MINISTÈRE DU DÉVELOPPEMENT DURABLE
ET DES INFRASTRUCTURES
Département des transports

Administration des enquêtes techniques

FINAL REPORT

FATAL ACCIDENT ON BOARD *IBN BATTUTA* ON 29 SEPTEMBER 2011

DATE OF ISSUE: 2 Mai 2018

ADMINISTRATION OF TECHNICAL INVESTIGATIONS

CIVIL AVIATION – RAILWAYS – MARITIME – RIVER – ROAD

Ministry of Sustainable Development and Infrastructure

Department of Transports

Administration of Technical Investigations

Report N° AET/TM-2018/01

FINAL REPORT

Fatal accident on board *IBN Battuta* on 29 September 2011

Administration des enquêtes techniques (AET)

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FOREWORD

In accordance with Directive 2009/18/EC of the European Parliament and of the Council of 23 April 2009 establishing the fundamental principles governing the investigation of accidents in the maritime transport sector and Luxembourg amended law dated 30 April 2008 on technical investigations in relation to accidents and serious incidents which occurred in the domains of civil aviation, maritime transport, railways and vehicle traffic on public roads, it is not the purpose of the maritime accident investigation to apportion blame or liability.

The sole objective of the safety investigation and the Final Report is the prevention of accidents and incidents.

Consequently, the use of this report for purposes other than accident prevention may lead to wrong interpretations.

Note 1: The present safety investigation is mainly based on factual information provided by the ship operator.

Note 2: All times indicated in this report are in Vietnamese Local Time (LT, UTC +7), unless stated otherwise.

CONTENTS

GLOSSARY OF ABBREVIATIONS AND ACRONYMS

AET	Administration des enquêtes techniques (Luxembourg safety investigation authority)
AM	Ante Meridiem
bar	Unit of pressure
cm	Centimetre
cm/s	Centimetre per second
CSD	Cutter suction dredger
E	East longitude
ECR	Engine control room
H	Hinged
HM	Hazard management
ILO	International Labour Organization
IMO	International Maritime Organization
km	Kilometre
kN	Kilo Newton
kts	Knots
kW	Kilo Watt
LED	Light Emitting Diode
LT	Local Time
m	Metre
MCA	Maritime and Coastguard Agency
MGN	Marine guidance note
MSC	Maritime Safety Committee
N	North latitude
PM	Post Meridiem
POH	Power operated, hinged
POS	Power operated, sliding or rolling
PS	Port side
Ro-Ro	Roll on-Roll off
s	Seconds
S	Sliding or rolling
SOLAS	International Convention for the Safety of Life at Sea
t	Ton
UTC	Universal Co-ordinated Time
VDR	Voyage Data Recorder
WTD	Power operated sliding watertight door (in the context of this report)
WTDs	Power operated sliding watertight doors (in the context of this report)

1. SUMMARY

On 1 March 2011, the cutter suction dredger (CSD) IBN Battuta arrived in Vietnam for a dredging project located in Vung Ang – Ha Tinh, 350 km South of Hanoi.

Due to the forecast tropical storm NESAT, the vessel interrupted the ongoing dredging project and departed on 28 September 2011 for the port of Da Nang in the South of Vietnam. In the morning of 29 September 2011, the vessel dropped anchor in the port of Da Nang. While the vessel was at anchor, the deck crew (including the Apprentice Dredge Operator) was painting the walls of the pump room, as part of regular maintenance.

At 10:05 AM, the Apprentice Dredge Operator, presumably on his way to join the deck crew for a coffee break, was found stuck in the power operated sliding watertight door (WTD) between the pump room and the engine room. At 10:35 AM, after being transported ashore, the Apprentice Dredge Operator was declared dead at quay by a doctor.

Based on the findings of the safety investigation, the following three recommendations were addressed to the Luxembourg Maritime Administration:

LU-MA-2018-001

AET recommends that the Luxembourg Maritime Administration considers mandating that all vessels on the Luxembourg Merchant Fleet registry shall operate the remote control stations for power operated watertight doors in accordance with SOLAS Regulations II-1/13.8.1 to 13.8.3[1].

LU-MA-2018-002

AET recommends that the Luxembourg Maritime Administration proposes an amendment to the IMO's Maritime Safety Committee that all vessels shall operate the remote control stations for power operated watertight doors in accordance with SOLAS Regulations II-1/13.8.1 to 13.8.3[1].

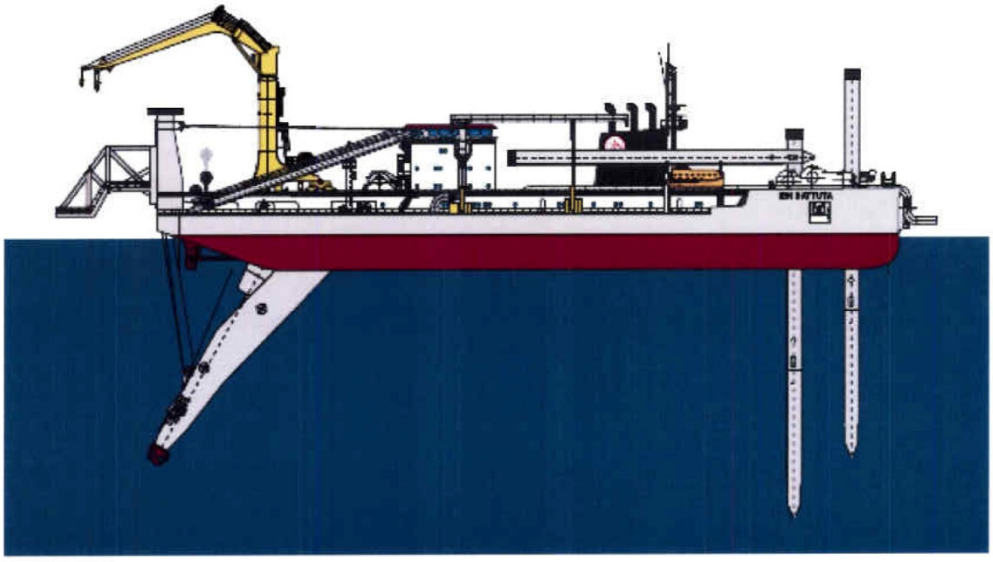
LU-MA-2018-003

AET recommends that the Luxembourg Maritime Administration promotes the safe operation of remotely operated watertight doors by disseminating the "lessons learned" from the investigated event to all operators.

[1] Formerly SOLAS consolidated 2004 edition regulations II-1/15.8.1 to 15.8.3

2. FACTUAL INFORMATION

2.1. SHIP PARTICULARS



Ship Name:	IBN Battuta
Flag:	Luxembourg
IMO N°:	9448970
Call sign:	LXUT
Type:	Cutter suction dredger
System ship type	Other cargo ship
Built:	2010
Builder:	ULJANIK d.d.
Hull material:	Steel
Hull Info:	Double Hull 4 watertight compartments 1 continuous deck
Length overall:	138.5 m
Breadth:	26 m
Depth:	8.8 m
Draught:	5.9 m
Gross tonnage:	8015 t
Engine power and/or type:	Diesel 7000 kW / Electric 2 x 3500 kW
Service speed:	13 kts
Equipment:	2 main anchors, chain diameter 5.6 cm, very high tensile strength steel

2.2. VOYAGE PARTICULARS

IBN Battuta arrived in Vietnam on 1 March 2011 to start dredging on a project which was targeted to be completed by 1 March 2013. The location of the dredging project was Vung Ang – Ha Tinh, 350 km south of Hanoi.

The vessel was contracted by a Taiwanese company to perform the following works: dredging of access channel and basin, and reclamation of dredged materials.

On 21 September 2011, the vessel stopped the dredging project and stayed at anchor. On 28 September 2011, the vessel prepared to sail to the port of Da Nang in order to seek shelter from the tropical storm NESAT.

On 29 September the vessel arrived at the port of Da Nang at positon 16°07.6' N, 108°11.1' E, where it dropped anchor.

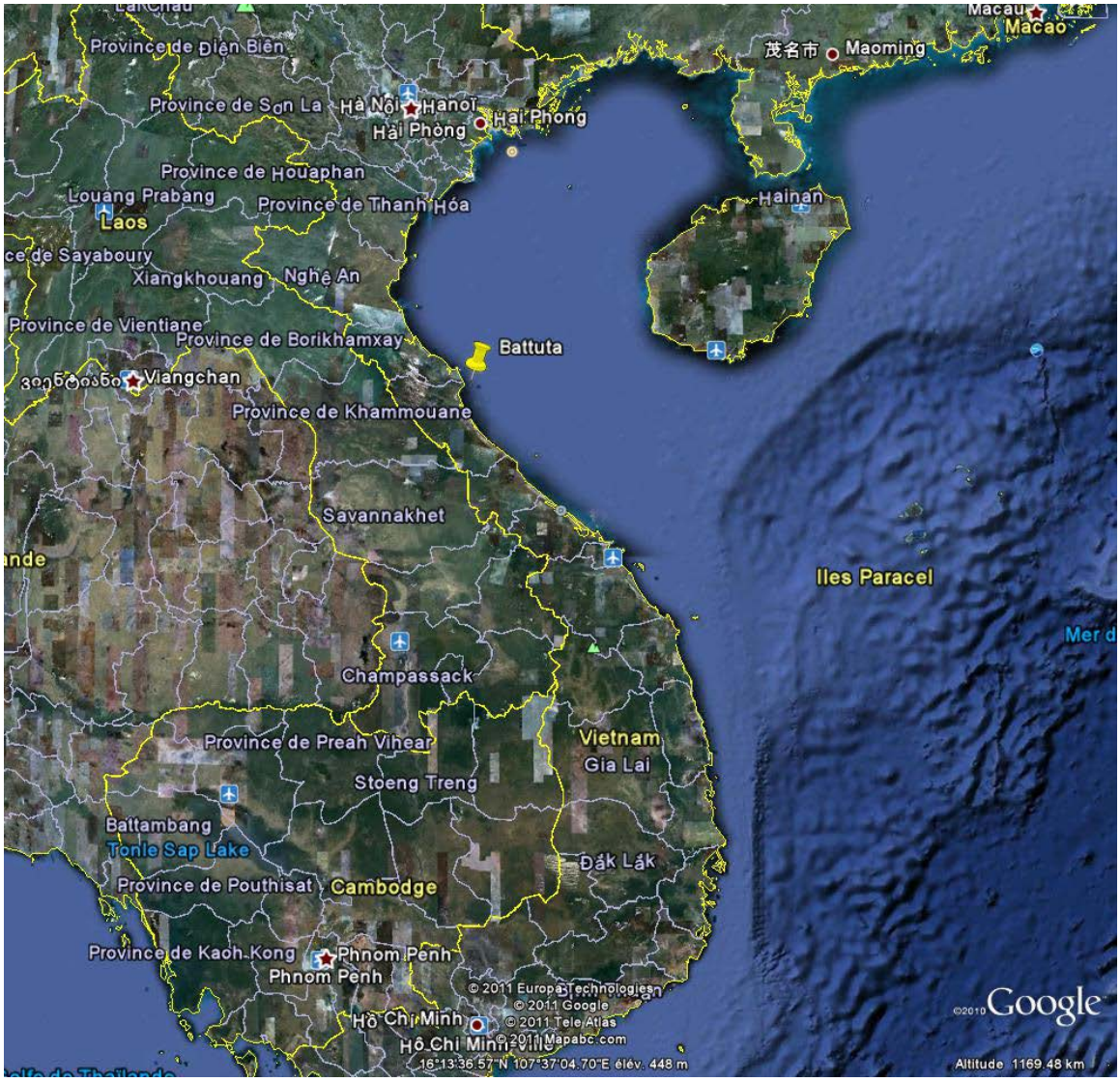


Figure 2.1 – Port of Da Nang

2.3. MARINE CASUALTY OR INCIDENT INFORMATION

Accident details

Time and date:	29 September 2011 at 10:05 AM
Location of accident:	power operated sliding watertight door number 3 between the pump room and the engine room
Persons on board:	40
Deceased:	Male, Aged 50, Belgium National, Apprentice Dredge Operator, Cause of death – Multiple trauma
Experience of the victim:	The apprentice operator started working for this company in 2002 as Bosun. Subsequently he switched to cutter suction dredgers as Apprentice Dredge Operator, first on CSD Leonardo Da Vinci, from December 2010 until August 2011, and then on CSD lBN Battuta from September 2011 onwards.
Medical Certificate: *(ILO convention N°73)*	Issued without restrictions in December 2010.

2.4. SHORE AUTHORITY INVOLVEMENT AND EMERGENCY RESPONSE

Not applicable.

2.5. WEATHER AND SEA CONDITIONS

Due to the tropical storm NESAT and the rain season, the swell was strong. The wind was gusting between 60 and 80 kts.

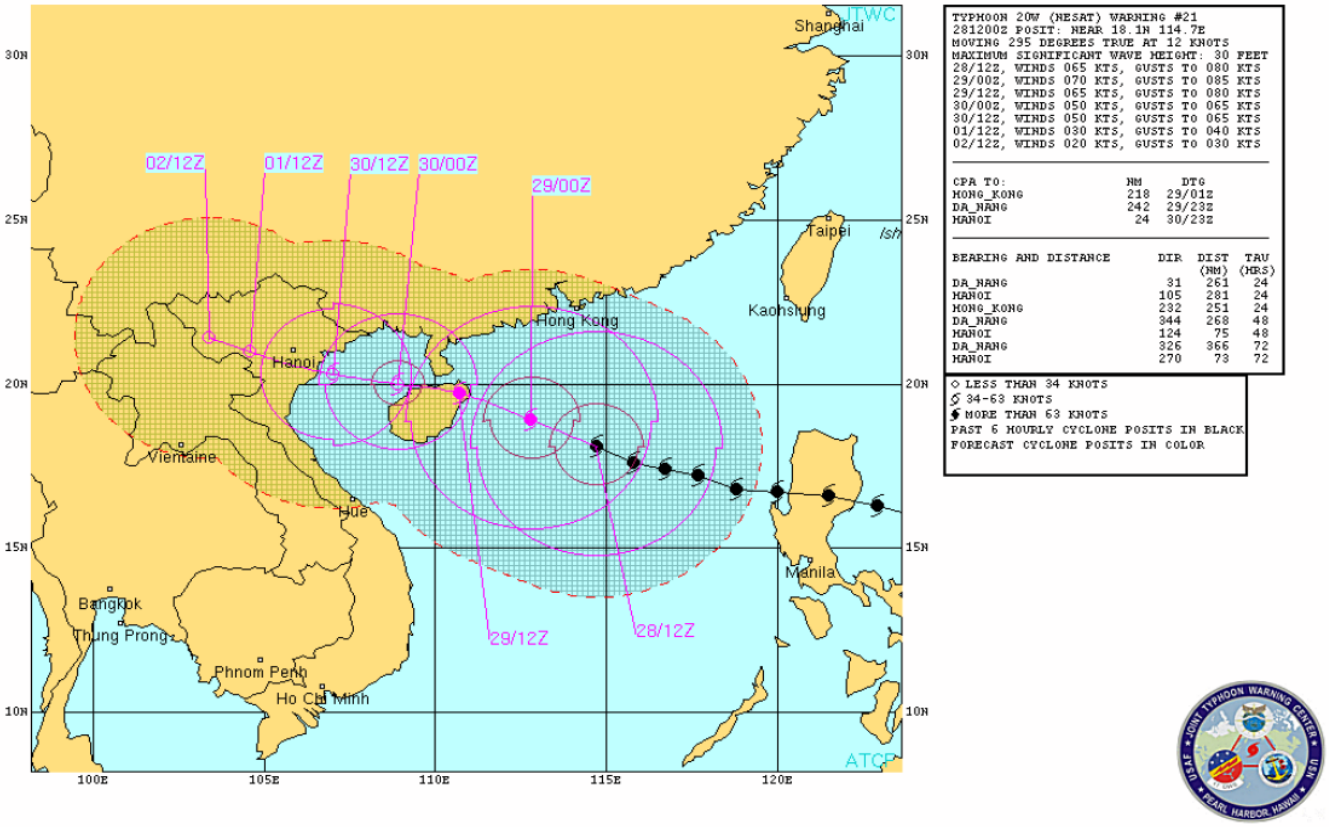


Figure 2.2 – Storm track forecast for NESAT
(Source: BMT ARGOSS)

3. NARRATIVE

3.1. SEQUENCE OF EVENTS

3.1.1. 21 September 2011

Due to the increasing swell caused by the stormy weather, the vessel stopped dredging and stayed at anchor.

After 21 September 2011, the main activities performed by the crew were maintenance jobs. The operating system of the power operated sliding watertight doors (WTDs) was switched from 'doors closed' mode to 'local control' mode during maintenance.

3.1.2. 23 September 2011

The Apprentice Dredge Operator signed on and received his vessel familiarization training as defined in the operator's procedures. The safe operation of WTDs was not part of the familiarization.

3.1.3. 28 September 2011

At 05:12 AM, the stern anchor was heaved and the vessel prepared to sail in a southern direction in order to seek shelter from the tropical storm NESAT. The Master of the vessel signed off and turned the command over to another Master. The Chief Mate signed on.

At 12:05 PM, the port side (PS) bow anchor was brought up and at 12:30 PM, the vessel departed for the port of Da Nang in the South of Vietnam to avoid the adverse weather and sea conditions caused by tropical storm NESAT. Before setting sail, the system of the WTDs was switched from ‘local control’ mode to ‘doors closed’ mode.

3.1.4. 29 September 2011 / day of the occurrence

At 05:55 AM, the day shift started their activities. The deck crew (including 1st Dredge Operator, 2nd Dredge Operator, Apprentice Dredge Operator and several deckhands) was scheduled to do paintwork in the pump room.

At 08:15 AM, the vessel dropped anchor in the port of Da Nang at positon 16°07.6’ N, 108°11.1’ E.

At around 10:00 AM, both the 1st Dredge Operator and 2nd Dredge Operator informed the Apprentice Dredge Operator that it was time for a coffee break. The Apprentice Dredge Operator told them that he would follow them soon. The 1st and 2nd Dredge Operator left the pump room and went to the bridge wing for a coffee. The deckhands had already left the pump room earlier in order to work on other ongoing tasks.

The Apprentice Dredge Operator's last known working location was in the pump room where he was painting. The pump room is below the starboard barge loading system located on the deck below the tween deck.

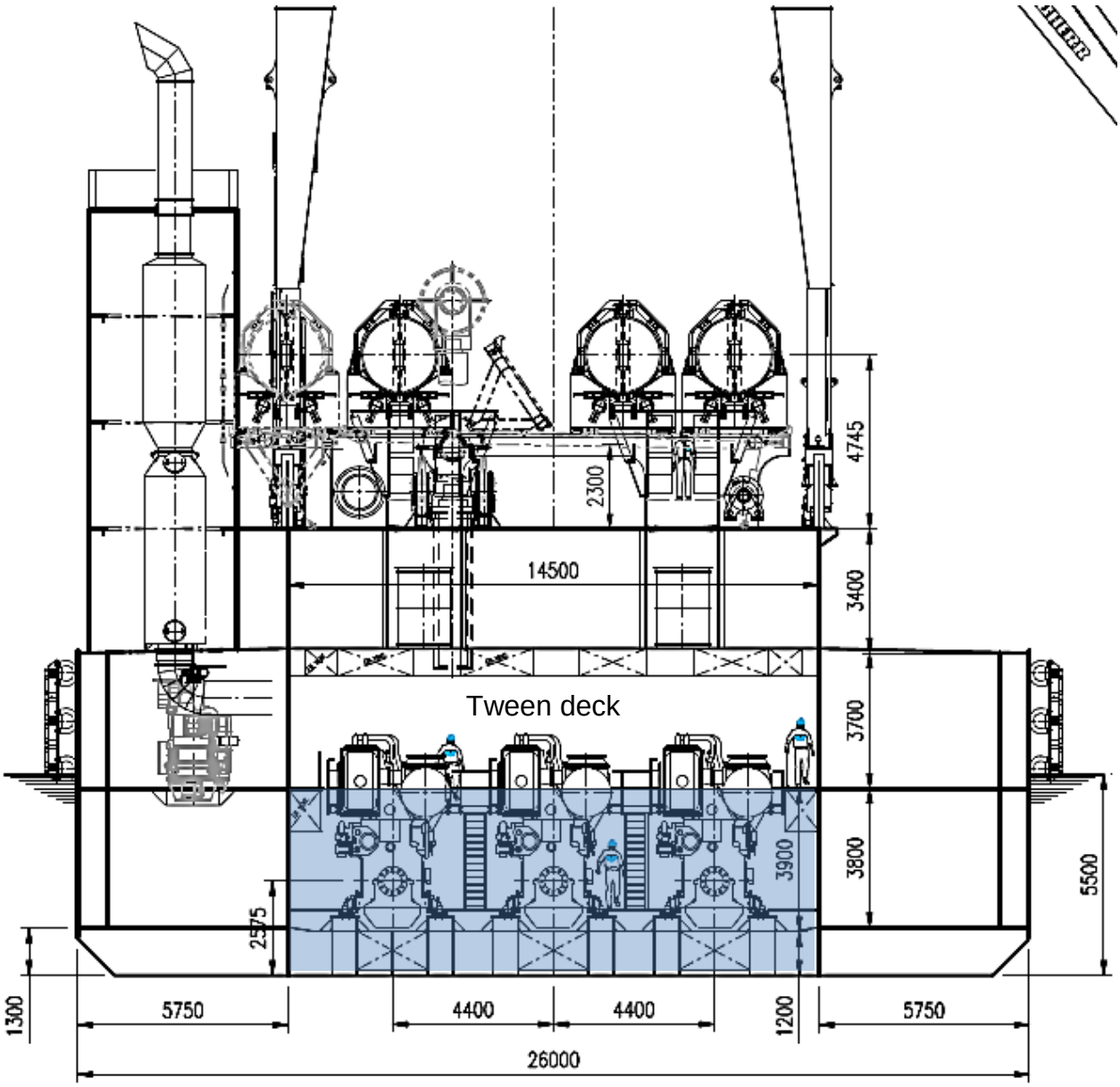


Figure 3.1 – Cut plane of IBN Battuta
(Source: Operator)

According to the Voyage Data Recorder (VDR) logs, at 10:04:11 AM, the control handle of WTD 3 (door between the pump room and the engine room) was moved to 'open' position. The VDR logs show that WTD 3 was not fully opened during that operation, as the proximity switch 'Door fully open' has not been triggered.

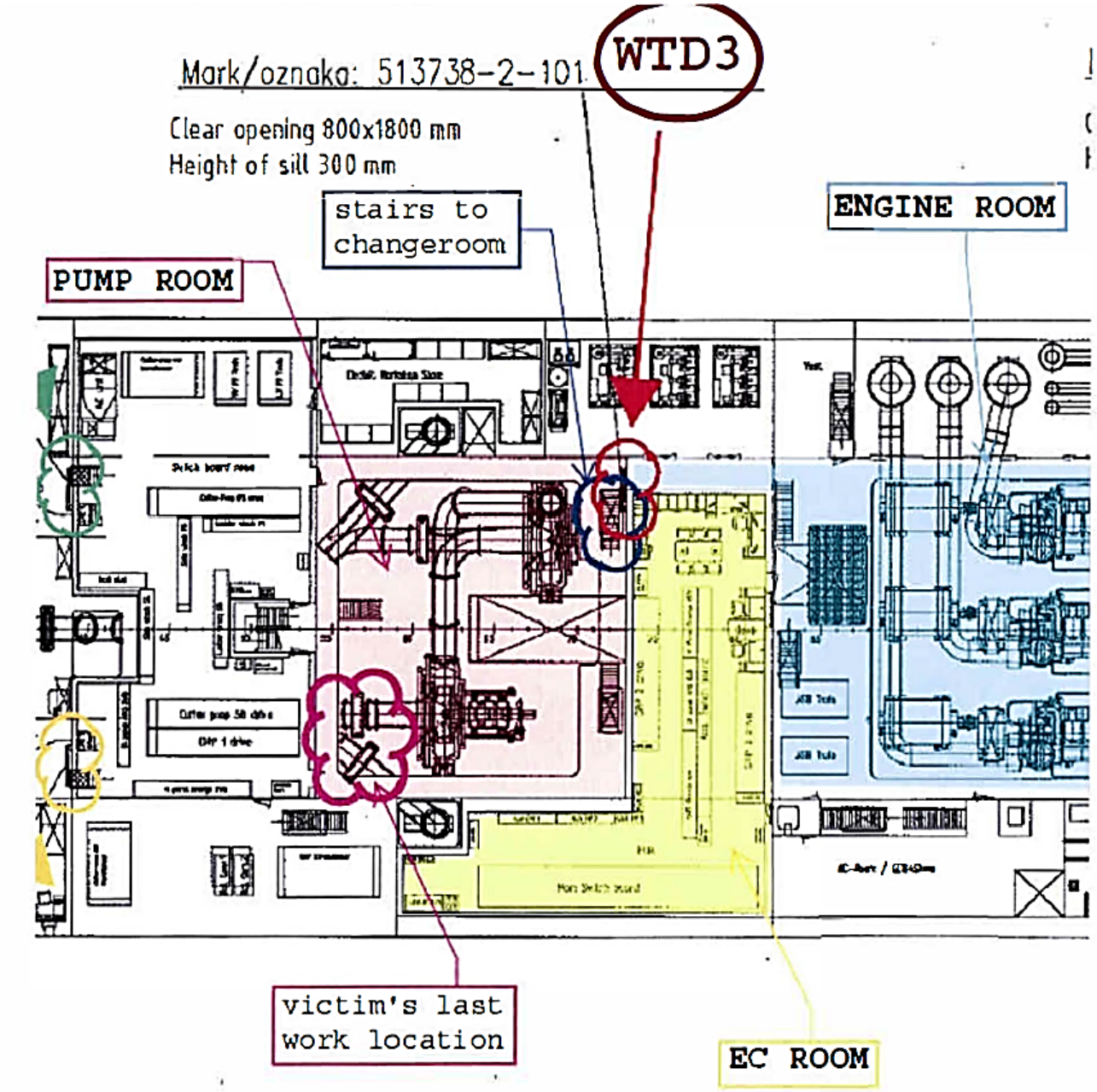


Figure 3.2 – Hydraulic doors layout of IBN Battuta
(Source: Operator)

At approximately 10:05 AM, the 2nd and 3rd Engineer went to check an overboard valve on the platform situated near the engine control room (ECR) and WTD 3. When they approached WTD 3 from the ECR, they saw that the Apprentice Dredge Operator was stuck in the WTD 3. His body faced the closing part of the sliding door, with the left leg and the left arm located on the side of the engine room and his head, the right leg and the right arm located on the side of pump room. WTD 3 was fully opened at 10:06:02 AM and the Apprentice Dredge Operator was laid down on the floor in the pump room. The Chief Engineer, who was in the ECR with the 2nd and 3rd Engineer, was also informed about the occurrence.

In the meantime, an electrician called the bridge via portable radio and notified the occurrence.

Figure 3.3 – Accident scene
(Source: Operator)

At 10:07:51 AM, the WTD 3 was completely opened and secured in the open position with a steel bar. The power supply of the pump motor was subsequently switched off. The Chief Mate arrived on the scene of the occurrence and found the Apprentice Dredge Operator lying on the floor in a stable position. The Chief Engineer checked the Apprentice Dredge Operator for vital signs.

The pulse was weak and the Apprentice Dredge Operator was unconscious. The Chief Mate went back to the bridge and arranged the victim's evacuation with the assistance of the company's local agent.

At around 10:20 AM, the Apprentice Dredge Operator was transported in the launch boat of the company's local agent ashore, where an ambulance awaited him. The boat arrived at the quay of Da Nang River Port approximately fifteen minutes later. The doctor from the emergency medical services checked the vital signs of the Apprentice Dredge Operator and started re-animation, but without success. The doctor declared the Apprentice Dredge Operator deceased at the River Port quay.

The body of the Apprentice Dredge Operator was taken to the morgue at the Da Nang General Hospital. According to the doctor's report, the cause of death was a multi-trauma.

On the same day, the accident scene was cordoned off and all the power operated sliding watertight doors were put out of service and WTD 3 was secured in open position.

3.1.5. 1 October 2011

The Chief Engineer was informed by the local authorities that the accident scene was released and could be cleaned up. The hydraulic pressure of the operating system of WTD 3 was verified and it was found to be at 150 bar, the standard operating value. The pressure was released from the hydraulic system and the door was cycled (opened/closed) four times.

3.1.6. 8 – 9 October 2011

On 8 and 9 October 2011, an expert from the manufacturer of the WTDs checked the status of the WTDs' operating system and subsequently performed operational tests. The system was found to be operating in accordance with the design specifications.

3.2. ADDITIONAL INFORMATION

3.2.1. Watertight doors

3.2.1.1. Purpose of watertight doors

Watertight doors provide access to compartments separated from each other by watertight bulkheads. On cruise liners, Ro-Ro ferries, dredgers, pipe and cable layers, and other special purpose vessels, machinery spaces can extend along almost the entire length of the vessel. The watertight bulkheads subdivide this space, usually located below the waterline, into separate compartments, thus providing the watertight integrity of the vessel in case of water ingress.

3.2.1.2. Type of watertight doors

The 4 power operated sliding watertight doors on board IBN Battuta, manufactured by the German company “Schoenrock Hydraulik Marine Systeme GmbH”, have a clear opening of 80 x 180 centimetres.

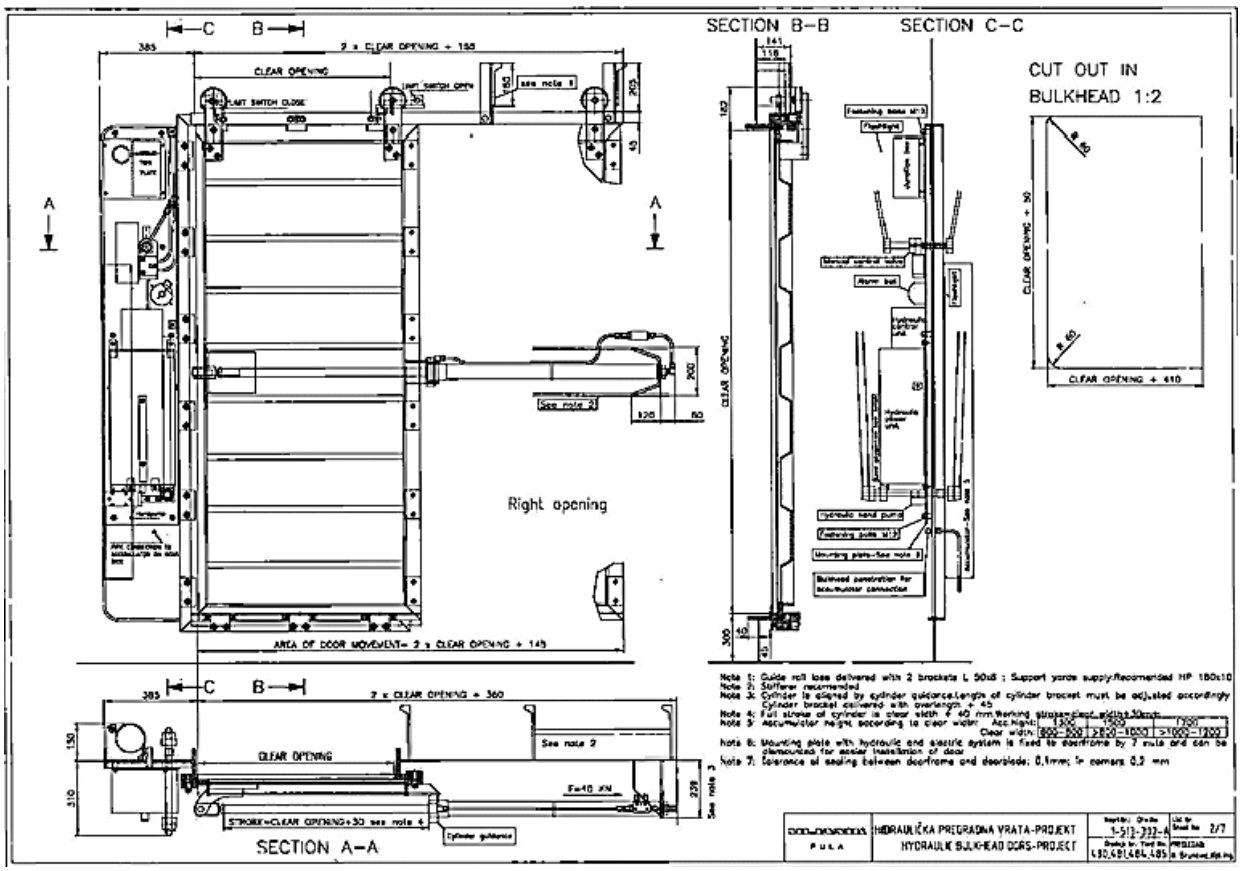


Figure 3.4 – Scheme of a watertight door
(Source: Operator)

3.2.1.3. Operation of power operated watertight doors

On the occurrence vessel, the WTDs can be operated in two different modes, the 'local control' mode and the 'doors closed' mode. The selection of either mode is done on the bridge by selecting the appropriate position on the 'Master Mode Switch'.

Watertight doors on the occurrence vessel are equipped with a local control handle for the opening and closing of the door. The opening of a power operated watertight door can be commanded with the control handle in both operating modes. The operational status (closed, half and open) of the WTDs is shown on an indication panel on the bridge and logged in the VDR data file.

WTDs can be closed remotely from the bridge (by selecting 'doors closed' mode), from the manual closing unit in the emergency station, or by local door operation (control handle or its local manual closing unit).

Moving the control handle to 'open' position triggers the limit switch, cutting the power to the solenoid valve and activating the mechanical valve. Hydraulic pressure will be applied to the cylinder to open the door. The door stops moving when the control handle is released to neutral position.

Moving the control handle to 'closing' position also triggers the limit switch, the power to the solenoid will be cut and the door closes.

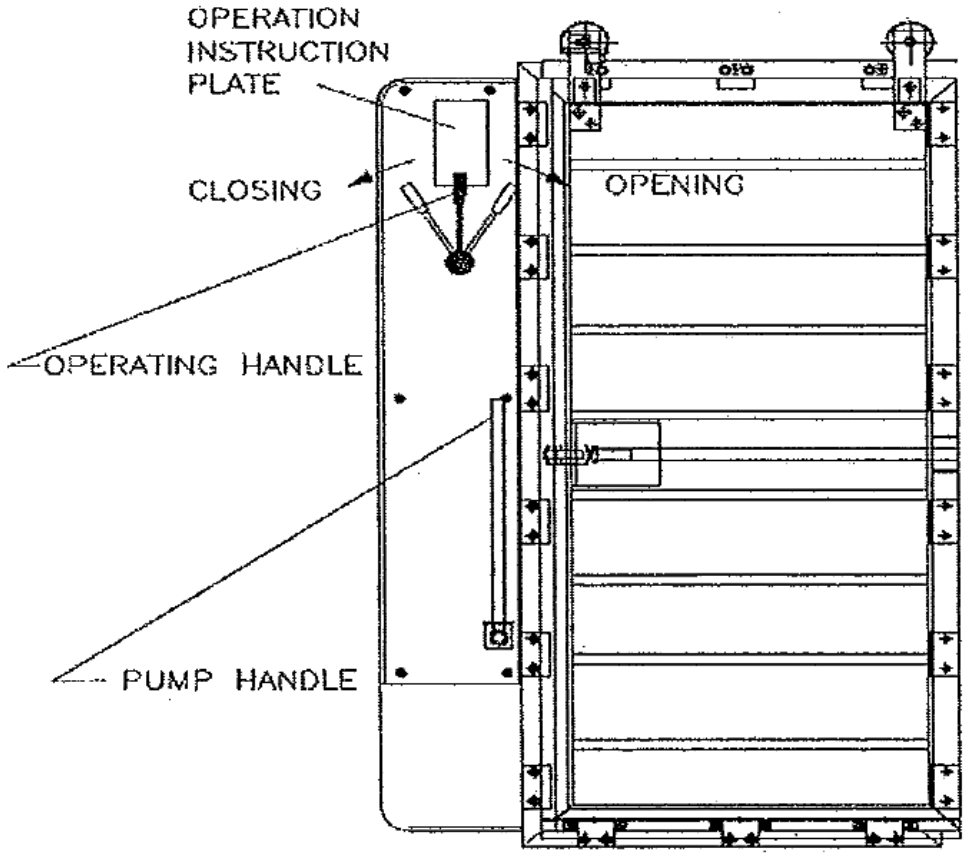


Figure 3.5 – Description of a WTD
(Source: Schoenrock Hydraulik Marine Systeme GmbH)

When the operating system of the WTDs is switched to 'doors closed' mode, all power operated watertight doors are remotely closed. A red light located on both sides of the WTD will be activated (in flashing mode) and will stay activated as long as the 'Master Mode Switch' remains in 'doors closed' position.

The WTDs can still be opened with the local control handle, but it will be closed remotely as soon as the control handle is released and returns to neutral position. The automatic closure of the WTD is designed to trigger an audible alarm[2] (unserviceable for WTD 3 at the time of the occurrence). In addition to that, a yellow light, located on both sides of the WTD, will be flashing whenever the door is remotely closed.

3.2.1.4. Operational procedures for WTDs on occurrence vessel

It was decided by the operator that the standard operating mode of the WTDs on the fleet was the 'doors closed' mode. This decision was taken in reference to the SOLAS regulation II-1/22.1 stating that *'all watertight doors shall be kept closed during navigation'*. The rationale behind this decision was to remove the human factor in the WTDs' closing sequence and subsequently prevent the loss of a vessel due to a human error related to the operation of a WTD.

On the date of the occurrence, there was no standard operating procedure available to the crew of IBN Battuta on how to safely operate the WTDs. However, an operation instruction plate was posted at each WTD and a user manual from the manufacturer, containing a functional description and an electrical description of the watertight doors, was available on the bridge.

The WTDs' user manual states in its electrical description, paragraph 6.6.3 '*Required mode of control switches'*, that:

'Doors closed mode is only to be used in an emergency, normal mode is Local control. Using Doors closed mode as a normal mode is a violation of SOLAS. Closing from Master Mode Switch requires warnings of passengers and crew.'

[2] Excerpt from the user manual: Door alarm: When the operating handle is in use, the local Warning Bell and Flashing lights (yellow) will be disabled. For doors in middle position with the operating handle in neutral position, the local Warning bell and Flashing lights (yellow) will be triggered.

3.2.1.5. Inspection of the involved WTD

From 8 to 9 October 2011, a technician from the WTDs' manufacturer checked the status of the WTDs' system.

The relevant findings from the technician's Service Engineering Report are as follows:

- The indications of the mimic panel on the bridge were checked: all doors were displayed as out of service and closed. The power had been switched off and the pressure had dropped down. WTD 3 was in 'open' position, the remaining doors were indicated as closed. Additional yellow LED's indicated the following alarms: 'loss of power', 'loss of pressure' and 'low oil level'.

Figure 3.6 – Control and indication panel of the WTDs' system
(Source: Schoenrock Hydraulik Marine Systeme GmbH)

- The alarm horn of WTD 3 was inoperative.

- The warning lights (yellow flashing lights) on both sides of the WTD 3 were operational.

- The WTD 3 needed 28 seconds to completely close and 15 seconds to fully open, which is within prevailing SOLAS provisions requiring a minimum of twenty seconds and a maximum of forty seconds to close a WTD.

- The remaining parts and parameters of the WTD 3 were in accordance with the design specifications and prevailing regulations.

3.2.1.6. Logs of WTD 3

The WTD 3 logs show that on 29 September 2011, prior to the occurrence, the door had been opened three times.

Time	*Status*	*Open*	*Closed*
09:44:22	Half	0	0
09:44:44	Closed	0	1
09:45:01	Half	0	0
09:45:19	Closed	0	1
09:47:10	Half	0	0
09:47:30	Closed	0	1

The logs show that the total operating times of WTD 3, starting with the triggering of the ‘half’ status up to the door closure (‘closed’ status) took respectively 22 s, 18 s and 20 s. It should be noted that during none of these three operations, the door had reached the ‘open’ status.

The log entries which can be attributed to the timeframe of the occurrence are the following:

Time	*Status*	*Open*	*Closed*
10:04:11	Half	0	0
10:06:02	Open	1	0
10:06:18	Half	0	0
10:06:42	Open	1	0
10:06:48	Half	0	0
10:07:00	Open	1	0
10:07:31	Half	0	0
10:07:51	Open	1	0

At 10:04:11, the control handle of WTD 3 was moved to ‘open’ position, triggering the ‘half’ status. This status remained unchanged until the Apprentice Dredge Operator was found trapped in WTD 3 by his colleagues. The door was then completely opened and reached the ‘open’ status at 10:06:02.

During the rescue process, the control handle was released three times and subsequently returned to ‘half’ status at 10:06:18, 10:06:48 and 10:07:31. As the central operating console for watertight doors was still in ‘doors closed’ mode, each time the control handle was released to neutral, WTD 3 was closed remotely and had to be re-opened by the rescuing crew by moving the local control handle to ‘open’ position. The door was finally blocked in open position with a steel bar at 10:07:51.

3.2.1.7. Log based estimation of door openings

The following formulas allow a conservative estimation of the opening widths for each passage of WTD 3, based on the times logged by the VDR. It is assumed that the opening and closure velocities are mostly constant, as required by SOLAS Regulation 15.7.1.7 (consolidated 2004 edition). The time needed by the hydraulic system to reverse the movement from opening to closure is not considered in the estimation. It would have the effect of reducing the opening width since there would be no door movement during the reversal.

$W_{(O)}$: Door opening width
$v_{(O)}$: Opening velocity
$t_{(O)}$: Opening time
$v_{(C)}$: Closure velocity
$t_{(C)}$: Closure time
$t_{(O-C)}$: Opening + closing time
$t_{(R)}$: Time of movement reversal

When a WTD is <u>not fully opened</u>, the logged time from 'half' status to 'closed' status represents the time needed to open the door to a certain width and close it by the same width. Based on the measured opening and closure velocities, this provides the following formula:

$$W_{(O)} = v_{(O)} * t_{(O)} = v_{(C)} * t_{(C)}$$

$$\rightarrow (v_{(O)} * t_{(O)}) - (v_{(C)} * t_{(C)}) = 0 \qquad (1)$$

A second formula can be obtained from the fact that the total time needed to open and to close the door is the sum of the opening time, the time of movement reversal and the closure time:

$$t_{(O-C)} = t_{(O)} + t_{(C)} + t_{(R)} \qquad t_{(R)} = 0 \text{ (not considered)}$$

$$\rightarrow t_{(O)} = t_{(O-C)} - t_{(C)} \qquad (2)$$

These 2 formulas can further be developed as follows:

(2) -> (1) $[v_{(O)} * (t_{(O-C)} - t_{(C)})] - (v_{(C)} * t_{(C)}) = 0$

$$(v_{(O)} * t_{(O-C)}) - (v_{(O)} * t_{(C)}) - (v_{(C)} * t_{(C)}) = 0$$

$$(v_{(O)} * t_{(O-C)}) - [t_{(C)} * (v_{(O)} + v_{(C)})] = 0$$

$$\rightarrow t_{(C)} = (v_{(O)} * t_{(O-C)}) / (v_{(O)} + v_{(C)})$$

The opening width can be estimated as follows:

$$W_{(O)} = v_{(C)} * t_{(C)} = [(v_{(O)} * v_{(C)}) / (v_{(O)} + v_{(C)})] * t_{(O-C)}$$

$W_{(O)} = [(5.35 \text{ cm/s} * 2.86 \text{ cm/s}) / (5.35 \text{ cm/s} + 2.86 \text{ cm/s})] * t_{(O-C)}$

$W_{(O)} = 1.864 \text{ cm/s} * t_{(O-C)}$

WTD 3 openings based on VDR logs:

$t_{(O-C)1} = 22 \text{ s} \rightarrow W_{(O)1} = 41 \text{ cm}$

$t_{(O-C)2} = 18 \text{ s} \rightarrow W_{(O)2} = 34 \text{ cm}$

$t_{(O-C)3} = 20 \text{ s} \rightarrow W_{(O)3} = 37 \text{ cm}$

The values show that during the 3 passages, WTD 3 has only been opened by approximately half of the clear opening of 80 cm and started closing when the local control handle was released to neutral position.

3.2.2. Relevant conventions and resolutions

3.2.2.1. International Convention for the Safety of Life at Sea (SOLAS) 1960

SOLAS 1960 Part B – "*Subdivision and stability Regulation 13*" applies to passenger vessels[3] and requires that all hydraulic watertight doors shall:

- be capable of being closed in sixty seconds or less,
- be kept closed during navigation and opened only when the working of the ship makes it necessary, but immediately closed on completion,
- give an audible signal during the closing operation.

It also states: "*The door shall take a sufficient time to close to ensure safety."*

No requirements for the control mode (remote or local) to be used are provided.

3.2.2.2. Regulations for passenger ships

The Consolidated 2004 edition of SOLAS on watertight doors: Part B – "*Subdivision and Stability Regulation 15 Openings in watertight bulkheads in passenger ships"* are applicable to ships constructed on or after 1 February 1992. The technical requirements for watertight door control mode, closure rates, warning signals and alarms, both at remote and local stations are detailed in Regulation 15 of Part B.

SOLAS Regulation 15.8.1 states: *"The "master mode" switch shall normally be in the "local control" mode. The "doors closed" mode shall only be used in an emergency or for testing purposes."*

[3] A passenger ship is a ship which carries more than twelve passengers.

Regulation 15 requires that all watertight doors shall be capable of being closed from an operating console on the bridge in not more than sixty seconds with the ship in upright position, and SOLAS Regulation 15.7.1.6 requires that all power-operated sliding watertight doors shall be provided with an audible alarm distinct from any other alarm in the area, which shall sound for five to ten seconds before the door begins to close in remote mode and shall continue to sound until it is completely closed. It also requires under 15.7.1.7 that:

"*…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 20 s or more than 40 s with the ship in the upright position*."

The Regulation also states that Flag States may consider an intermittent visual signal, at doors in passenger areas and areas of high ambient noise such as machinery space, to supplement the audible alarm. There is no requirement for any local indication to show when doors are in remote operation.

The 'Master Mode Switch' on the operating console on the bridge is required to always be kept in 'local control' mode and the remote mode shall be used only in an emergency or for testing purposes. All watertight doors must be kept closed during navigation except when required to be opened to permit the passage of passengers or crew, or when work in the immediate vicinity of the door necessitates them to be opened; they shall be closed immediately afterwards. If considered absolutely necessary, certain watertight doors may be kept open with dispensation from the Flag State and this shall be clearly indicated in the ship's stability information.

3.2.2.3. Regulations for cargo ships - Amendments to SOLAS

For the vessel IBN Battuta, classified as a cargo vessel, the following amendments to SOLAS, based on the regulations for passenger ships, apply:

On 25 May 2005, the International Maritime Organization's (IMO), Maritime Safety Committee (MSC) issued **circular 1176** titled "*Unified interpretations to SOLAS chapters II-1 and XII and to the technical provisions for means of access for inspections"*. Section 8 - SOLAS Chapter II-1, Parts B and B-1 "*Doors in watertight bulkhead of passenger ships and cargo ships, Interpretation*" states under *8.3. "Operation mode, location and outfitting",* that:

"Doors should be fitted in accordance with all requirements regarding their operation mode, location and outfitting, i.e. provision of controls, means of indication, etc., as shown in Table 1 below. This table should be read in conjunction with paragraphs 3.1 to 5.4 below."

Under Paragraph 8.3.3.2. *"Remote"*, it is stated that:

"Where indicated in Table 1, doors should be capable of being remotely closed by power from the bridge. Where it is necessary to start the power unit for operation of the watertight door, means to start the power unit is also to be provided at remote control

stations. The operation of such remote control should be in accordance with SOLAS regulations II-1/15.8.1 to 15.8.3."

Table 1 – Internal doors in watertight bulkheads in cargo ships and passenger ships

Position relative to equilibrium or intermediate waterplane	1. Frequency of use whilst at sea	2. Type	3. Remote control[6]	4. Indication locally and on bridge[6]	5. Audible alarm[6]	6. Notice	7. Comments	8. Regulation
I. Passenger ships								
A. At or below	Normally closed	POS	Yes	Yes	Yes	No	Certain doors may be left open, see SOLAS II-1/15.9.3	SOLAS II-1/15.9.1, 15.9.2 and 15.9.3
	Permanently closed	S, H	No	No	No	Yes	See Notes 1 + 4	SOLAS II-1/15.10.1 and 15.10.2
B. Above	Normally open	POS, POH	Yes	Yes	Yes	No		SOLAS II-1/15.9.3 SOLAS II-1/20.1 MSC/Circ.541
	Normally closed	S, H	No	Yes	No	Yes	See Note 2	
		S, H	No	Yes	No	Yes	Doors giving access to ro-ro deck	SOLAS II-1/20-2
II. Cargo ships								
A. At or below	Used	POS	Yes	Yes	Yes	No		SOLAS II-1/25-9.2
	Normally closed	S, H	No	Yes	No	Yes	see Notes 2 + 3 + 5	SOLAS II-1/25-9.3
	Permanently closed	S, H	No	No	No	Yes	see Notes 1 + 4	SOLAS II-1/25-9.4 SOLAS II-1/25-10
B. Above	Used	POS	Yes	Yes	Yes	No		SOLAS II-1/25-9.2
	Normally closed	S, H	No	Yes	No	Yes	See Notes 2 + 5	SOLAS II-1/25-9.3 SOLAS II-1/25-10

Type of WTDs: POS: Power operated, sliding or rolling, POH: Power operated, hinged, S: Sliding or rolling, H: Hinged

Notes:
1. Doors in watertight bulkheads subdividing cargo spaces.
2. If hinged, this door should be of quick acting or single action type.
3. SOLAS requires remotely operated watertight doors to be sliding doors.
4. The time of opening such doors in port and closing them before the ship leaves port should be entered in the logbook.
5. The use of such doors should be authorized by the officer of the watch

On 4 December 2008, the International Maritime Organization's (IMO), Maritime Safety Committee (MSC) issued **Resolution MSC.281 (85)** "*Explanatory notes to the SOLAS chapter II-1 Subdivision and damage stability*".

Regulation 13-1.1 *"Openings in watertight bulkheads and internal decks in cargo ships"* states:

"…

2) All openings in the shell plating below the upper deck throughout that region of the ship should be treated as being below the freeboard deck, similar to the bulkhead deck for passenger ships (see relevant figure under regulation 13 above), and the provisions of regulation 15 should be applied."

On 10 December 2010, the International Maritime Organization's (IMO), Maritime Safety Committee (MSC) issued **circular 1380** "*Guidance for watertight doors on passenger ships which may be opened during navigation*" where, under point 4 *"Operation of watertight doors",* it is stated that:

"Power-operated watertight doors are designed to be remotely closed in a short period of time with a force the magnitude of which is sufficient to overcome not only the weight of the door but also water flowing through its opening, both while a ship is listing

15º in either direction. The operation of watertight doors involves possible dangers to persons passing through a closing door and injury or loss of life is likely to occur to anyone trapped in the door's path. 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."

3.2.2.4. Safe use of power operated watertight doors

The *Marine Guidance Note (MGN) 35 (M+F)*, published by the UK's Maritime and Coastguard Agency (MCA), gives guidelines on the safe use of power operated watertight doors. According to MGN 35, irrespective of the selected operating mode of the WTDs, the procedure for transit should be the following:

"*Open the door completely using the local control lever; reach through the opening and, holding down the local control lever on the other side in the fully open position, step through*."

3.2.3. Hazard Management (HM)

The vessel operator has implemented a system which is intended to identify and manage all standard and known risks and impacts of the company group.

The HM aims to limit the risks of exposure to work related hazards, either by eliminating the hazards as the preferred method (Elimination; Substitution/Alternative) or, if not feasible, by putting control measures into place to mitigate the risks (Engineering Control/Isolation; Collective Protection Means; Administrative Control; Personal Protective Equipment). The adopted mitigation approach is to reduce the risk to 'As Low As Reasonable Practicable'.

The risks and their impacts are assessed in relation to both the consequences and the likelihood of an occurrence and subsequently categorized into three different levels on the basis of a matrix. The three levels are:

- Low Significant Risk - Trivial/Acceptable Impact Level
- Medium Significant Risk – Moderate Impact Level
- High Significant Risk – Substantial/Not Acceptable Impact Level

The 'Means of control' associated to the Risk/Impact Levels (low to high) are defined as follows:

- Not necessarily required
- Required
- Required to reduce the significance of the risk/impact to an acceptable level

The HM Process is based on a Risk and Impact Assessment register elaborated by the operator at different levels - Organisational and Task level. The HM provides various

documents and tools to manage and communicate the means of control defined in the Risk and Impact Assessment register.

The timeline below shows the four different HM phases and the associated assessment and documentation tools.

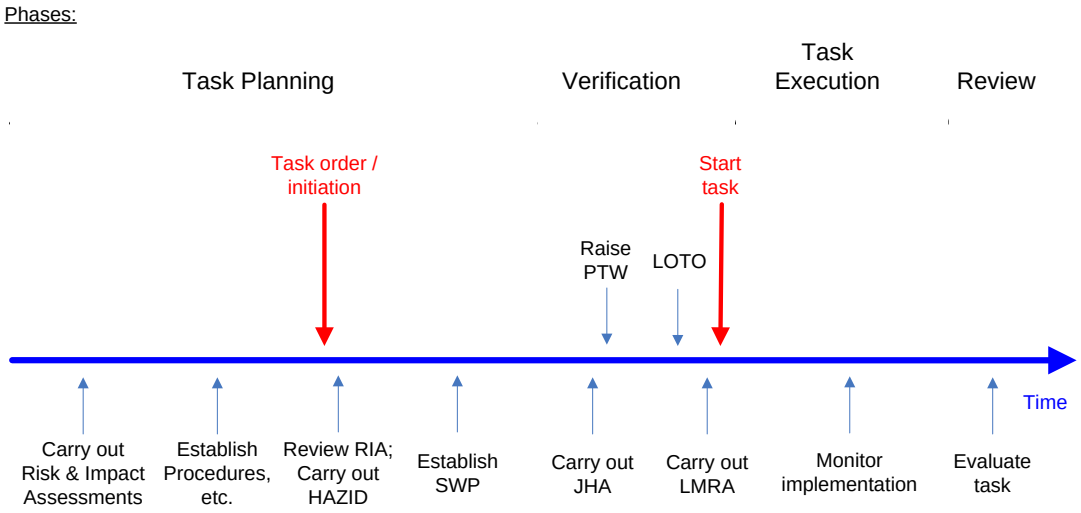


Figure 3.7 – Hazard Management Timeline
(Source: Operator)

3.2.4. Experience of the Apprentice Dredge Operator

The Apprentice Dredge Operator joined the operator in 2002. He was working on three other vessels before joining the IBN Battuta on 23 September 2011.

On the first vessel, the WTDs were hand-operated.

On the second vessel, the WTDs could be switched between automatic and local mode. In automatic mode, a push button had to be operated to open the WTDs.

The third vessel didn't have WTDs.

When signing on onboard IBN Battuta on 23 September 2011, the Apprentice Dredge Operator received a vessel familiarization. This familiarization did not include the safe operation of the WTDs.

3.2.5. Similar event in the operator's fleet

On March 31, 2014 while the hopper dredger VASCO DA GAMA was afloat in a shipyard in Singapore and operating in 'doors closed' mode, a scaffolder from a subcontractor was trapped in a WTD while passing through. The ship's electrician, who was working close to the WTD, heard the trapped scaffolder scream and came to his rescue by opening the WTD with the local control handle. The victim was brought to the Medical Center of the shipyard and transferred to a Hospital.

3.2.6. Corrective actions taken by the operator

3.2.6.1. On board IBN Battuta

The operator took the following corrective actions to avoid a similar accident onboard IBN Battuta:

- Occurrence was communicated during a daily crew-meeting;
- Training was given to all personnel on board with regard to the safe operation of the WTDs;
- Audible alarm of WTD 3 was repaired.

3.2.6.2. At Group level

The operator took the following corrective actions to avoid a similar accident at group level:

- At each power operated watertight door an operational procedure was posted (signboard/instructions were placed in way of the door) and this change was communicated throughout the fleet. The procedure states that this type of WTDs should be completely opened before passing through and the control handle should not be released while passing the door. (implemented on 1 November 2011)

3.2.7. WTDs with anti-crush protection

Some manufacturers have developed WTDs with an anti-crush protection as a safety guard. During remote closure of power operated WTDs, the protection system identifies objects obstructing the doorway and subsequently stops the movement of the door. Existing door systems may eventually be retrofitted with such a protection system.

The use of an anti-crush protection could require the implementation of an additional operating mode when remote closing is activated in order to enable complete door closure without protection in case of an emergency (safety override).

As an example, the manufacturer of the WTDs of the occurrence vessel has developed an anti-crush protection system which uses a laser beam sensor to detect obstacles in the doorway during power operated closure and to subsequently stop the remote operation of the door. In order to account for the added protection system, the manufacturer has implemented a ‘Master Mode Switch’ with 3 different modes on the control and indication panel (Figure 3.8):

- ‘local control’
- ‘doors closed with safety’
- ‘doors closed - safety override’

Figure 3.8 – Example: Master Mode Switch with anti-crush protection
(Source: Schoenrock Hydraulik Marine Systeme GmbH)

4. ANALYSIS

4.1. RECONSTITUTION OF THE ACCIDENT

The investigation could not establish the exact sequence of events which ultimately led to the accident and the death of a crewmember. The following analysis is based on the information provided mainly by the operator.

The VDR logs show that at 10:04:11 AM, the local control handle of WTD 3 (between the pump room and the engine room) was moved to the ‘open’ position. It is assumed that the operation of the handle occurred from the pump room. The VDR logs also show that WTD 3 never reached the ’open’ position during that operation.

The operating system of the WTDs was in ‘doors closed’ mode during the occurrence and there were no direct witnesses of the event. It can be reasonably assumed that the Apprentice Dredge Operator opened WTD 3 himself on his way from the pump room to the engine room by moving the control handle to the ‘open’ position. It is not clear why the Apprentice Dredge Operator intended to enter the engine room, as he was supposed to join his colleagues at the bridge wing for a break. The direct path from the pump room to the bridge wing would follow the stairs located in the pump room and leading up to the change-room. A passage through the engine room was hence not required.

It is unlikely that the Apprentice Dredge Operator has been trapped in the position he was found in on his passing of the doorway to the engine room. The opening of the door would require the operation of the control handle located at shoulder level, which would be hardly achievable with the back of the body facing the handle. The most probable scenario is that the Apprentice Dredge Operator stepped through the opening doorway while holding the handle located in the pump room in ‘open’ position and then reversed his path to get back to the pump room while or after releasing the handle. Based on the previously observed WTD 3 openings, it is probable that the door has only been opened by as much as to allow the quick passage of the doorway. Due to the selected ‘doors closed’ mode, WTD 3 started to close when the handle was released to neutral position. The Apprentice Dredge Operator then got trapped in the door with his back towards the operating panel, hence unable to operate the control handle on either side of the door to stop or reverse the movement of the sliding door.

At 10:06:02 AM, the WTD 3 was completely opened by the crewmembers providing assistance to the Apprentice Dredge Operator. The elapsed time from the moment the control handle was supposedly moved by the Apprentice Dredge Operator to the ‘open’ position, until the door was fully opened by the crewmembers assisting the victim onsite, was 111 seconds.

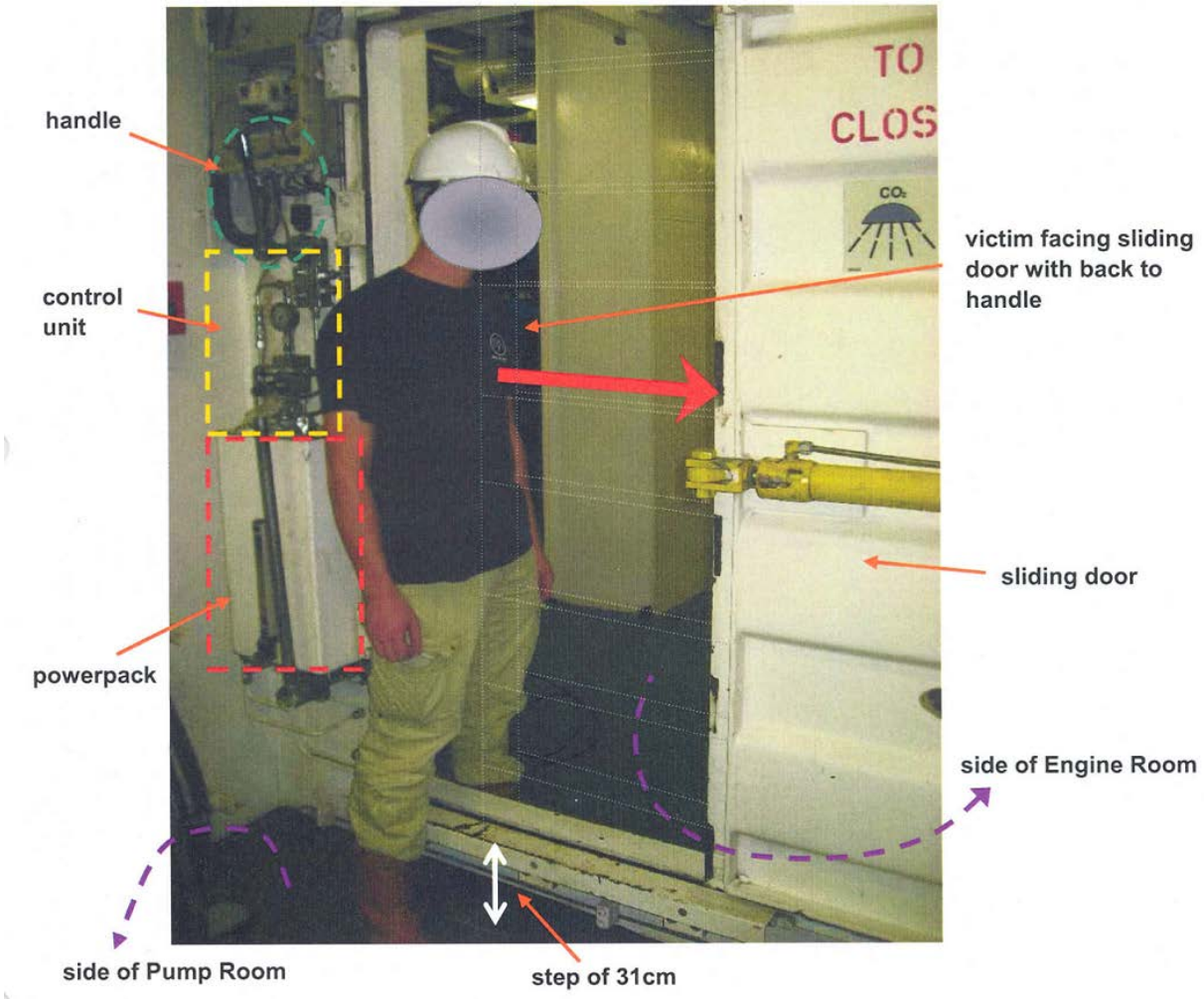


Figure 4.1 – Simulation of the Apprentice Dredge Operator's position (Source: Operator)

4.2. OPERATION OF WTD 3

As measured after the occurrence, during the functional tests by the WTDs' manufacturer, it took fifteen seconds to fully open the WTD 3. Based on a clear opening of 80 cm, the mean opening speed can be estimated at 5.35 cm/s. WTD 3 needed twenty-eight seconds to close completely, which gives a mean closing speed of 2.86 cm/s.

It can be assumed that WTD 3 was opened wide enough to allow a normal passage of the Apprentice Dredge Operator from the pump room to the engine room. For comparison, the three cycles of WTD 3 prior to the occurrence took respectively 22 s, 18 s and 20 s for the door to open and close. Based on the measured opening and closing speeds of WTD 3, it can be evaluated that the door had been opened by respectively 41 cm, 34 cm and 37 cm during those three cycles.

It can be estimated that the Apprentice Dredge Operator's body, while trapped in WTD 3, was exposed to a force of 40 kN for at least eighty seconds.

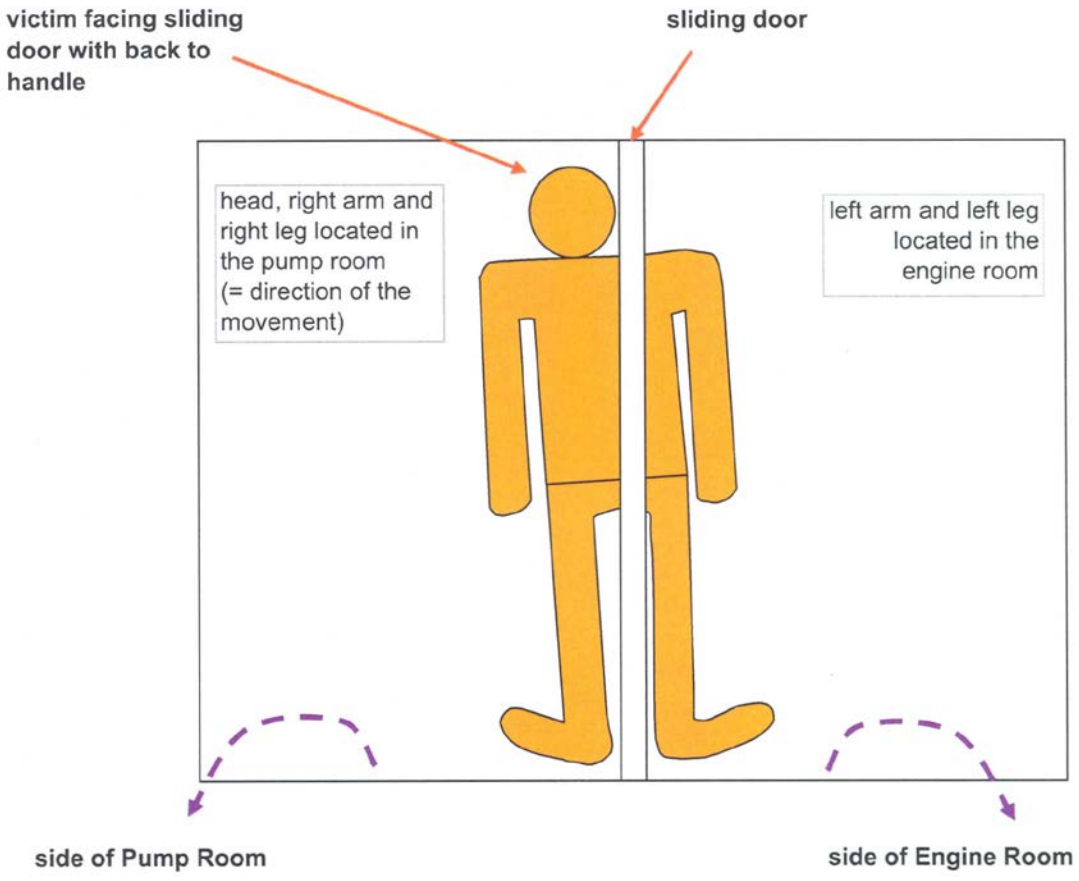


Figure 4.2 – Apprentice Dredge Operator's position

Based on the short experience onboard IBN Battuta (paragraph *3.2.4. Experience of the Apprentice Dredge Operator*), it can be expected that the Apprentice Dredge Operator was not familiar with the operation of the type of power operated watertight

doors used on the occurrence vessel. He signed on six days before the event and on the first four days, the WTDs were operated in ‘local control’ mode, meaning that when the control handle was released to neutral, the power operated sliding doors stopped moving and remained in their actual position.

SOLAS requires that *‘all watertight doors shall be kept closed during navigation except when necessarily opened for the working of the ship, and shall always be ready to be immediately closed (SOLAS regulation II-1/22.1).* However, this requirement is not related to a specific operational mode of power operated watertight sliding doors. In fact, SOLAS Regulation 15.8.1 states that for passenger ships, *‘the "master mode" switch shall normally be in the "local control" mode. The "doors closed" mode shall only be used in an emergency or for testing purposes’.* While this requirement does not explicitly apply to cargo ships, SOLAS does recommend its implementation also on cargo ships in **circular 1176** and **Resolution MSC.281 (85),** as shown in paragraph *3.2.2.3. Regulations for cargo ships - Amendments to SOLAS*.

In the investigated event, the operator chose as standard procedure throughout the fleet to operate the WTDs in “doors closed” mode while at sea. This type of operation reduces the risk of WTDs to remain open by removing the human element in the closing sequence. Furthermore, it also eliminates the need on the bridge to switch to ‘doors closed’ mode in case of an emergency, thus removing another potential human performance element.

The ‘doors closed’ mode exposes the human body to a potential risk on every passage of a WTD, especially in the absence of an implemented procedure within the operator’s hazard management system to mitigate the risk. Once the closing of the door has been remotely triggered, it can only be reverted by appropriate use of the local control handle. There are no safety guards to detect a potential object or obstacle obstructing the door opening and to eventually stop the door from closing. The force applied by the hydraulic cylinder to close WTD 3 was 40 kN. A human body getting trapped in a closing door for an extended time and exposed to a force of that magnitude is likely to sustain fatal injuries.

The force required to close a WTD during an emergency is determined by the conditions it is likely to be exposed to. It shall be able to reliably move to a full closure within a defined timeframe, with the ship listed to a certain angle to either side and while important water quantities are flowing through the opening. In view of the forces in use to close a WTD and in the absence of safety guards preventing injuries to the human body, the power operated remote closure of the WTDs should be used exclusively in emergencies and for testing purposes.

4.3. RISK EVALUATION

In the event of an emergency, the WTDs act as safety barriers when closed. Conversely, whenever a WTD is not closed, the safety barrier is removed. A safety relevant factor is the period of time for which a WTD is not closed.

In terms of closing speed, there is no difference in the operation of a WTD regardless of the operating mode (‘local control’ or ‘doors closed’). If appropriate procedures for manually closing the WTDs after each passage are in place and adhered to, there should be no negative impact on ship safety when operating the WTDs in “local control” mode. The timespan for which the WTDs remain open during a passage would not be impacted when compared to the operation in ‘doors closed‘ mode. Furthermore, with the WTDs’ status being shown on the bridge and logged on the VDR, the adherence to a WTD operating procedure by crew and passengers can be monitored and corrective actions can be taken accordingly, if deemed necessary.

Remote operation of WTDs in ‘doors closed’ mode exposes the human to a potential hazard during each passage, without providing much benefit to ship safety. It removes the responsibility of the bridge to switch to ‘doors closed’ mode in case of an emergency.

The decision to permanently operate in ‘doors closed’ mode can ultimately be seen as a tradeoff between a vulnerable ‘soft’ defense in the form of a procedure relying on human performance and a robust ‘hard’ engineered defense in the form of an automated WTD closure, creating a hazard at each passage .

4.4. HAZARD MANAGEMENT

When the operator decided to use the ‘doors closed’ mode as standard operating mode during navigation, he introduced a safety hazard for the onboard crew and passengers on every passage of a WTD due to the automatic closure and the absence of safety guards preventing a human body to get trapped in the doorway.

While the decision to operate in ‘doors closed’ mode was not contrary to SOLAS provisions for cargo ships, the fact to create a related hazard for crew and passengers at group level should have triggered an evaluation process within the company’s HM system. The aim of this process should have been to identify the risks and impacts of such a decision and, if appropriate, to implement control measures (e.g. procedure with associated implementation measures) to mitigate the risks.

At the time of the occurrence, a risk and impact evaluation had been carried out by the operator, but no safe working practice had been implemented, neither within the operators HM system, nor on board IBN Battuta. This is not in accordance with the practice recommended by the IMO.

After the occurrence, the operator decided to implement a safe working practice at group level on how to safely operate a WTD at all times (irrespective of the mode of closure). The safe working practice was implemented within the operators HM system on 1 November 2011.

4.5. WTDS WITH ACTIVE PROTECTION

The use of power operated watertight sliding doors with an anti-crush protection system as a safety guard would allow the standard operation in a dedicated mode with an active protection. This type of operation would eliminate the risk of an accident when passing through a WTD, while at the same time reducing the risk of WTDs to remain open by removing the human element in the closing sequence. In case of an emergency, the safety guard could be removed to ensure the power operated closure of the WTDs.

The current SOLAS regulations do not address the implementation of a safety guard which would serve as an anti-crush protection for power operated sliding doors on passenger or cargo ships.

5. CONCLUSIONS

- The operator's standard operating mode of the WTDs throughout the fleet was the 'doors closed' mode.

- The 'Master Mode Switch' on the central operating console for watertight doors was in 'doors closed' mode, thus resulting in the remote closing of WTD 3 once the local control handle was released to neutral.

- The audible alarm of WTD 3, indicating the remotely activated closing, was not working at the time of the occurrence.

- When signing on onboard IBN Battuta, the Apprentice Dredge Operator received a vessel familiarization training which did not include the safe operation of the WTDs.

- Absence of an implemented safe working practice for the safe passage through power operated sliding watertight doors within the operator's hazard management system to mitigate the risk of pathing through WTDs. This was differing from the standard practice recommended by the IMO and increased the risk associated with every passage through the door openings.

- The Apprentice Dredge Operator's body got trapped in WTD 3 during remote closure and was exposed to a force of 40 kN for approximately eighty seconds.

- The Apprentice Dredge Operator deceased from a multi-trauma.

6. SAFETY RECOMMENDATIONS

LU-MA-2018-001 to the Luxembourg Maritime Administration

AET recommends that the Luxembourg Maritime Administration considers mandating that all vessels on the Luxembourg Merchant Fleet registry shall operate the remote control stations for power operated watertight doors in accordance with SOLAS Regulations II-1/13.8.1 to 13.8.3[4].

LU-MA-2018-002 to the Luxembourg Maritime Administration

AET recommends that the Luxembourg Maritime Administration proposes an amendment to the IMO's Maritime Safety Committee that all vessels shall operate the remote control stations for power operated watertight doors in accordance with SOLAS Regulations II-1/13.8.1 to 13.8.3[4].

LU-MA-2018-003 to the Luxembourg Maritime Administration

AET recommends that the Luxembourg Maritime Administration promotes the safe operation of remotely operated watertight doors by disseminating the "lessons learned" from the investigated event to all operators.

[4] Formerly SOLAS consolidated 2004 edition regulations II-1/15.8.1 to 15.8.3

7. APPENDICES

HOW TO OPERATE WATERTIGHT DOORS ON BOARD A VESSEL

GOLDEN RULE:

ALL WATERTIGHT DOORS ARE TO BE KEPT CLOSED AT SEA

"LOCAL" MODE

The watertight door will open while you hold the lever / push the button and will stay in that position when you release it.
Close the door again with the lever / button immediately after use

"CLOSED" "REMOTE" OR "AUTOMATIC" MODE

The watertight door will open while you hold the lever / push the button and will automatically close as soon as you release

1 Verify the MODE of the watertight door you're about to use

2 Pull lever (or push the button) to open the door

Hold lever or button until the door is **fully open**

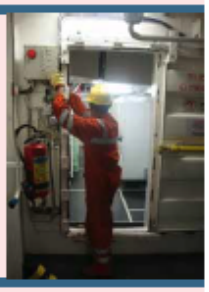
3 Release the lever / button and step through

3 An alarm will sound to indicate the door is opened in "closed" mode

4 Immediately after use:

Use the lever / button to fully close the door behind you

4 Use both hands to pull the levers / push the buttons on either side of the door while you step through. Ask help when moving objects



5 The door will close automatically as soon as the lever / button is released

If it's moving: you don't step through!