Marine Inquiry 09-202: Passenger vessel Oceanic Discoverer
Fatal injury, Port of Napier
19 February 2009

Final Report

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Approved for Publication: November 2011

Transport Accident Investigation Commission

About the Transport Accident Investigation Commission

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

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Important notes

Nature of the final report

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

Ownership of report

Citations and referencing

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

Photographs, diagrams, pictures

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

Location of accident

The *Oceanic Discoverer*

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Abbreviations

ABS	American Bureau of Shipping
AMSA	Australian Maritime Safety Authority
ATSB	Australian Transport Safety Bureau
Commission	Transport Accident Investigation Commission
COSWP	Code of Safe Working Practices
GS	general service
IACS	International Association of Classification Societies
IMO	International Maritime Organization
ISM Code	International Safety Management Code
MAIB	United Kingdom Marine Accident Investigation Branch
MSC	Maritime Safety Committee
PA	public address system
SOLAS	International Convention for the Safety of Life at Sea, 1974, as amended
STCW Code	Seafarers' Training, Certification and Watchkeeping Code
STCW Convention	International Convention on Standards of Training, Certification and Watchkeeping for Seafarers 1978, as amended in 1995 and 1997
UTC	universal co-ordinated time

Glossary

Administration	the International Safety Management Code defines an Administration as the Government of the State whose flag a ship is entitled to fly
mimic	a means of displaying the status of a system
watertight	capable of preventing the passage of water in any direction under a design head. The design head for any part of a structure should be determined by reference to its location relative to the bulkhead deck or freeboard deck, as applicable, or to the most unfavourable equilibrium/intermediate waterplane, in accordance with the applicable subdivision and damage stability regulations, whichever is the greater. A watertight door is thus one that will maintain the watertight integrity of the subdivision bulkhead in which it is located

Data summary

General particulars of vessel

Name	*Oceanic Discoverer*
Type	SOLAS passenger vessel
Class	American Bureau of Shipping (ABS)
Limits	unlimited
Classification	✠A1, Passenger Vessel, ✠AMS
Length	63 metres
Breadth	13 metres
Gross tonnage	1779
Built	2005 at NQEA Australia Pty Limited
Propulsion	2 Caterpillar 3512 B V12 diesel engines that each produced 1185.5 kilowatts at 1200 revolutions per minute
Service speed	12 knots
Owner/Operator	Coral Princess Cruises
Port of registry	Cairns, Australia
Crew	27

Incident particulars

Date and time	19 February 2009 at 1010[1]	
Location	Port of Napier	
Persons on board	crew:	27
	passengers:	46
Injuries	crew:	one fatal
	passengers:	nil
Damage	nil	

[1] Times in this report are New Zealand Daylight Time (UTC + 13 hours) and are expressed in the 24-hour mode.

1. Executive summary

General

1.1. On 19 February 2009, the Australian-registered passenger ship *Oceanic Discoverer* was at its berth in the New Zealand port of Napier. The crew were conducting a fire and emergency drill, of which part was to close and test the hydraulically closed watertight doors.

1.2. The master closed the watertight doors remotely from the bridge. Some minutes later the chief engineer opened the watertight door to the engine room, but for some reason he became trapped by the door as he passed through the doorway. The chief engineer was trapped in the door for more than 8 minutes before he was found and the crew were able to free him. He was resuscitated but never regained consciousness and later died in hospital.

1.3. The watertight doors were normally set in the local-control mode, which meant that they would not automatically close after someone had walked through. At the time of the accident the doors were in the remote-close mode, which meant they would automatically close when the user released the opening handle. The crew on board the *Oceanic Discoverer* routinely passed through the watertight doors without fully opening them when the doors were in the local-control mode, a practice that was probably followed when the doors were in the remote-close mode as well.

1.4. The chief engineer possibly tried to pass through the door before it was fully open, and for some reason it began closing and trapped him.

1.5. The door had been set to close at twice the allowable closing speed, which would have likely contributed to the accident. It is possible that the audible alarm warning that the door was closing, was not working at the time. A failure of the audible alarm may have contributed to the accident.

1.6. The watertight door did not comply with the minimum requirements of the International Convention for the Safety of Life at Sea, 1974, as amended (SOLAS). The safety management system on board did not ensure that the watertight doors were maintained in a condition consistent with the regulations or good marine engineering standards.

1.7. The procedures for operating the watertight doors were the same for both modes of operation, even though the remote-close mode carried a much greater risk. This report discusses the inconsistency in advice given by the International Maritime Organization (IMO) and various maritime Administrations, and discusses the efficacy of trying to address a serious maritime safety issue with one recommended procedure when the safety issue spans a diverse number of systems and problems.

1.8. Recommendations were made to the Director of Maritime New Zealand to address with the IMO the issue of watertight door safety, and the Chief Executive Officer of the Australian Maritime Safety Authority (AMSA) to address issues with the safety management system on board the *Oceanic Discoverer*.

1.9. A recommendation was also made to the manufacturer of the watertight doors to address possible design issues with the watertight doors. This recommendation was copied to the International Association of Classification Societies (IACS) so that its member surveyors could be alerted to the safety issues identified in this report and begin monitoring for these when conducting watertight door surveys and tests.

Safety lessons

1.10. These are the generic lessons arising from the inquiry:

- always fully open a watertight door before passing through the doorway when the door is in the remote-close mode
- the faster the door closes, the greater the risk. Under no circumstances should watertight doors be set to close faster than the maximum allowable speed

- ship operators should adopt specific procedures for operating watertight doors in both local-control and remote-close modes. The procedures should be compatible with the doors' purpose and design, and the frequency with which they are used

- legislation governing the design and use of watertight doors should be flexible enough to achieve appropriate procedures for the use of any watertight door in any mode

- poorly maintained watertight doors are dangerous. Shipboard planned maintenance systems should be designed and followed to ensure that watertight doors are maintained in accordance with manufacturers' instructions, and in accordance with good standard marine engineering practice.

2. Conduct of the inquiry

2.1. The Transport Accident Investigation Commission (Commission) was notified of the accident on board the *Oceanic Discoverer* on 19 February 2009, the day the accident happened.

2.2. The accident was a very serious casualty as defined in the IMO Casualty Investigation Code, and was therefore one that under the Code the Flag State Australia would normally be required to investigate. The IMO Casualty Investigation Code at that time had not been ratified, so in the interim States had been invited to implement it on a voluntary basis.

2.3. The Commission notified the Australian Transport Safety Bureau (ATSB) of the accident and it was agreed that New Zealand as the Coastal State would lead the investigation with the assistance of the ATSB.

2.4. The Commission then opened an inquiry under Section 13 1(b) of the Transport Accident Investigation Commission Act and appointed an investigator in charge.

2.5. A team of 3 investigators attended the ship that same day, and during the course of the following 2 days interviewed crew members, acquired relevant on-board documentation, retrieved data from the ship's voyage data recorder, and inspected and made a number of tests on the watertight door.

2.6. The Commission researched the subject of accidents involving watertight doors worldwide and considered the various levels of international and State regulation. The Commission also referred to previous accident reports involving watertight doors.

2.7. During the course of the investigation, the appointed investigator in charge changed twice owing to staff movements.

2.8. On 22 June 2011 the Commission approved a draft final report to be sent to interested persons for comment. A copy of the draft final report was also sent to the ATSB for comment.

2.9. The Commission received several submissions from interested persons, and those submissions have resulted in some changes to the draft final report.

2.10. The Commission approved the final report for publication on 24 November 2011.

3. Factual information

3.1. Narrative

3.1.1. The voyage data recorder provided a time-stamped record of events, such as a radio log and watertight door open/closed status. The time-dependent data presented here is derived from the voyage data recorder output.

3.1.2. At about 0730 on 19 February 2009 the passenger vessel *Oceanic Discoverer* berthed at the Port of Napier.

3.1.3. At 1001 on the bridge, the master made an announcement over the public address system (PA) that a crew-only emergency drill would be taking place and that no passenger participation would be required. Soon afterwards, at 1002, the master sounded the emergency signal and the crew assembled at their designated muster stations.

3.1.4. Following the muster, one crew team started to run out fire hoses as part of a fire drill. At 1003 the chief engineer started the general service (GS) pump for the fire hoses.

3.1.5. At 1006 the master made an announcement on the PA that he was about to close the power-operated watertight doors and that personnel should stand clear. He then operated the master switch on the bridge operating station and the doors closed (see Figure 1).

3.1.6. At 1008 the first mate told the master that the 2 fire hoses were charged. The hose from the garbage room hydrant was hammering.

3.1.7. The chief engineer, who had just come out of the engine room, discussed the water hammer with the first mate and second engineer. The 3 of them went down the stairs and into the garbage room to investigate the hammering. The chief engineer told the second engineer to go into the engine room and look at the GS pump. The first mate later said that when the second engineer walked through the watertight door, their conversation was interrupted by the watertight door alarm.

3.1.8. The first mate returned to C Deck to close up the fire drill, leaving the chief engineer at the bottom of the stairway next to the engine room entrance. The first mate told the master via radio that they had completed the fire segment of the drill.

3.1.9. Just before 1010 and less than 20 seconds after the second engineer had gone through the watertight door into the engine room, the watertight door opened again and did not re-close. At 1010 the first mate called the chief engineer asking him to turn off the GS pump, but no response was heard.

Inside the engine room (forward of the watertight door)

3.1.10. After looking at the GS pump, the second engineer turned around and saw the chief engineer trapped in the watertight door. He tried to open the door by operating the handle, but found that it was hitting the right shoulder of the trapped man.

3.1.11. The second engineer saw someone on the other side of the door through the gap between the door and the door jamb. The other person had raised the alarm. The second engineer fetched a spanner and started to remove the watertight door handle from its shaft; it was loosened, which enabled more movement but not enough to open the door.

3.1.12. Some crew members entered the engine room through an emergency access to assist the second engineer. Before completely removing the bolt holding the handle to the shaft, the second engineer was called away to help with other remedial actions.

3.1.13. Along with other remedial actions, one crew member was tasked with releasing the lower hydraulic ram on the door.

3.1.14. At 1018 the lower hydraulic ram was removed from the door, thus allowing the door to be pushed aside to free the chief engineer.

Outside the engine room (aft of the watertight door)

3.1.15. A short time after the first and second mates had returned to C Deck, the second mate went back down to the garbage room to inspect the fire hose. As the second mate neared the bottom of the steps he noticed that there was someone in the doorway. The second mate soon realised that the person was the chief engineer and that he was trapped in the watertight door. The second mate immediately tried, without success, to open the door using the handle.

3.1.16. The second mate raised the alarm; the master who was on C Deck came down the stairs to investigate then returned to C Deck to request first aid and resuscitation equipment. The master also requested calls to emergency services for fire and ambulance and he sent one of his crew to ask for a medic from a navy ship that was close by.

3.1.17. Various unsuccessful attempts were made to open the door, including using the alternative handles for the hydraulic system of the door.

3.1.18. The master went to the bridge to switch the door system to local-control operation.

3.1.19. The first aid equipment was assembled and the paramedics from the naval vessel arrived on the scene.

3.1.20. When the door ram had been removed, the chief engineer was carried up to C Deck where attempts were made to resuscitate him. When the ambulance paramedics arrived, they managed to revive him and he was taken to Hawke's Bay Hospital.

3.1.21. On 9 March 2009 the chief engineer died without regaining consciousness.

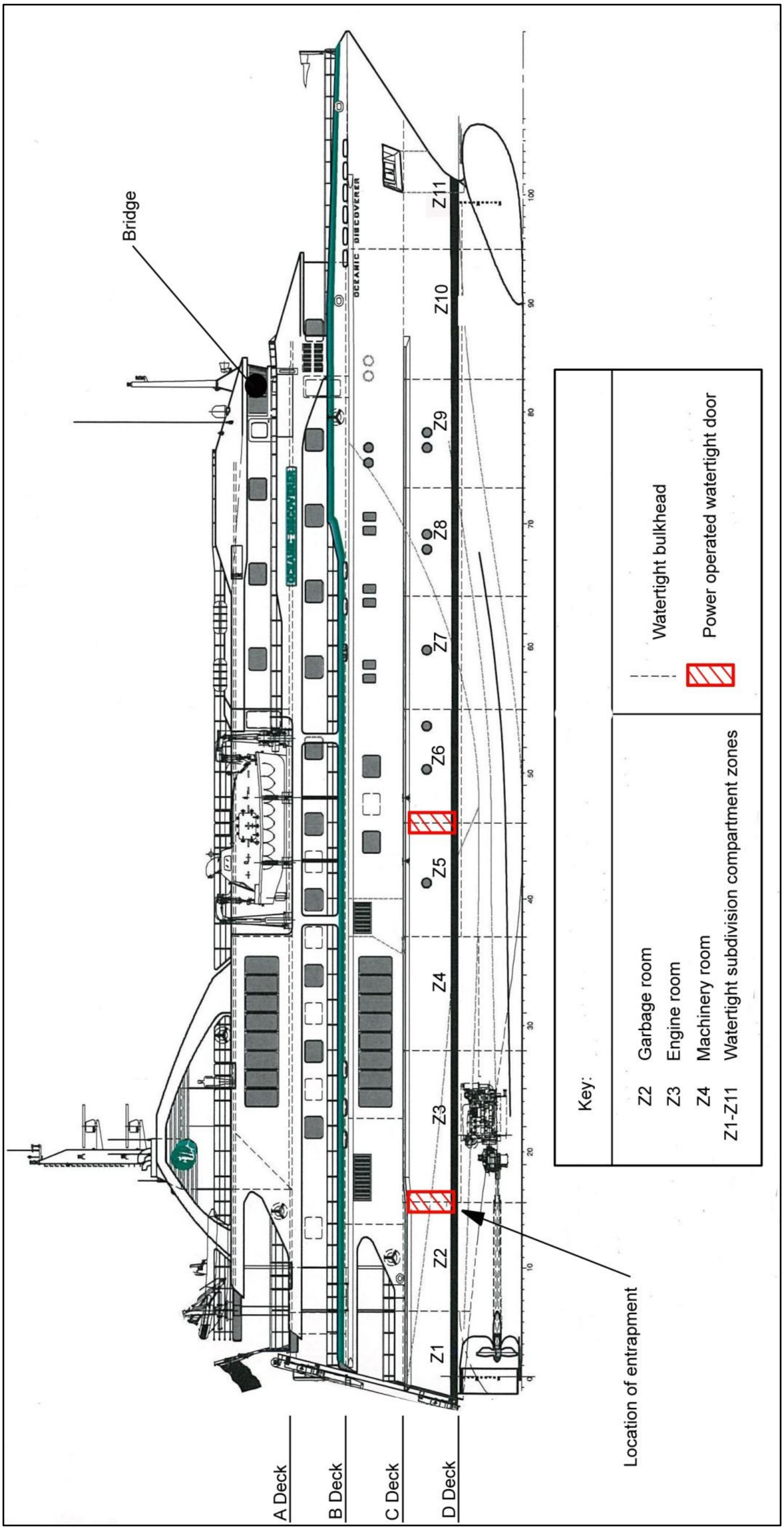

Figure 1
General arrangement of the *Oceanic Discoverer*
(adapted from NQEA Australia PTY Limited. Drawing 02 004-0002-F)

3.2. Vessel information

3.2.1. The passenger ship *Oceanic Discoverer* was owned by Coral Princess Cruises of Cairns, Australia. It had been purpose built in 2005 by NQEA Australia Pty Limited. The ship held valid certification issued by the Government of Australia or under its authority by the ABS classification society for a passenger vessel under SOLAS.

3.2.2. The general particulars of the *Oceanic Discoverer* can be seen at the beginning of this report.

3.3. Personnel information

3.3.1. The ship had a crew of 27 at the time of the accident. The crew was made up of the master, the first and second mates, the chief engineer with first and second engineers, and 21 others.

3.3.2. The chief engineer (who was trapped in the door) had first joined the *Oceanic Discoverer* on 25 May 2006, and by 9 July 2007 he had completed the orientation checklist. He held a current engineer class 2 certificate of competency, which allowed him to serve as a chief engineer on ships with up to 3000 kilowatts main engine power.

3.4. Watertight doors on *Oceanic Discoverer*

Design and construction of doors

3.4.1. A key provision of SOLAS was that a passenger ship was required to be divided by watertight bulkheads into a number of watertight compartments. This ensured that if one compartment were breached, flooding would be restricted and the ship would remain afloat.

3.4.2. Watertight doors were fitted in bulkheads where it was necessary for personnel to pass through the bulkheads. The doors were watertight when closed, thus maintaining the watertight integrity of the subdivision. Door designs varied depending on the application and could be manually operated doors with simple hinge designs or power-operated doors with local and remote controls.

3.4.3. The *Oceanic Discoverer* had both manual- and power-operated watertight doors. The *Oceanic Discoverer*'s power-operated watertight doors were electro-hydraulic. An electrical pump was used to accumulate hydraulic pressure, which was then used via hydraulic rams to move the door.

3.4.4. The IMO advised that power-operated watertight doors were designed to be remotely closed in a short period of time, with a magnitude of force sufficient to close the doors against their own weight when the ship was listing 15 degrees to either side and also against any water that might be flowing through the doorways. Watertight doors could also be closed to maintain the integrity of a fire subdivision.

3.4.5. The operation of a watertight door involves danger to persons passing through the closing door, and injury or loss of life is likely to occur to anyone who is trapped in the door when it closes. The audible alarm that sounds for a few seconds before the door starts moving, and continues sounding while the door is in motion, is intended to reduce the human element risk (International Maritime Organization, 2010).

3.4.6. Under SOLAS there were requirements governing the use of watertight doors during the operation of ships with respect to maintaining watertight integrity (International Maritime Organization, 1994). In a collision a ship could sustain structural damage that could potentially prevent an open watertight door being closed. At the time of build the shipyard provided a flooding damage control booklet (NQEA Engineers and Shipbuilders, 2005).

3.4.7. The power-operated watertight door where the accident occurred was one of 2 identical electro-hydraulic sliding doors on the ship, as shown in Figure 1. Designed by the Norwegian company IMS AS, the doors had been manufactured and supplied by a subsidiary of the company based in the United States of America. The doors had been constructed to SOLAS Part B Chapter II-1 Regulation 15.

3.4.8. The manufacturer supplied the 2 electro-hydraulic watertight doors to the shipyard part assembled. Along with the actual doors, it supplied 2 additional hand pumps for remote closing with close/open indication, a control cabinet, a control panel and mimic, a user manual and installation documentation.

3.4.9. The manufacturer advised the Commission that a function test plan was followed by IMS AS prior to shipping the doors to its customers; some of the tests were simulated. Final adjustments and acceptance tests (including door operating speeds) could not be completed until the doors had been installed by the shipyard. The tests were completed to the satisfaction of the Administration and classification society ABS. The test procedure was included in the documentation provided by IMS AS for the shipyard.

3.4.10. Each of the 2 electro-hydraulic sliding watertight doors on the *Oceanic Discoverer* had an independent hydraulic system with an electrical supply from the emergency switchboard. A hydraulic pump and accumulator maintained hydraulic pressure in the system and the capacity of the accumulator was designed to perform 3 full movements of the door in the event of a power failure (for example, fully open, fully close and fully open the door).

Maintenance of the watertight doors

3.4.11. The door manufacturer recommended a comprehensive maintenance programme for the watertight doors, which included weekly and monthly tests. The weekly tests had to include a functional test, which involved checking the closing speeds of the watertight doors. The functional test procedure booklet supplied by the manufacturer included a sample test sheet (for use by the operator), which prompted a check of the closing door time (i.e. "closing time 20 <t<40"). However, there was no evidence that this functional test sheet had been used in the maintenance system on board the vessel.

3.4.12. Further, the planned maintenance system on board the *Oceanic Discoverer* did not include any weekly test of the watertight doors, and the doors were not included in the list of critical machinery/equipment/systems. Instead, the planned maintenance system included a monthly maintenance task listed as "greasing". The maintenance engineers' instruction sheet for this task included the instruction "Lube, check operation of weather/watertight doors and hatches…; ensure door closes properly…". It also made reference to a "comprehensive manual located in the engine room".

Operation of the doors

3.4.13. A schematic drawing and photographs of the door are shown in Figure 2. The doors were opened and closed using operating handles, and could also be controlled remotely. In its neutral position the operating handle was vertical and held there by a spring. To open the door the handle was rotated 90 degrees from vertical in the direction of opening, as seen in Figure 2 (a). To close the door the handle was rotated 15 degrees from vertical in the direction of closing (b). If the handle was released, the spring would return it to its neutral position.

3.4.14. Manufacturer-supplied operating instructions were posted at the door itself, as shown in Figure 3 and Figure 4.

3.4.15. The door was held closed by a mechanical lock. When the operating handle was rotated in the opening direction, approximately the first 70 degrees of rotation served to disengage the mechanical lock. The hydraulic pressure would be directed to open the door once the handle was rotated to 90 degrees.

3.4.16. The mechanical lock was designed to engage after the door reached the full close position. The purpose of this was that in the event of a loss of pressure in the hydraulic system, the door would be retained in the closed position even if the ship was rolling violently. On the accident door the lock did not engage and it is possible that it had been that way since commissioning.

3.4.17. When the door was in the opening position, its operating handle protruded into the doorway as seen in Figure 2 (a). Thus when opening the door a person could see the handle on the other side of the doorway in order to reach through to hold the handle before transit.

3.4.18. In the event of electrical failure and empty accumulator, the door could be activated using a manual pump (its handle is shown in Figure 2).

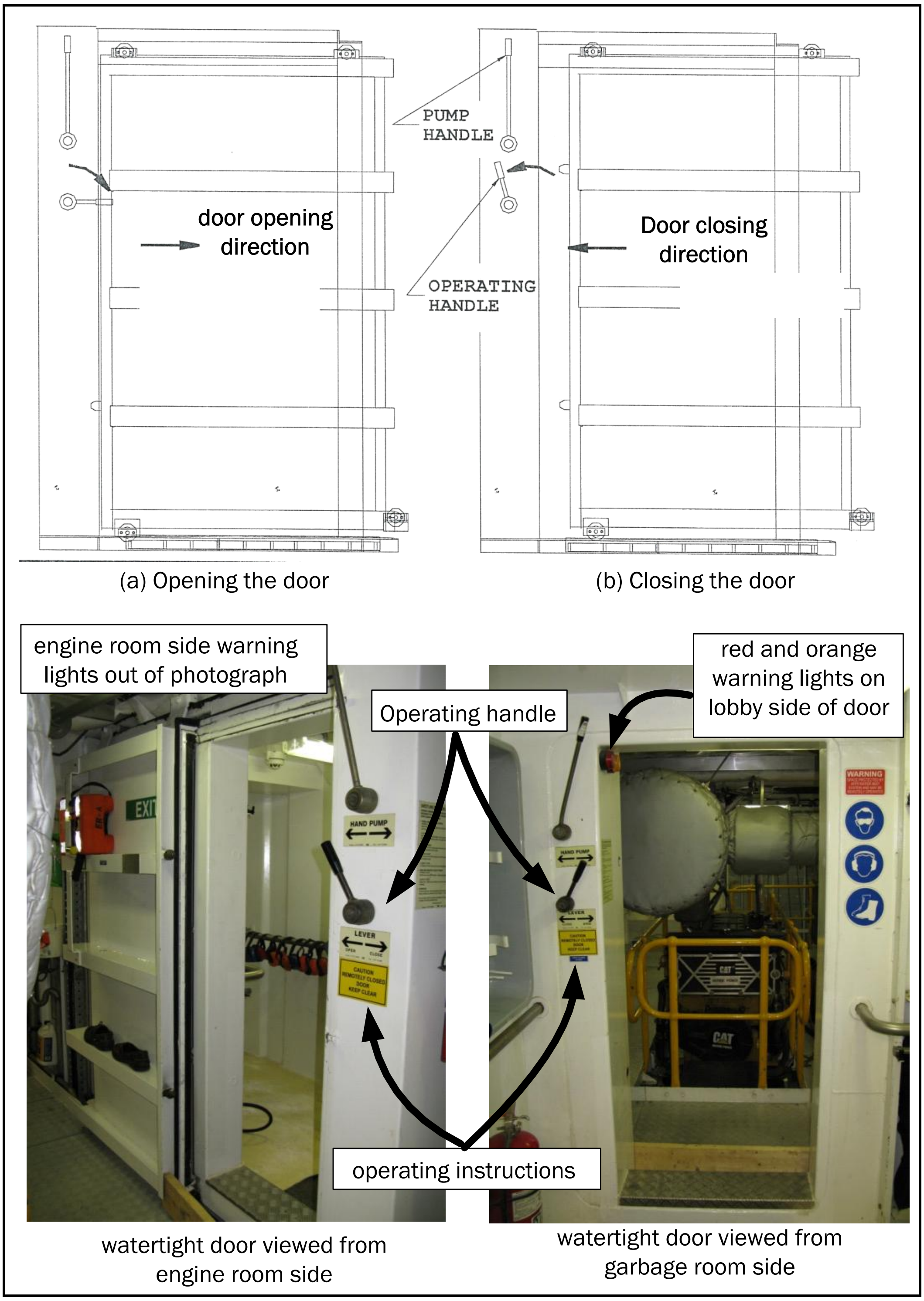

Figure 2
Operating controls and indicators for the watertight door

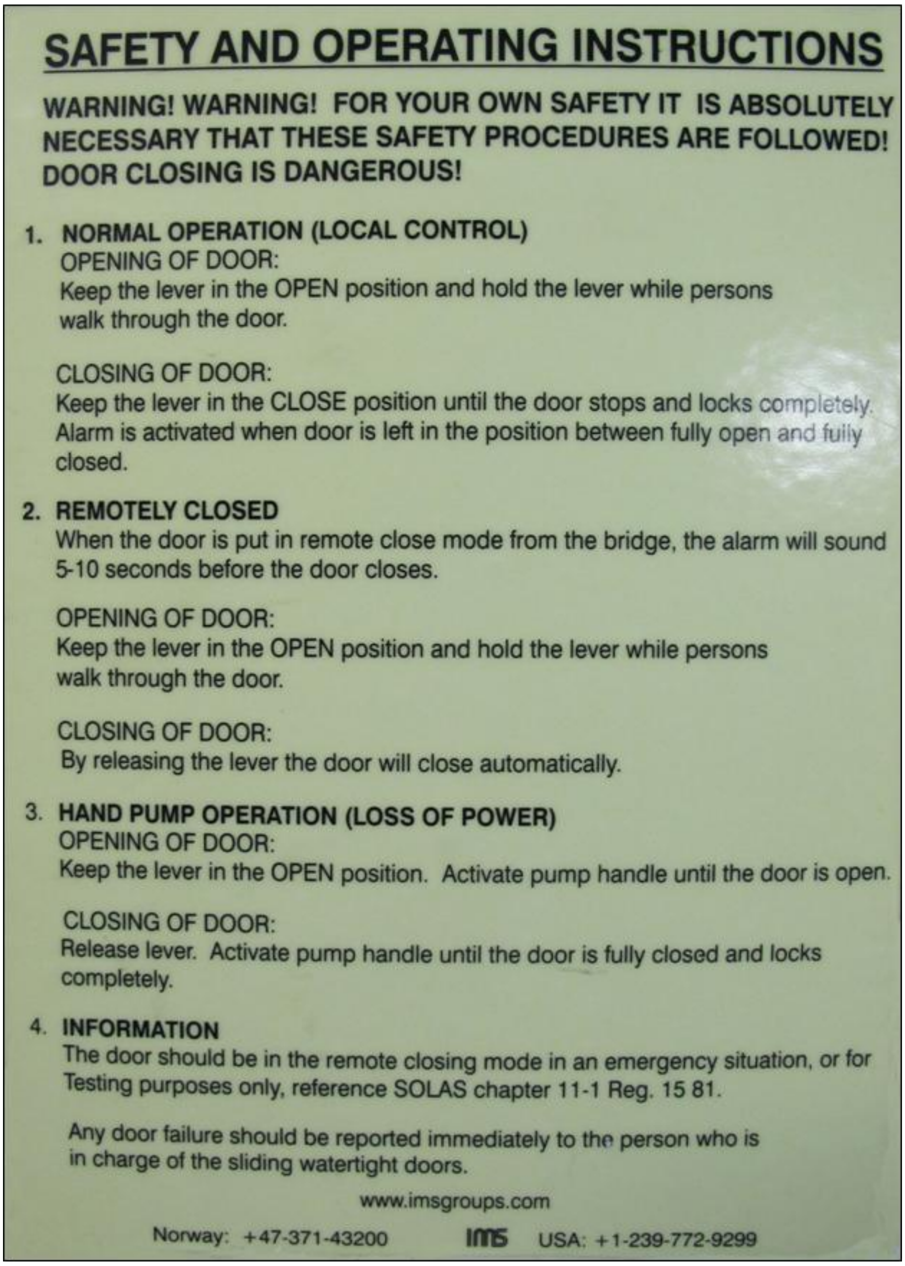

Figure 3
Safety and operating instructions attached to door jamb

3.4.19. The aft watertight door (that trapped the chief engineer) had an additional emergency control station located at the entrance to the stairwell on C Deck. The station could be used to close the door, not open it.

3.4.20. The electro-hydraulic sliding watertight doors could be operated in one of 2 modes; the mode of operation was selected from an operating station located on the bridge of the ship, as seen in Figure 1. The 2 modes of operation were “local-control” and “remote-close”; their differences are shown in Table 1.

3.4.21. The watertight door control panel located on the bridge is shown in Figure 5. A master control switch on the control panel could set both doors to local-control or remote-close mode. Alternatively the doors could be independently set to either mode by using the separate door switches (DOOR 1 and DOOR 2) shown in Figure 5.

3.4.22. The bridge operating station had a bi-colour light for each door to show its status: red for an open door and green for a closed door. A system fault with a particular door was indicated by the illumination of a separate yellow light along with an audible alarm.

Door parameter	Mode of door operation	
	Local-control	Remote-close
Door movement	Door would respond to operating handle as outlined in 3.4.11. When the operating handle was in neutral position the door would not move.	Door automatically closed unless operating handle was held in door opening position.
Warning lights at the door (seen in Figure 4)	Orange warning light flashed when door was stationary and not fully open or fully shut. Light would not operate when door was moving.	If the door was not fully shut when the door was switched to remote-close mode then the orange warning light would flash for 5 to 10 seconds before the door started to close. In remote-close mode a red light fitted on both sides of the door flashed continuously regardless of the door's position or movement.
Audible alarm (siren) at the door	Audible alarm operated when door operating handle was in neutral position while door was neither fully open nor shut. Alarm would not operate when door was moving.	If the door was not fully shut when the door was switched to remote-close mode then the audible alarm would operate for 5 to 10 seconds before the door started to close

Table 1
Table showing differences between the 2 modes of door operation

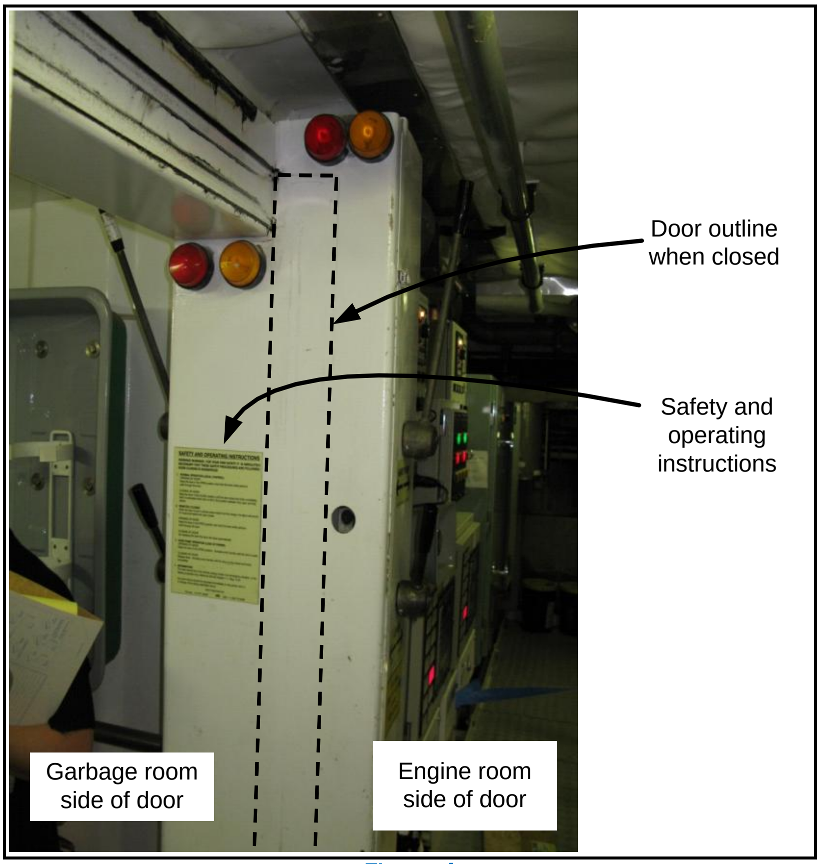

Figure 4
Warning lights on door

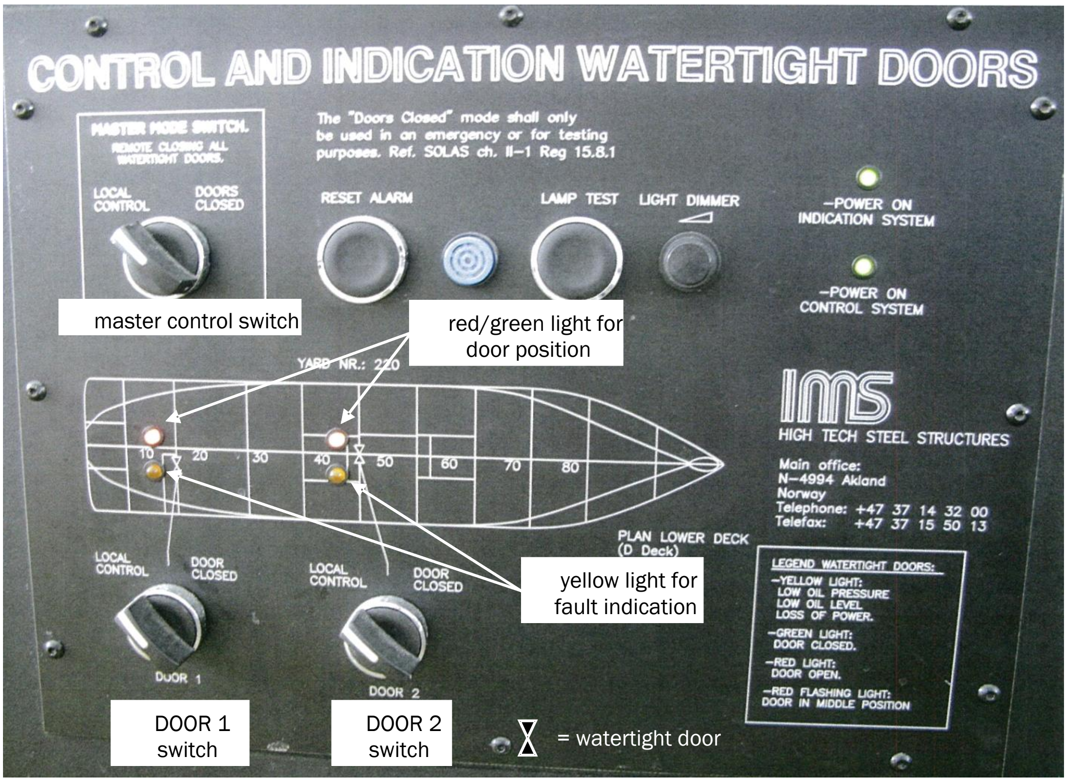

Figure 5
Power-operated watertight door control panel on bridge

3.5. Legislation surrounding watertight doors

3.5.1. The *Oceanic Discoverer* was a SOLAS[2] ship and at the time of build was subject to the SOLAS requirements for watertight doors, which were contained in SOLAS 94/95 as amended Chapter II-1 Construction: structure, subdivisions and stability, machinery and electrical installations (International Maritime Organization, 1994). These requirements included the design, construction and operational requirements for power-operated watertight doors.

3.5.2. SOLAS 94/95 as amended, Chapter II-I Regulation 13 Openings in watertight bulkheads below the bulkhead deck in passenger ships part 7.4 stated:

> Control handles shall be provided at each side of the bulkhead at a minimum height of 1.6 m above the floor and shall be so arranged as to enable persons passing through the doorway to hold both handles in the open position without being able to set the power closing mechanism in operation accidentally. The direction of movement of the handles in opening and closing the door shall be in the direction of door movement and shall be clearly indicated.

3.5.3. SOLAS 94/95 as amended Chapter II-1 Regulation 15 was applicable to ships constructed after 1 February 1992 and included the following regulations for power-operated watertight doors on passenger ships. Regulation 15.7 referred to power-operated sliding watertight doors and stated in part that each power-operated sliding watertight door:

> … shall be provided with controls for opening and closing the door by power from both sides of the door and also for closing the door by power from the central operating console on the bridge.
>
> shall be provided with an audible alarm, distinct from any other alarm in the area, which will sound whenever the door is closed remotely by power and which shall sound for at least 5s [seconds] but no more than 10 s before the door begins to

[2] A ship engaged on international voyages.

> move and shall continue sounding until the door is completely closed. In the case of remote hand operation it is sufficient for the audible alarm to sound only when the door is moving. Additionally, in passenger areas and areas of high ambient noise the Administration may require the audible alarm to be supplemented by an intermittent visual signal at the door.
>
> shall have an approximately uniform rate of closure under power. The closure time, from the time the door begins to move to the time it reaches the completely closed position shall in no case be less than 20s or more than 40s with the ship in an upright position.

3.5.4. These operating times were a compromise between minimising progressive flooding while the door was open and minimising the risk to crew transiting the door. This safety margin was intended to allow crew the opportunity to extricate themselves from the path of a closing door. There is no reference to opening speed or time.

3.5.5. Regulation 15.8 set out the requirements for central operating consoles on the bridge:

> 15.8.1 The central operating console at the navigating bridge shall have a master switch with two modes of control: a "*local-control mode*" mode which shall allow any door to be locally opened or closed after use without automatic closure, and a "doors closed" mode which shall automatically close any door that is open. The "doors closed" mode shall permit doors to be opened locally and shall automatically reclose the doors upon release of the *local-control mode* mechanism. The "master mode" switch shall normally be in the "*local-control mode*" mode. The "doors closed" shall only be used in an emergency or for testing purposes. Special consideration shall be given to the reliability of the "master mode" switch.
>
> 15.8.2 The central operating console at the navigating bridge shall be provided with a diagram showing the location of each door, with visual indicators to show whether each door is open or closed. A red light shall indicate a door is fully open and a green light shall indicate a door is fully closed. When the door is closed remotely the red light shall indicate the intermediate position by flashing. The indicating circuit shall be independent of the control circuit for each door.
>
> 15.8.3 It shall not be possible to open any door from the central operating console.

3.5.6. In May 2005 the IMO Maritime Safety Committee (MSC) issued circular MSC 1176, which set out proposed amendments to SOLAS Chapter II-1 with respect to watertight door design and testing. Section 8 of the circular part 3 Indication, regulation 3.4.3 stated:

> An indication (i.e. a red light) should be placed locally showing that the door in remote control mode ("doors closed mode"). Refer also to SOLAS regulation II-1/15-8.1. Special care should be taken in order to avoid potential danger when passing through the door. Signboard/instructions should be placed in way of the door advising how to act when the door is in "doors closed" mode.

3.5.7. In December 2006 the IMO MSC passed resolution MSC.216 (82), bringing into force on 1 January 2009 the amendments that had been set out in MSC circular 1176 (IMO, 2002). These amendments did not include regulation 3.4.3 above or any other requirements for indication on watertight doors.

3.5.8. Under the International Safety Management Code (ISM Code) (International Maritime Organization, 2010a) the owner of the *Oceanic Discoverer* was required to:

- have a safety management system to establish safeguards against all identified risks
- ensure that training was provided for all personnel concerned and ensure that such training was documented
- ensure compliance with mandatory rules and regulations and that applicable codes, guidelines and standards recommended by the IMO, Administrations, classification societies and maritime industry organisations were taken into account.

3.5.9. The International Convention on Standards of Training, Certification and Watchkeeping for Seafarers 1978, as amended (STCW Convention) (International Maritime Organization, 2005) set out standards for the training and certification of seafarers. Under the STCW Convention Chapter VI, it was a requirement that seafarers received familiarisation and basic safety training or instruction on emergency, occupational safety, medical care and survival functions.

3.5.10. The Seafarers' Training, Certification and Watchkeeping Code (STCW Code) (International Maritime Organization, 2005) supported the STCW Convention and set out the minimum mandatory requirements of this training. Chapter VI section A-VI/1 Part A of the STCW Code concerned familiarisation training and stated in part:

> 1. Before being assigned to shipboard duties, all persons employed or engaged on a seagoing ship other than passengers, shall receive approved familiarization training in personal survival techniques or receive sufficient information and instruction, taking into account of the guidance given in Part B, to be able to:
>
> .7 close and open the fire, weathertight and watertight doors fitted in the particular ship other than those for hull openings.

3.5.11. The IMO issued a marine guidance note (MGN 35) in October 1999 related to the safety of watertight doors. MGN 35 superseded marine safety notice (MSN) 1326 issued in 1988, although it did contain similar wording and intent. With respect to door operation MGN 35 stated:

> 2.1 It is essential therefore that when using a watertight door which has been closed, irrespective of the mode of closure, that both the local controls – one on each side of the bulkhead – are held in the "open" position while passing through the door. That can be done by first fully opening the door using the nearside control with one hand, reaching through the opening to the control on the far side and using the far side control to keep the door fully open until passage is complete.

3.5.12. The recommendation of MGN 35 that the door be fully open before a person walked through it is reflected in the United Kingdom's Code of Safe Working Practice (COSWP) for seafarers.

3.6. Procedures on board the *Oceanic Discoverer* for power-operated watertight doors

3.6.1. The *Oceanic Discoverer* was registered in Cairns, Australia. The Occupational Health and Safety (Maritime Industry) Act 1993 set out the responsibilities of Australian ship operators and employees with respect to occupational health and safety. The COSWP for Australian seafarers (Australian Government, 1999) provided broad guidance on the minimum requirements for protecting seafarers' health and safety as prescribed under the 1993 Act.

Section 9.3 of the COSWP for Australian seafarers gave guidance on watertight doors and stated:

> 9.3.1 All seafarers who might use watertight doors should be instructed in their safe use.
>
> 9.3.2 Power-operated watertight doors can be closed from the bridge and particular care should be taken when using such doors. If opened locally under these circumstances, a door will re-close automatically and crush anyone in its path as soon as local-control mode has been released. Both hands are usually required to operate the local-control modes, and for this reason no person alone should attempt to carry any load through such doors. The bridge should be notified whenever such doors are opened and immediately after they are closed.
>
> 9.3.3 Notices clearly stating the method of operating the local-control modes of watertight doors should be prominently displayed on both sides of the doors.
>
> 9.3.4 No attempt should be made to pass through a watertight door when it is closing or when the warning alarm is sounding.
>
> 9.3.5 Whenever a watertight door is energised, and under remote control transit is not allowed. If it is necessary to leave the area confined by such doors, emergency exits shall be used. A warning to that effect shall be displayed at the local operating point.

3.6.2. Through similar provisions to those in Australia, the New Zealand COSWP for Merchant Seafarers 2007 (Maritime New Zealand, 2007) gave guidance to incumbent New Zealand ship operators and seafarers with respect to occupational health and safety. The wording and intent of the New Zealand Code were similar to those of the Australian one for the safe operation of watertight doors.

3.6.3. Crew new to the *Oceanic Discoverer* were required by the ship management company to undergo familiarisation training before they could undertake their duties on board. All crew were required to be trained in the operation of the power-operated watertight doors, because all of them could have been required to use the power-operated watertight doors in their day-to-day routines or in an emergency situation.

3.6.4. As mentioned earlier, the chief engineer had completed his induction when he joined the ship in the rank of first engineer. In subsequent voyages when he served in the capacity of chief engineer, he had been responsible for the maintenance of the watertight doors on board the vessel and expected to give instruction to crew members on their safe operation.

3.6.5. The instruction on how to provide familiarisation for the watertight doors was given in the training manual as follows:

> A short explanation on the operation of the watertight doors and the possibility of them being remotely operated from the bridge, impress on them the importance of leaving the door closed and using another means of escape if necessary.

The crew who were spoken to said that the familiarisation process impressed on them the danger posed by using the doors, and also included a discussion on how to use them.

3.7. Watertight door usage on the *Oceanic Discoverer*

3.7.1. Both power-operated watertight doors on the *Oceanic Discoverer*, including the accident door, were normally kept closed and in local-control mode.

3.7.2. The aft watertight door was frequently used to access the engine room by the ship's crew. Post-accident interviews with the crew indicated that the normal method of transiting the closed door was to open the door wide enough to let the person pass through. They would then reach through the gap in the doorway, grip the open-close lever on the other side of the door and hold it down before passing through. Once through the door they would use the lever to close the door behind them.

3.7.3. The *Oceanic Discoverer*'s voyage data recorder yielded 18 hours of watertight door usage leading up to the accident. In that time the door was opened 39 times. This data was used to construct a histogram to show how long the door was opened for, as seen in Figure 5. The data also demonstrated that the door was left closed as required under SOLAS regulations.

3.7.4. The data in the histogram confirmed the procedure the crew said they routinely used to pass through the accident door. Based on the tested door speed, it would have taken a minimum of about 20 seconds for a person to open fully, pass through and close the door. The histogram showed that 34 of the recorded 39 transits of the door were completed in 13 seconds or less. The door was opened for about 9 seconds when the second engineer went through it; less than 20 seconds later the door was used again by the chief engineer and he became trapped. The door would have opened approximately 42 centimetres (about halfway) when the second engineer went through it.

3.7.5. It was not determined which of these recorded transits, if any, were made by the chief engineer. However, as mentioned, the crew routinely went through the door in the same manner; the chief engineer did not advise them any differently and it is assumed that he routinely exhibited the same behavioural traits as the rest of the crew.

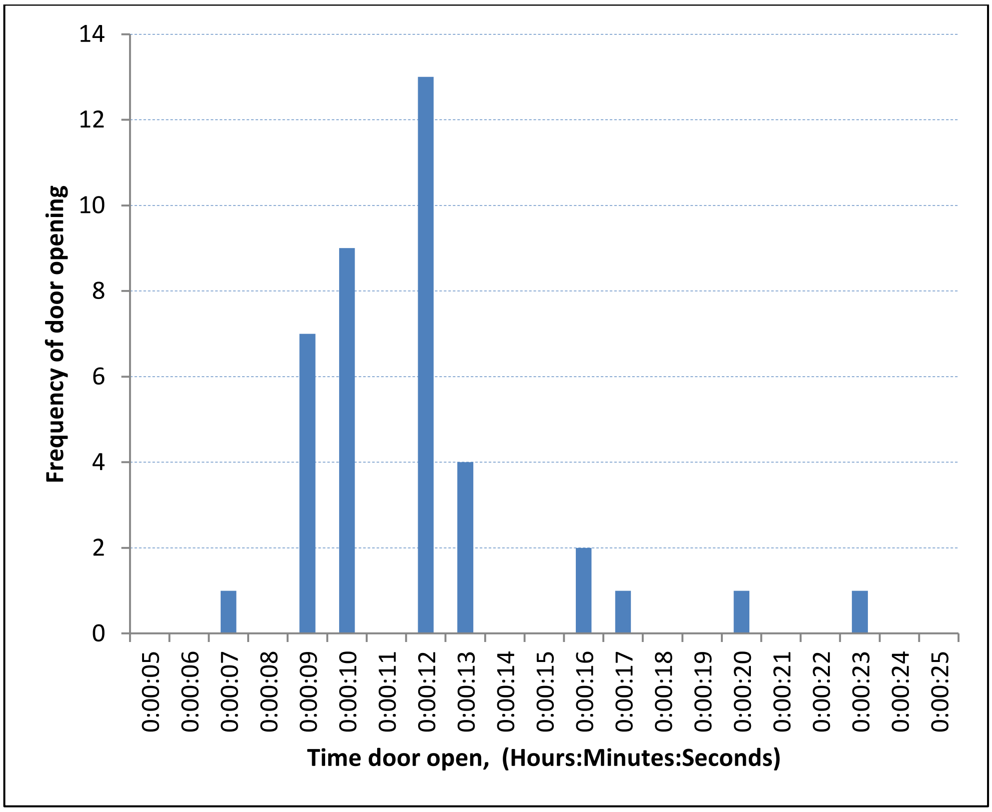

Figure 6
Histogram showing length of time door was opened during transits

3.8. Post-accident testing of power-operated watertight doors on *Oceanic Discoverer*

3.8.1. After the accident the engine room watertight door was electrically isolated and left undisturbed until investigators from the Commission attended the ship. Investigators reattached the disconnected door ram and examined the door and associated systems before conducting a function test of the door.

3.8.2. The following points were noted during the examination and function tests on the accident door:

- the door moved in the correct direction in relation to the operating handle
- it took on average 9.3 seconds for the door to travel from fully open to the closed position and similarly from the fully closed to the fully open position. Hence the door was closing within about half the minimum time recommended under the SOLAS regulations (20 seconds); see section 3.5.3. That is to say the door closed at about twice the speed it should have. The Commission was not able to determine how long the doors had been operating at this speed; it is possible that it had been like this since the ship started service, as the documentation at the ship trials did not record the operating time for the power-operated watertight doors
- the audible alarm fitted on the engine room side did not operate. The electrical connections were loose and there were non-standard repairs evident on the unit
- the red alarm light fitted on each side of the door operated correctly when the door was switched to remote-close from the bridge
- the orange alarm lights fitted on each side of the door operated correctly in both local-control and remote-close modes
- a load cell placed between the door and the door jamb recorded a closing force of about 16.19 kilonewtons (1650 kilograms)

- a non-standard repair was evident where the spring on the door operating lever had been replaced by a bungee cord
- the mechanical lock for keeping the door in the closed position was not latching correctly. It is possible that it had been this way since commissioning.

3.8.3. Tests on the open-close lever in both the remote-close and local-control modes showed the following:

- the door started to open when the lever was turned 90 degrees from the neutral position in the open direction
- the door started to close when the open-close lever was turned about 15 degrees from the neutral in the close direction.

3.8.4. It was noted that when the open-close lever was slowly released from the opening position of 90 degrees from vertical (the lever had a full travel about 100 degrees from vertical), there was a position at about 75 degrees where the door would start to close, whether in local-control or remote-close mode, as shown in Figure 7.

3.8.5. The other power-operated watertight door on board the ship was also examined and function tested. This door was found to be operating satisfactorily but, as with the engine room door, the door closing period was about 9 seconds or about half the recommended time under SOLAS regulations.

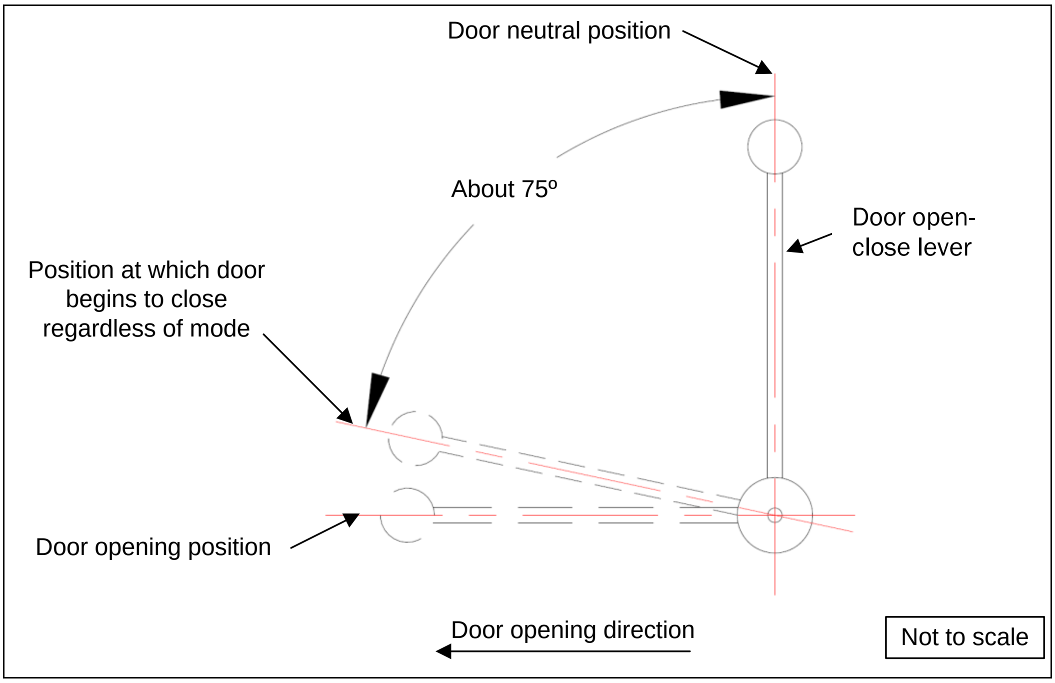

Figure 7
Diagram showing position of door handle where door begins to close regardless of mode

4. Analysis

4.1. Introduction

4.1.1. The watertight bulkheads on the *Oceanic Discoverer* were necessary for the ship to comply with the damaged stability requirements set by the IMO through SOLAS. They were necessary to divide the ship into enough watertight compartments so that if 2 were damaged through mishap, the ship would remain afloat. The watertight doors in these bulkheads were necessary to allow crew access between the watertight compartments for the normal day-to-day operation of the ship.

4.1.2. The fundamental purpose of the watertight doors therefore was to allow crew to pass between watertight compartments with relative ease and safety. An open watertight door was a risk to the ship because it was a breach in what should have been a watertight compartment. When considering whether a watertight door is fit for purpose, the design of the opening and closing system should be considered as well, because that is its main purpose.

4.1.3. The need to place openings in watertight bulkheads was not unique to the *Oceanic Discoverer*. Many other ships faced the same dilemma. To maintain the watertight integrity of the bulkheads, the doors had to be normally closed in case a collision or grounding damaged or distorted the structure around the door, preventing it being closed. The ship was therefore more vulnerable when the doors were open.

4.1.4. The watertight doors needed to be heavy and needed to be closed with some force to provide seals capable of matching the strength of the bulkheads. The doors then created a hazard capable of causing serious harm to anyone passing through them, and in fact there have been at least 13 recorded deaths in the past 21 years attributable to the use of watertight doors. To put this in perspective though, there are many ships operating around the world that have been designed with similar watertight doors and those doors will be used many times each day. The Commission has not attempted to quantify this number, but it would be safe to say that the number of people passing through watertight doors each day would be measured in thousands rather than hundreds.

4.1.5. The risk to people posed by watertight doors has been recognised for decades. The IMO standards for the design and operation of watertight doors recognised that risk and attempted to strike a balance between mitigating the risk to people and mitigating risk to the ship. The risk to people, however, still exists, so various administrations have issued guidelines to seafarers on the safe operation of watertight doors.

4.1.6. This report discusses:

- possible scenarios leading to the chief engineer becoming trapped in the door
- design features of the door that could have contributed
- maintenance issues with the door that could have contributed
- the various conflicting schools of thought from the IMO and other organisations on how the doors should be operated.

4.2. What possibly happened

4.2.1. No-one knows exactly what happened to the chief engineer because no-one saw him pass through the door. The investigation inquired into the health, fatigue and medical status of the chief engineer, but after careful consideration the Commission decided that none of these issues was likely to have contributed to the accident.

4.2.2. The chief engineer was trapped for just over a minute before his plight was noticed. Thereafter it took about 7 minutes to free him.

4.2.3. The medical reports show that it was the crushing force of the door preventing him breathing that resulted in severe cerebral hypoxia (reduced supply of oxygen to the brain), which rendered him unconscious. He was resuscitated on board before being transferred to hospital, where he was initially mechanically ventilated for several days.

4.2.4. The autopsy report said the cause of death was "hypoxic[3] ischaemic[4] encephalopathy[5] following a crush injury to the chest, abdomen and pelvis".

4.2.5. What we do know is that less than 20 seconds before becoming trapped, the chief engineer was standing outside the watertight door to the engine room. He then decided to pass through the watertight door to enter the engine room for some reason, and that was when he became trapped. The voyage data recorder showed the door opening and not closing again at that time.

4.2.6. The vessel was carrying out a fire drill. About 2 minutes before the chief engineer became trapped, the master made an announcement on the PA that he was going to close the watertight doors remotely, then did so. From that time a red light on either side of the door would have been flashing to alert anyone approaching the door that it was in remote-close mode. Both these flashing red lights were tested and found to be working after the accident.

4.2.7. The first mate said that a conversation with the chief engineer was interrupted by the watertight door audible alarm when the second engineer passed through the watertight door on his way to the engine room. The watertight door was in remote-close mode at that time so that would have been the indication that the door was closing automatically behind the second engineer, but to a passer-by it could equally have meant that the door operating handle had been returned to the neutral position and the door was neither fully open nor fully closed, if the door was in local-control mode.

4.2.8. What we do not know is whether this audible alarm was working at the time the chief engineer tried passing through the door, because it was tested and found to be **not** working after the accident.

4.2.9. The chief engineer was found trapped in the doorway with his back to the closing door, which would be the expectation because someone operating the open/close handles would do so while facing them. In other words the inclination would be to step sideways through the door. This would also be true if someone were going to pass through the door when the gap was narrow; before the door was fully open, for example.

4.2.10. The crew spoken to after the accident said that their normal method for passing through a watertight door was to open it just far enough to pass through the gap. They would then reach through to the operating handle on the other side and keep it in the opening position while they stepped through the doorway. This was the method they were taught on board, and was in conformity with the COSWP for Australian seafarers. The operator contended that the chief engineer would have also used this method, but no-one knows whether he did so at the time of the accident.

4.2.11. At times a person might simply release the handle and step through the doorway when the door was in the local-control mode, because the door would not automatically begin closing. This is discussed in more detail in section 4.5 Operation of the watertight doors.

4.2.12. We do not know whether the chief engineer knew that the watertight door was in the remote-close mode. He should have because that fact had been announced over the PA minutes earlier, and the red light at the top of the door jamb would have been flashing to alert him to the fact.

4.2.13. If the chief engineer thought that the watertight door was in the local-control mode, it is likely he would have opened and passed through the same way he always did. He would not therefore have been expecting the door to start closing automatically if and once he let go of the handle. If he had not reached through to the handle on the other side to continue the opening sequence as he passed through the door, or if his hand had slipped off the handle, the door would have immediately started closing on him from behind.

4.2.14. The chief engineer would have rarely used the door in remote-close mode because that mode was only used during drills and real emergencies. For this reason it is unclear what method he

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[3] Hypoxic means prolonged reduction of oxygen availability.
[4] Ischaemic means prolonged interruption of blood circulation.
[5] Encephalopathy means significant brain injury.

used to open and pass through the doorway at the time of the accident when the door was in remote-close mode. It is also unclear whether he would have done anything different owing to the mode the door was in.

4.2.15. A contributing factor to the chief engineer becoming trapped in the door was that once it had closed on his body he would not have been able to use the open/close handle to open the door. The handle's arc of movement was obstructed by his shoulder, the same problem faced by the other crew when trying to release him.

4.2.16. The speed at which the door closed was another factor that would have likely contributed to the chief engineer becoming trapped in the door. The closing speed had been set at more than twice the maximum allowed by SOLAS, thereby leaving him with less time to realise the door was closing and to jump clear.

4.2.17. There are 2 further factors that may have contributed to the accident. The first is that if the chief engineer had not fully opened the door before passing through it, he would have had less time to clear the door safely before becoming trapped. The second was that the audible alarm should have warned him that the door was closing. However, if it was not working at the time of the accident, the chief engineer would not have had that warning.

4.2.18. There was another factor that would not have contributed to the accident, and that was the peculiarity that when the operating handle was placed at about 75 degrees from vertical in the "opening" arc, the door would begin to close, even with the door in local-control mode (as shown in Figure 7). When the door was in local-control mode it should have remained stationary unless the handle was in the opening or closing position. Releasing the door handle from its opening position when in the local-control mode should have caused the door to stop and stay where it was. This was a serious design or maintenance fault. Anyone passing through the door in the belief that they were opening the door in local-control mode could have been caught out if they eased the downward pressure on the handle enough for it to take up the position at about 75 degrees from vertical (Figure 7). Instead of the door stopping where it was, it would have begun closing on them. The reason for this peculiarity not contributing to this accident was that the door was in remote-close mode, so the user would have been expecting the door to close automatically when the handle reached this position.

4.2.19. The Commission did not get a satisfactory answer from the manufacturer about this peculiarity. Its response was that it should or could not happen, yet when the Commission tested the same model door on a New Zealand-registered ship, the peculiarity was replicated.

4.2.20. The Commission has made a recommendation to the manufacturer to research the peculiarity and inform the industry of its findings.

4.2.21. Of the 5 factors discussed, one was an operational factor and the other 4 related to design or maintenance. The 2 aspects are discussed further below.

Findings

The chief engineer was rendered unconscious when he was prevented from breathing by the crush force of the watertight door in which he was caught. He later died.

The circumstances surrounding why the chief engineer became trapped in the door could not be established with any certainty because there were no witnesses to the accident.

The crew were not taught to and did not routinely open the watertight door fully before passing through the doorway, so it is possible that the chief engineer did not fully open the door on this occasion, which would have contributed to his becoming trapped.

The doors were set to close with a speed that was twice the maximum allowable under the SOLAS regulations, which would likely have contributed to the chief engineer becoming trapped.

A peculiarity where the watertight door could have self-closed even with it in the local-control mode would not have caused the chief engineer to become trapped because the door was in remote-close mode. However, the condition was a danger to crew at any time during normal shipboard operations.

4.3. Design issue

4.3.1. The way in which the watertight door operating handle protruded into the door frame created a risk to users of the door, and once the chief engineer became trapped was ultimately the reason why neither he nor anybody else could free him using the door operating handle.

4.3.2. The manufacturer's instructions for using the door were to open it with the operating handle on one side, then reach through and grab the connected handle on the other side to enable the user to continue opening the door until they had passed through the opening.

4.3.3. The operating handle was located and oriented so that, in the opening position, it was clearly visible to the user within the doorway. The problem this created was that if someone or some object were caught in the door, their presence could block the handle from being moved into the opening position. That was why the crew were initially unable to open the door. The operating handle was blocked by the chief engineer's chest, preventing it being moved into the open position.

4.3.4. The handle needed to be oriented in a position where it could be seen or easily located, but need not have been oriented so that it could be blocked by anything in the doorway. This was a design or installation error that needs to be rectified.

4.3.5. The crew member who was attempting to remove the operating handle from its spindle would have succeeded in allowing the door to be opened. Unfortunately he was directed to another remedial action before he could remove it. Whether the chief engineer would have survived had the crew member succeeded in removing the handle is a matter of medical speculation that the Commission sees no benefit in exploring. The crew were faced with an unusual and stressful situation and were making a valiant attempt to free the chief engineer from the door, which eventually they succeeded in doing.

Finding

The door operating handle protruding so far inside the watertight doorway space was an unnecessary design or installation feature that meant the chief engineer was not able to free himself when the door closed on him.

4.4. Maintenance issues and the safety management systems

4.4.1. The safety-critical purpose of the watertight doors and the hazards that they can pose to crew have been referred to above. The planned maintenance system on board the *Oceanic Discoverer* included a reference to watertight doors. The system referred to the more comprehensive manufacturer's instruction and maintenance manuals located in the engine room. The manufacturer's manuals gave a programme of monthly and weekly maintenance tasks to be carried out. Those tasks had not been transferred into the planned maintenance system, where the only action appeared as a tick against the fact that the manufacturer's manuals existed.

4.4.2. SOLAS required that a watertight door drill be held weekly. Records on board the vessel indicated that a weekly drill was planned, but the *Oceanic Discoverer*'s Official Log-Book indicated these were not always held. The door manufacturer also recommended various monthly and weekly maintenance tasks, including a weekly functional test. This test involved testing the door closing speed. It does not appear, however, that the weekly functional test was part of the planned maintenance system for the doors.

4.4.3. Following the accident the Commission observed staff working on the doors to rectify a number of faults. It was obvious from the condition of the panels that had to be removed to perform the checks, and how difficult they were to remove, that they had not been removed for a long time. The regular maintenance required by the manufacturer would have required the removal of the panels.

4.4.4. The post-accident inspection and testing of the watertight doors revealed a number of maintenance and operational deficiencies. Some of the deficiencies were serious, and would have contributed to the accident.

4.4.5. The most serious deficiency was the speed at which the doors had been set for opening and closing. Both doors on board had been set to operate at more than twice the allowable speed. A faster door operating speed meant that crew could move around between watertight compartments with more ease, but it also meant a greater risk to crew should something go wrong. The faster operating speed of the door would likely have been a factor contributing to the chief engineer becoming trapped in the door regardless of the circumstances. The door speed was adjusted to within allowable limits soon after the accident.

4.4.6. The door alarm was not working after the accident, which was another serious deficiency. The crew said it had been working earlier that day. The sound unit of the alarm had developed a fault that prevented it working. The electrical connection to the alarm was also faulty. It was not connected properly and the type of connector used was not compatible with the wiring. A new alarm had to be purchased to restore the audible alarm. If the alarm was not working at the time of the accident, it could have contributed to the accident.

4.4.7. Another serious deficiency found after the accident was that the locking mechanism for the door was not engaging. It could not be established how long it had been in that condition, although the mechanism did require adjustment to rectify the problem. This deficiency would have meant that, in the event of losing hydraulic pressure to the door, the door would have not remained closed against the movement of the vessel when at sea, as it was required to do. The operator contended that the mechanism could have been damaged as a result of the crew working to free the trapped chief engineer. The Commission considers this unlikely, as the mechanism was protected by a cover and not engaged or in the closed position during the rescue.

4.4.8. The spring that returned the operating handle to the neutral position had broken and been replaced with an elastic cord. A replacement spring was purchased following the accident to reinstate the system to its original state.

4.4.9. In summary, the condition of the watertight doors on board the *Oceanic Discoverer* did not comply with the various rules and regulations that they were required to. The manufacturer's instructions for maintenance and testing had not been followed and there were aspects of other maintenance carried out on the doors that did not meet good marine engineering practices.

4.4.10. The ship underwent several audits, surveys and other routine checks each year, designed to test systems and components. Some of these inspections were designed to check that policies and processes were in place to deal with all aspects of on-board safety; while others were designed to test standards and the operation of specific equipment where that equipment was safety critical, such as watertight doors.

4.4.11. The maintenance and testing requirements recommended by the manufacturer had not been properly entered into the ship's planned maintenance system. A robust safety management system is supposed to identify critical components and procedures and ensure that they are appropriately dealt with in the ship's normal operations. Equally, risks are supposed to be identified and either eliminated or mitigated. With respect to the watertight doors, this work had already been done for the operator through the lessons learned from previous accidents involving watertight doors, yet the company system was not dealing with the risk in an appropriate way. If this issue was an indicator of the health of the safety systems on board the *Oceanic Discoverer*, they probably need reviewing and upgrading before they meet the intent of the ISM Code.

Findings

The watertight doors on board the *Oceanic Discoverer* had not been maintained and tested in accordance with the manufacturer's instructions and did not meet the performance standards required by the IMO and the Flag State Administration.

The excessive closing speed of the watertight door was an issue of non-compliance with SOLAS that likely contributed to the chief engineer becoming trapped in the door.

The audible door closing alarm was not working after the accident. If it was not working at the time of the accident, that could have contributed to the chief engineer becoming trapped in the door.

The safety management system on board the *Oceanic Discoverer* did not deal in an appropriate way with the maintenance, testing and operation of the watertight doors, which were safety-critical apparatus that presented a known risk to the crew.

4.5. Operation of the watertight doors

4.5.1. The watertight doors on the *Oceanic Discoverer* were normally used in the local-control mode. In this mode the door should theoretically never have closed automatically, but instead required a purposeful movement of the handle to the close-door position before the door could close.

4.5.2. The manufacturer's instructions were very clear that crew were to follow its instructions on how to operate the doors. It is worth quoting the introduction to the operating instructions posted at the door (see Figure 3):

> Safety and operating instructions
> Warning! Warning! For your own safety it is absolutely necessary that these safety procedures are followed! Door closing is dangerous!

4.5.3. The operating instructions make no mention of opening the door all the way before passing through the doorway. The instructions simply say to keep the door operating handle in the door-opening position until you have passed through the door. This is good safe advice that, if adhered to, should allow safe passing in any mode, local-control or remote-close; advice that had been given to the crew of the *Oceanic Discoverer* in their training

4.5.4. One problem that could emerge though, is that some crew who use the doors frequently could revert to the practice of not reaching through and continuing to open the door as they pass through it. The doors are rarely used in remote-close mode; during drills and actual emergencies being the exceptions. For almost every time that a crew member opens the door, it will stop and stay where it is. Frequent door users will naturally refine their techniques to quicken the process, possibly leading to the door being opened just enough to pass through. Even in local-control mode this would increase the risk of being caught in the door should it revert to remote-close mode or malfunction in some way.

4.5.5. Following on from problem one above is that if a door user becomes accustomed to passing through the door with a minimal gap, their inclination could be to revert to this practice, even if the door is in remote-close mode. This has been discussed as a possible scenario for how the chief engineer became trapped. In such a case the door would begin closing again on the user immediately the handle was released.

4.5.6. In its report on the entrapment of a crew member in a watertight door in 2008, the United Kingdom Marine Accident Investigation Branch (MAIB) commented on this human trait: "individuals are frequently prepared to take manageable risks when faced with monotonous, repetitive or time-consuming tasks" and that "It is evident that for many the procedures for passing through watertight doors are perceived as excessive and time-consuming, particularly when operating doors that are in frequent use".

4.5.7. The crew on the *Oceanic Discoverer* acknowledged that they routinely passed through the door opening before it was fully open, which was confirmed by the study of data from the ship's voyage data recorder. This practice conformed with the COSWP for Australian seafarers when the door was in local-control.

4.5.8. The voyage data recorder also revealed that shortly before the accident the second engineer passed through the watertight door while it was about half open, even though the door was in remote-close mode; this did not conform with the COSWP for Australian seafarers.

4.5.9. In an even earlier report on the death of a crew member trapped in a watertight door in 1998, the MAIB referred to a UK shipping notice that commented that identical operating instructions for both modes of control [local-control and remote-close] can lead to misuse and nullifies the guidance and instructions given for [in that case] another type of watertight door. The report went on to say that "by applying the same procedure for both modes of operation, use of the door when in local-control has become over-complicated and inappropriate". The Commission agrees with this opinion.

4.5.10. The guidance given in both the Australian and New Zealand COSWPs appeared to recognise this risk. Although not clearly stated, the Codes inferred that when the doors were in remote-close mode they should have been fully opened before passing through. For the reasons given above this is sound advice. The Australian and New Zealand Codes were silent on what procedure to follow when the doors were in local-control mode. The Commission has interpreted this as giving operators the freedom to make their own policy, having first weighed up all the risks.

4.5.11. The manufacturer's instructions did not give this advice. In its instructions the wording on how to open the door was the same for both modes of operation. There would be some safety benefit in manufacturers' recommending that when watertight doors are in remote-close mode the door be opened all the way before passing through the doorway, because this mode of operation presents a greater risk.

4.5.12. There is, however, another problem. The IMO safety circular issued in 1988, and reissued in 1999, advised that watertight doors should be fully opened in all circumstances, irrespective of mode, before a user passes through the opening. This recommended procedure is reiterated in the UK COSWP. The protection and indemnity (P&I) club Skuld has also reiterated the advice in the form of "lessons learned".

4.5.13. There can be no doubt that to open the door fully before passing through it will be safer than only partially opening it. The problem arises over the practicality of achieving worldwide compliance with this advice. The minimum time to open and close a compliant watertight door is 20 seconds to close, plus whatever time it takes to open it; 40 seconds if the opening speed is the same as the closing speed. Forty seconds might not seem a long time reading about it here in this report, but it would appear to be a long time to someone using the door, more so to someone having to use the door frequently during the day, day in and day out.

4.5.14. Opting for the conservative approach and advising full opening of the doors in all cases is one approach, but with the knowledge of human behaviour there would be an underlying acknowledgement that not every person on every ship would comply with that advice, because the rule might not be considered compatible with the task.

4.5.15. Another approach could be to acknowledge that with this type of watertight door (fitted to the *Oceanic Discoverer*) it might not be practicable to require the crew to open it fully all the way, but instead focus strictly on the requirement to have the door open or opening at all times when passing through it, in line with the door manufacturer's instructions for the watertight doors on the *Oceanic Discoverer*.

4.5.16. Another approach could be to phase out the style of door fitted to the *Oceanic Discoverer* and require doors that automatically open all of the way with a momentary push on the handle, and close again with another momentary push of the handle. This kind of door achieves the purpose of fully opening the door, or having it opening while passing through, and can be closed again without having to remain waiting at the door until it closes. This style of watertight door is currently in use today and to some extent gets around the disruption-to-workflow issue created by the types of door on the *Oceanic Discoverer*.

4.5.17. The diverse designs of ships and their watertight doors mean the watertight door issue will be difficult to resolve with a single instruction such as the one currently made by the IMO. Although the number of deaths attributed to the operation of watertight doors is low in comparison with the number of times they are used every day worldwide, it is happening often enough for the relevant IMO sub-committee to consider again, perhaps with a focus on other methods such as door design to resolve this issue.

4.5.18. A safety recommendation has been made to the Director of Maritime New Zealand to raise this issue again at the IMO for its consideration.

Findings

The method by which the crew of the *Oceanic Discoverer* were trained to operate the watertight doors was in accordance with the manufacturer's instructions, and was in accordance with the Australian COSWP for opening the door when in local-control.

Shortly before the accident the second engineer passed through the watertight door while it was about half open, even though the door was in remote-close mode; this did not conform with the COSWP for Australian seafarers.

A requirement to open all watertight doors fully before passing through the opening is the safest practice, but this might not be practicable for all types of door on all ships, all of the time.

The issue of serious harm caused by the operation of watertight doors on ships will be difficult to address with a single approach based on operational procedures alone. Other aspects such as design approval will need to be considered.

5. Findings

5.1. The chief engineer was rendered unconscious when he was prevented from breathing by the crush force of the watertight door in which he was caught. He later died.

5.2. The circumstances surrounding why the chief engineer became trapped in the door could not be established with any certainty because there were no witnesses to the accident.

5.3. The crew were not taught to and did not routinely open the watertight door fully before passing through the doorway, so it is possible that the chief engineer did not fully open the door on this occasion, which would have contributed to his becoming trapped.

5.4. The doors were set to close with a speed that was twice the maximum allowable under the SOLAS regulations, which would likely have contributed to the chief engineer becoming trapped.

5.5. A peculiarity where the watertight door could have self-closed even with it in the local-control mode would not have caused the chief engineer to become trapped because the door was in remote-close mode. However, the condition was a danger to crew at any time during normal shipboard operations.

5.6. The door operating handle protruding so far inside the watertight doorway space was an unnecessary design or installation feature that meant the chief engineer was not able to free himself when the door closed on him.

5.7. The watertight doors on board the *Oceanic Discoverer* had not been maintained and tested in accordance with the manufacturer's instructions and did not meet the performance standards required by the IMO and the Flag State Administration.

5.8. The excessive closing speed of the watertight door was an issue of non-compliance with SOLAS that likely contributed to the chief engineer becoming trapped in the door.

5.9. The audible door closing alarm was not working after the accident. If it was not working at the time of the accident, that could have contributed to the chief engineer becoming trapped in the door.

5.10. The safety management system on board the *Oceanic Discoverer* did not deal in an appropriate way with the maintenance, testing and operation of the watertight doors, which were safety-critical apparatus that presented a known risk to the crew.

5.11. The method by which the crew of the *Oceanic Discoverer* were trained to operate the watertight doors was in accordance with the manufacturer's instructions, and was in accordance with the Australian COSWP for opening the door when in local-control.

5.12. Shortly before the accident the second engineer passed through the watertight door while it was about half open, even though the door was in remote-close mode; this did not conform with the COSWP for Australian seafarers.

5.13. A requirement to open all watertight doors fully before passing through the opening is the safest practice, but this might not be practicable for all types of door on all ships, all of the time.

5.14. The issue of serious harm caused by the operation of watertight doors on ships will be difficult to address with a single approach based on operational procedures alone. Other aspects such as design approval will need to be considered as well.

6. Safety actions

General

6.1 The Commission classifies safety actions by 2 types:

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

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

6.2 Safety actions addressing safety issues identified during an inquiry

(a) Australian Maritime Safety Authority (AMSA) sent an investigator to the vessel immediately following the accident. AMSA's immediate actions included the detention of the vessel and the issuance of an improvement notice in relation to the doors under the Occupational Health and Safety (Maritime Industry) Act 1993.

(b) As a result of AMSA's investigation and intervention, the company was required to address the safety management system, onboard emergency preparedness procedures, and familiarisation of personnel involved with the system. The vessel and the company are subjected to periodic audits of the safety management system by AMSA in accordance with the ISM Code. The ISM Code includes the requirement that the safety management system ensures procedures for implementing corrective action following hazardous occurrences, including measures to prevent recurrences.

7. Recommendations

General

7.1 The Commission may issue, or give notice of recommendations to any person or organisation that it considers the most appropriate to address the identified safety issues, depending on whether these safety issues are applicable to a single operator only or to the wider transport sector. In this case, recommendations have been issued to Maritime New Zealand, Australian Maritime Safety Authority, IMS AS, with notice of these recommendations given to International Association of Classification Societies.

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

Recommendations

7.3 The issue of serious harm resulting from the operation of watertight doors remains a safety issue that has not been resolved by the maritime industry worldwide, and some advice to mariners in its various forms, including that given by the International Maritime Organisation, could unintentionally exacerbate the issue.

The Commission therefore recommends that the Director of Maritime New Zealand forwards this report to the IMO, draws its attention to the issues discussed around rules, regulations and advice given to mariners for the operation of watertight doors, and invites the IMO to revisit the issue through other mechanisms that will address the human element, through watertight door design for example. (025/11)

7.4 The operating handle of the watertight door protruded into the doorway when it was in its opening position which was why the door could not be opened when the engineer was trapped.

The Commission recommends that the manufacturer assess the design and/or installation of the doors such that this safety issue is resolved. The solution should be promulgated through the International Association of Classification Societies (IACS) and any other way it can. (026/11)

7.5 The watertight doors on the *Oceanic Discoverer* had an unexplained design or maintenance peculiarity where the door would begin to self-close even when in the local-control mode. This peculiarity was observed on one other vessel that the Commission visited.

The Commission therefore recommends that the watertight door manufacturer investigate this safety issue, provides a solution, and promulgates that solution through the International Association of Classification Societies (IACS) and any other way it can. (027/11)

This recommendation has been sent to the IACS for its information so that Class surveyors can check for this peculiarity when surveying this make of watertight door. (027/11)

7.6 The safety management system on board the *Oceanic Discoverer* did not adequately address the issue of watertight door maintenance, which could be an indicator that other aspects of the safety system need improving

It is recommended to the Director of the Australian Maritime Safety Authority that he oversees a special audit of the Safety Management System on board the Oceanic Discoverer with at least a focus on the planned maintenance system and how it addresses the identification and maintenance of safety critical machinery and components. (028/11)

7.7 On 25 November 2011 the watertight door manufacturer (IMS AS) responded to the recommendation made to them as quoted below.

Door manufacturers response to recommendation (026/11):

> Ref to SOLAS II-1 Reg 13.7.4: "Control handles shall be provided at each side of the bulkhead at a minimum height of 1.6 m above the floor and shall be so arranged as to enable persons passing through the doorway to ***hold both handles in the open position*** without being able to set the power closing

mechanism in operation accidentally. The ***direction of movement of the handles in opening and closing the door shall be in the direction of door movement*** and shall be clearly indicated"

The above regulation is the basis for our operating handles design. This existing arrangement may have and may, if kept, in the future as well save lives in another critical situation, with high stress level, smoke or loss of lighting. Changing the operating levers with this existing demand from SOLAS as referred to above (telling that it shall be possible to keep both levers pointing towards open pos. during passing) seems difficult unless the regulation is changed.

Door manufacturers response to recommendation (027/11):

IMS is still in the opinion that this will not happen without a provoked action. We will due to your recommendation, make this a check point (as below) in our test procedure:
"Check that the inductive switch position is correct adjusted. The door shall by real slow operation of the direction lever not start to close before it start to open".

8. Key lessons

8.1. Always fully open a watertight door before passing through the doorway when the door is in the remote-close mode.

8.2. The faster the door closes, the greater the risk. Under no circumstances should watertight doors be set to close faster than the maximum allowable speed.

8.3. Ship operators should adopt specific procedures for operating watertight doors in both the local-control and remote-close modes. The procedures should be compatible with the doors' purpose and design, and the frequency with which they are used.

8.4. Legislation governing the design and use of watertight doors should be flexible enough to achieve appropriate procedures for the use of any watertight door in any mode.

8.5. Poorly maintained watertight doors are dangerous. Shipboard planned maintenance systems should be designed and followed to ensure that watertight doors are maintained in accordance with manufacturers' instructions, and in accordance with good standard marine engineering practice.

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ISSN 1173-5597 (Print)
ISSN 1179-9072 (Online)