Smoke Detection Apparatus) This system draws air samples from the area of protection through a network of pipes, filters out the dust and then analyses the sample to see if it is polluted and to what degree. The result can be used for local or remote alerting and if fitted to associated relays can be connected to a system for automatic shut down of the systems to prevent a fire developing. As this system can be fine-

tuned to suit the particular need of each individual environment it has been installed in civil and military shipping [E430].

- **ALGOREX-** (a Grinnel fire detection system) This type of system looks more like a conventional smoke detection system but the sensors each have their own microprocessors to evaluate the data at the source: individual heads can be programmed with parameters suitable for the particular location [E430].
- **UNITOR** This is an integrated system which will as well as being connected to a system of smoke, heat or other fire detectors, monitors other sensors on equipment which will indicate the likelihood of a fire situation before the production of combustible products [E430].
- **CCTV-** (Closed Circuit Television) This can be used in conjunction with other systems to provide an additional level of supervision of the protected area and can monitor the environment for optical changes which indicate the development of a fire [E430].

8.123 The issue of a camera providing pictures of what was occurring inside the MMS at the time of the commencement of the fire has been raised by people giving evidence during the inquiry.[T1424] Had the MCR team had more idea of what was occurring within the MMS at the commencement of the fuel leak and immediately after the fire started, different strategies may have been employed which could have mitigated the tragic consequences of the fire.

Conclusions

8.124 The present system of isolating the MMS detection zones to prevent false alarms is dangerous.

8.125 The fire detection system fitted to the MMS of WESTRALIA is not fit for purpose.

8.126 There are a number of possible systems available to enhance the level of fire protection.

Recommendations

8.127 The fire detection system should be upgraded in the WESTRALIA.

8.128 A CCTV system should be installed in the MMS, MCR and HQ1.

MMS Evacuation Siren

8.129 Immediately following the MCR being alerted that a major fire had broken out within the MMS, LCDR Crouch activated the MMS evacuation siren. Both LCDR Crouch and PO Herridge gave evidence that the siren failed to operate [T1628, T1690, T2835]. However, PO Francis gave evidence that he heard one blast on the siren when in the MMS [T1461]. Thinking the fire had damaged the cabling LCDR Crouch opened the MCR door to the MMS, stepped onto the catwalk and yelled for everyone to evacuate the area [T2835].

Recommendation

8.130 Audible warning devices activated by buttons placed on each level of the MMS and in the MCR should be fitted. The cabling should have appropriate fire protection.

Emergency Lighting and Reflective Tape

8.131 PO Hollis exited the MMS via the port ladder shortly after PO Francis. Having made it up to the top plates PO Hollis could not find the door to the MMS due to the darkness and disorientating effects of the smoke [T1807].

8.132 PO Hollis was working his way along the bulkhead looking for the opening when WO Bottomley opened the door, grabbed him and pulled him inside the MCR. By the time PO Hollis evacuated the MMS, the handrail on the port ladder was hot enough to burn his left-hand [T1807].

Conclusion

8.133 There was insufficient lighting or reflective tape at a low level to guide personnel to safety.

Recommendation

8.134 Additional emergency lighting and reflective tape should be placed at a low level on designated escape routes, ladders and doors to assist personnel to evacuate the MMS in smoke or darkness. An arrangement similar to that used to identify escape routes in commercial passenger aircraft would be ideal.

Finding

8.135 When WESTRALIA sailed there were a number of deficiencies in the materiel state of the ship. The two serious deficiencies, the flexible supply and return fuel hoses and the CO₂ system were not readily apparent. At that time the flexible fuel hoses gave no sign of any inherent flaw. The condition of the CO₂ system, and particularly the tension of the operating wires, would only have been apparent to an expert on close inspection. At 0900 on 5 May 98 there was no obvious materiel deficiency that should have prevented the ship from sailing.