Watertight doors

Awareness

Content

Watertight sliding doors

1. Introduction and lessons learned
2. Technical, operational and maintenance issues
3. Summary and recommendations

Safety onboard

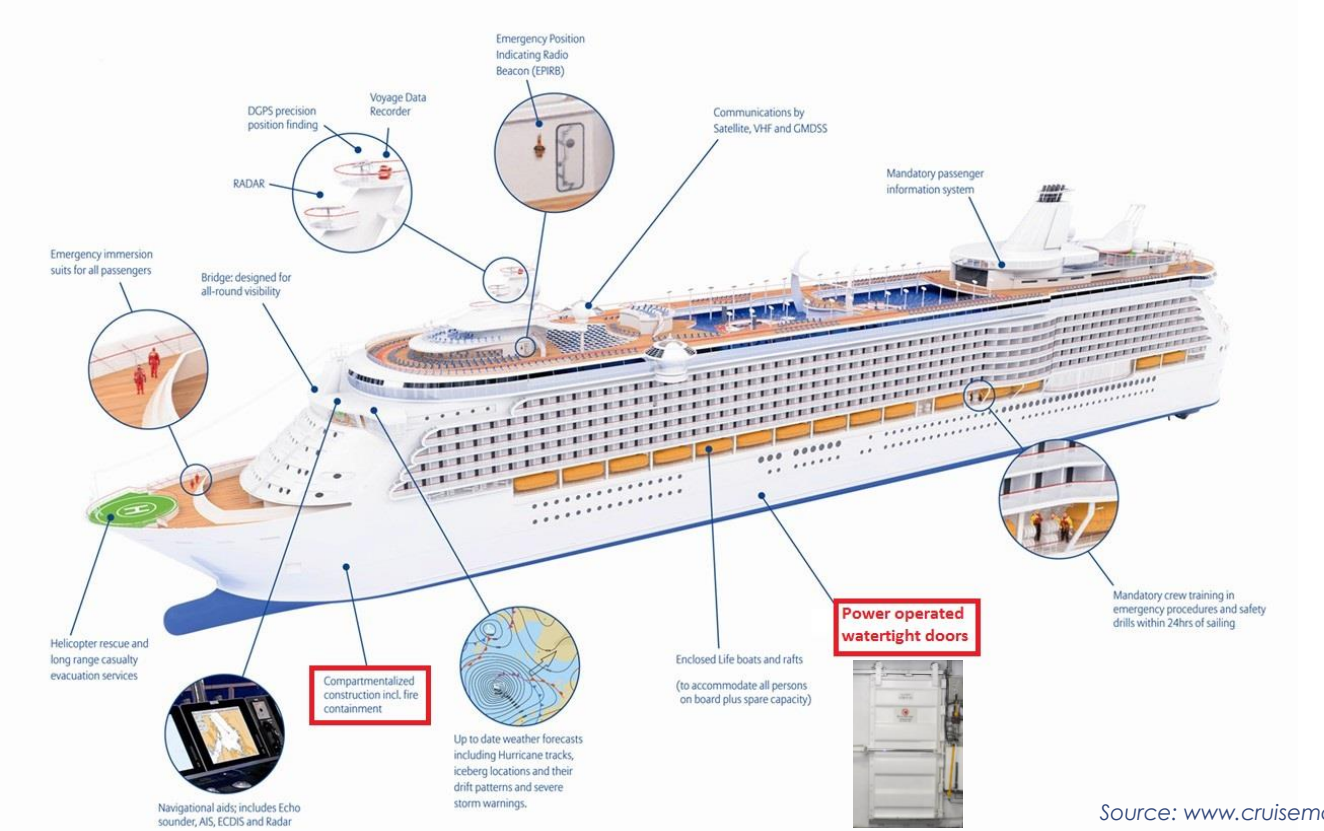
In the 21st century

- **Safety onboard is better than ever.**
- The future of seafaring continues to evolve in response to economic, political, demographic, and technological trends.
- The maritime industry work actively to improve safety records.
- Marine transportation can be considered one of the safest means of passenger transport overall.

Safety onboard has been improved through a combination of **technology**, **cultural & training** improvements and **regulations**

Safety onboard

Modern vessels are equipped with an array of safety innovations



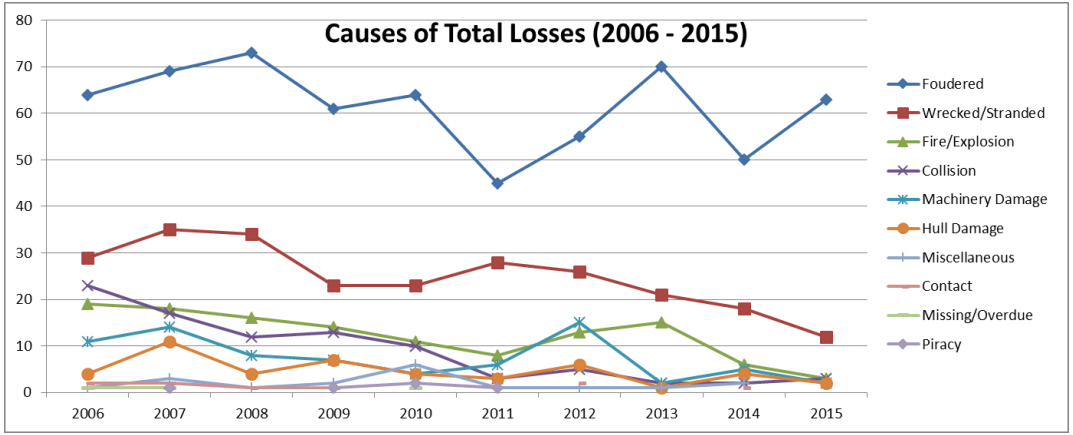
Source: www.cruisemapper.com

Safety onboard

Decline in total losses worldwide – 2006 to 2015

Large shipping losses have declined by 45% over the past decade, driven by an increasingly robust safety environment and self regulation.

Foundered (sunk or submerged) is the main cause of loss accounting for half **(50%)** of all losses over the past decade.
Grounding is the second major cause **(20%)**
Fire is the third major cause **(10%)**
Collision is the fourth major cause **(7.3%)**



Source: Allianz Global Corporate & Specialty, Safety and Shipping Review 2015

Watertight doors are important in case of foundering, grounding, collision and contact damages.

Awareness topic

Power operated watertight sliding doors

Safety of the ship

Safety of the people

- **Increase the integrity** of the watertight doors as a barrier in case of internal flooding or water ingress after damage.
- **Create a better understanding** of how the watertight doors are designed, and should be operated and maintained during normal and emergency conditions.
- **Promote situational awareness** of officers and crew members passing through these doors.
- **Prevent accidents and injuries** from happening.

Watertight sliding doors

Awareness target and relevance

Highly relevant for

- passenger vessels (cruise/ferry/RoPax)
- offshore vessels and units
- special purpose vessels
- large container vessels

while at sea and navigating in

- restricted visibility
- harsh weather
- icy waters
- congested waters
- close to land
- uncharted areas

or during periods of

- lay-up
- tow

Source: www.wftv.com

Source: www.ntsb.gov

Source: www.nps.gov

Source: www.offshore.no

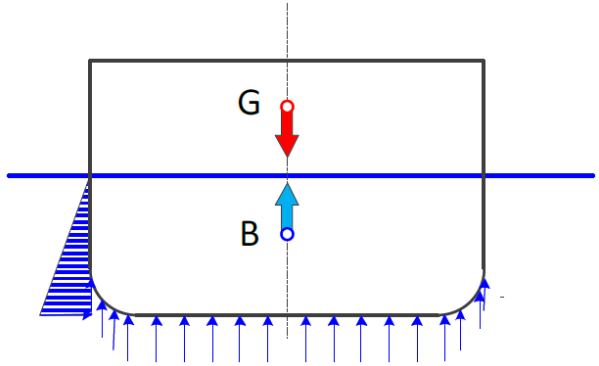
Basic buoyancy and stability theory

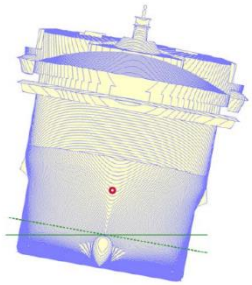
Hydrostatic stability

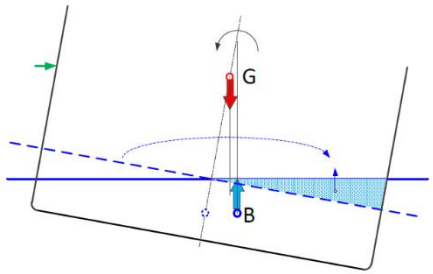
A vessel floats in a **stable position** when hydrostatic stability is obtained:

buoyancy = weight of the vessel

- **Positive stability** is the vessel's ability to roll back to the initial position after being exposed to a heeling moment
- A vessel will **capsize** if the sum of heeling moment become greater than the righting moment



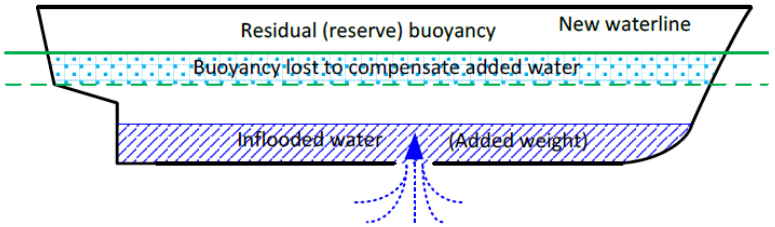




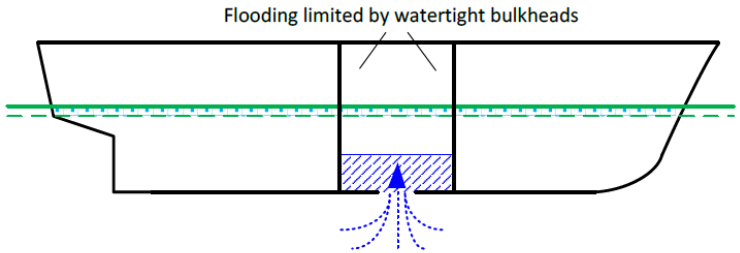
Basic buoyancy and stability theory

Watertight bulkheads

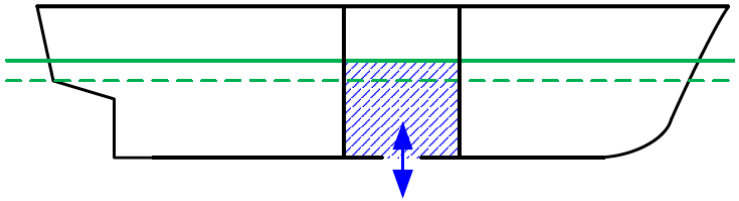
A vessel will **sink** when:
weight of the vessel **>** buoyancy



That is why **watertight bulkheads** are installed to limit the spread of water inside the vessel



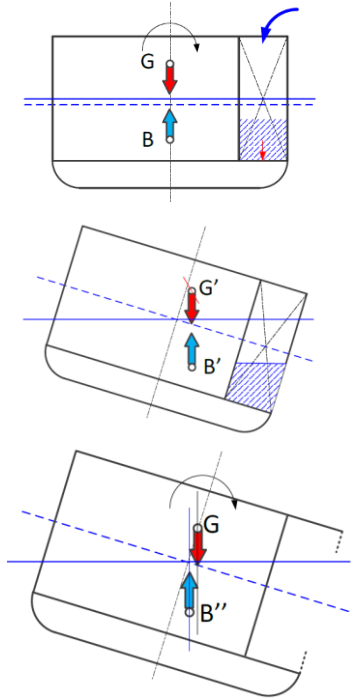
The **sinking stops** when:
water level inside the vessel compartment = the sea level outside



Basic buoyancy and stability theory

Damage stability = loss of buoyancy due to flooding of spaces

- **Filling a compartment** from the outside will increase the vessel's weight, the **vessel will sink deeper** to provide more buoyancy; and
- the centre of gravity shifts as weight increases. The **vessel will heel**, trying to balance weight and buoyancy
- **If the compartment is open to the sea**, the buoyancy of that space and its contents will eventually be lost. In this situation the buoyancy will not be able to prevent a **capsize if equilibrium cannot be found** at a larger angle.



The ship's volume should be divided by watertight bulkheads to avoid the spread of water and loss of stability.

Lessons learned

From major accidents

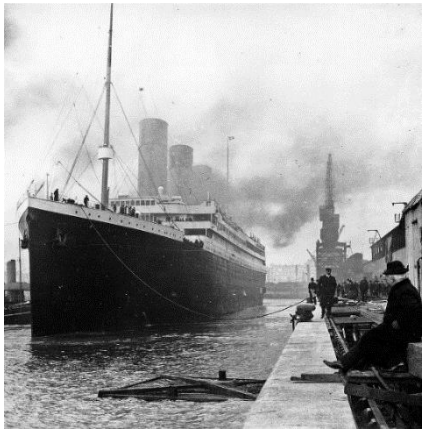
1912 - The *TITANIC* collided with an iceberg, which punctured the ship's hull and water flooded in.

2007 - The *Explorer*, struck an unidentified submerged object, reported to be ice, which punctured the ship's hull and water flooded in.

Lessons learned:

- Ship's need to be designed so that the flooding of compartments would not jeopardize the buoyancy and stability of the ship.
- Both *Titanic* and *Explorer* stayed afloat for many hours due to the **watertight bulkheads**, but eventually the ship sank.

Source: www.wikipedia.org



Source: www.wikipedia.org

What are the main risks

Power operated watertight sliding doors

Loss of vessel stability and buoyancy

in case of watertight doors left open or leaking during water ingress or internal flooding

Injury to crew and personnel

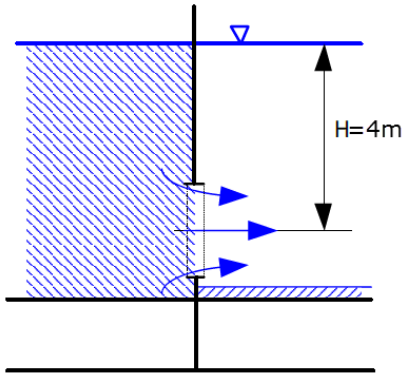
in case of being trapped in the door due to lack of competence, misuse or lack of training.

Fire onboard

in case of watertight doors left open smoke and fire might spread through the vessel causing injury to both people and vessel

Failure of the watertight barrier

Flooding through an open watertight door



Source: www.iunat.iupui.edu

Door size (2m * 0.8 m):	1.6 m^2
Head of water:	4 m
Flow rate:	**= 8.5 m^3/s**

5 minutes to fill an Olympic sized swimming pool

Keeping watertight doors closed is vital!

Safety of the ship

Why openings in the watertight bulkheads?

Watertight bulkheads

- may limit the commercial use of spaces on board
- make it difficult for the crew to move around between the spaces

Therefore, watertight doors are fitted in the watertight bulkheads.

In certain conditions, some watertight doors can remain open or be opened for limited periods of time while at sea.

Saving the ship has priority!

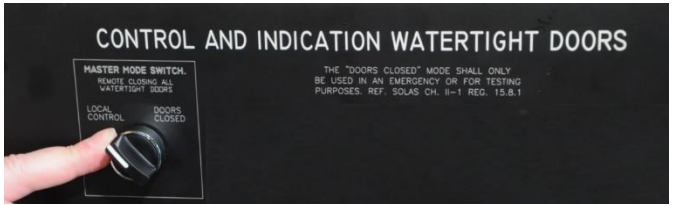
The bridge can take control of all watertight doors and close them.

Safety of the personnel

Another key priority

To safely passing through of a power operated watertight door can easily be achieved by:

- **having competence** on the correct operating and maintenance procedures.
- **having both hands free** to operate the controls and not carry any heavy load through a closed door unassisted.
- **open the door fully** before passing through and **never to pass through a moving door.**
- **stay aware of the situation** when the "DOORS CLOSED" mode has been activated on the bridge.
- **fully appreciate the crushing power** of watertight doors. There are many reports of serious injuries and deaths.



Managing conflicting goals

Safety of the ship and personnel

Safe operation ⟷ **Operational performance and commercial pressure**

Safety levels, as indicated by Regulators:

- International vs. domestic trade
- New vs. older vessels
- Different vessel types and sizes
- Regulations vs. real case experiences and simulations

Watertight doors shall be as few as possible and be kept closed while at sea

However, aspects of:

- safe operation of the machinery
- crew and passenger evacuation
- working environment

mixed with the survivability requirements of the vessel after flooding

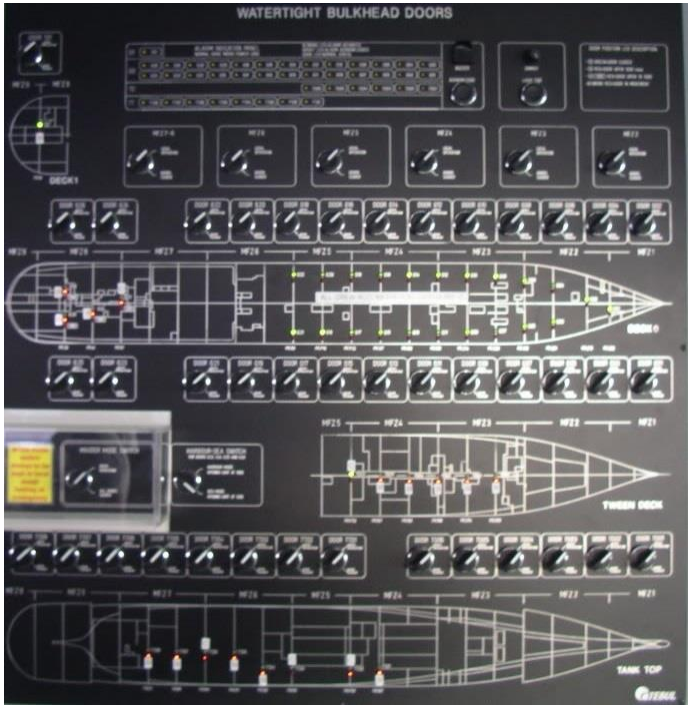
Poor operating and maintenance procedures and training schemes may lead to misjudgements!

Large passenger ships

Number of watertight doors

Today's norm is an **extensive** use of watertight doors in the transverse bulkheads on large passenger vessels; in the engine room, service areas and crew quarters below the waterline.

Flag Administrations may permit certain pre defined watertight doors to remain open while at sea, if considered absolutely necessary for the safe and effective operation of the ship.



Watertight doors

Latest trends

*"Some 20 years ago, the International Safety Management Code, adopted by IMO, represented a step-change in the **establishment of a safety culture in shipping**. The time has now come to generate another step-change. This will not be achieved through legislative measures alone. We must generate a new impetus in shipping to **go beyond compliance** with regulations and explore industry-wide mechanisms to ensure the safety culture is embedded throughout the entire industry," IMO Secretary-General Koji Sekimizu.*

IMO - updating regulations

- Amendments to SOLAS regulation II-1/22 – limiting the number of watertight doors permitted to remain open during navigation.
- Introduction of the POLAR Code – provide measures to maintain watertight integrity during vessel operation in the harsh and icy environment of the Artic.

Focus area

- Port State Control have found watertight doors with missing portions of gaskets, `hydraulic oil leaking, inoperable audible alarm and the means of doors closed indication at all remote operating positions found to be in a fault condition.
- Recent Shelf State inspections of offshore units, have observed several instances where designated watertight doors – which are to be closed at sea - have been routinely left open.

Technical, operational and maintenance issues

Part 2

Technical, operational and maintenance issues

1. **Watertight sliding doors**
   - Typical door types and locations

2. **Watertight integrity**
   - Requirements for internal openings

3. **Bridge control**
   - “Local Control” and “Doors Closed” mode

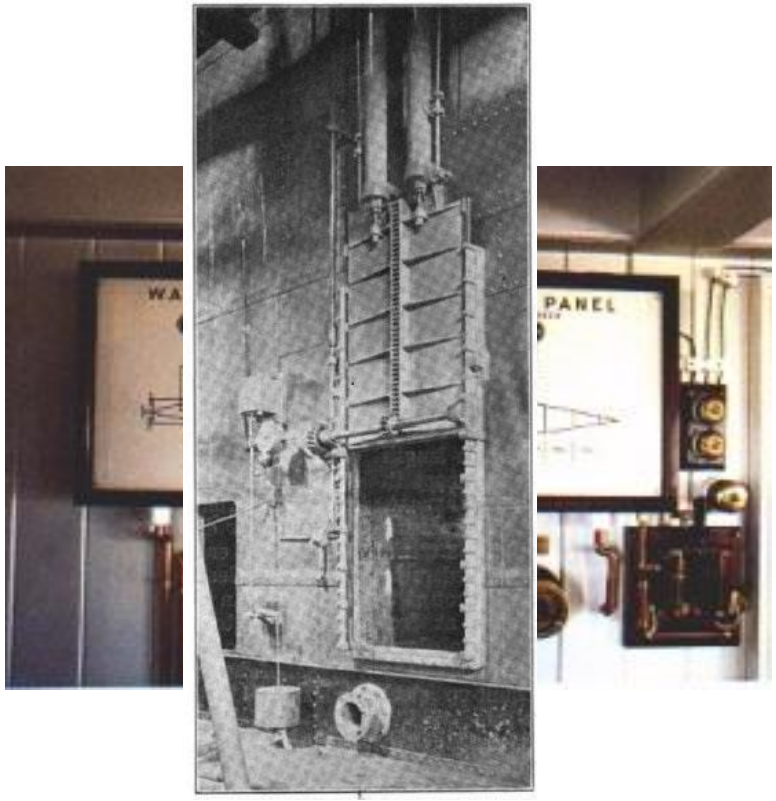
4. **Operation and maintenance**
   - Challenging conditions, drills and inspections

Power operated watertight sliding doors

Not a new invention

Titanic had 12 power operated watertight doors on the lower decks:

- vertically sliding and made of heavy cast iron
- powered by gravity and braked by two hydraulic cylinders
- closing time of 25-30 seconds
- locked by wedges in the frame
- remotely operated from the bridge with local warning bell sounding
- manual operation adjacent to the door and above the bulkhead deck
- automatic operated by a float under the floors
- **indication panel on the bridge was later installed on the other *Olympic*-class liners.**



Source: www.encyclopedia-titanica.org

Power operated watertight sliding doors

Today's design

Modern power operated watertight doors:

- horizontally sliding and made of steel
- powered by hydraulic cylinders or electric motors
- closing force of several tonnes
- closing time between 20-40 seconds
- locked by wedges or pins in the frame
- watertight by «steel to steel» or «rubber gasket»
- remotely closing from the bridge with local warning alarm and light
- manual and emergency operation adjacent to the door (and above the bulkhead deck on passenger ships)
- **digital system for indication and control and monitoring**

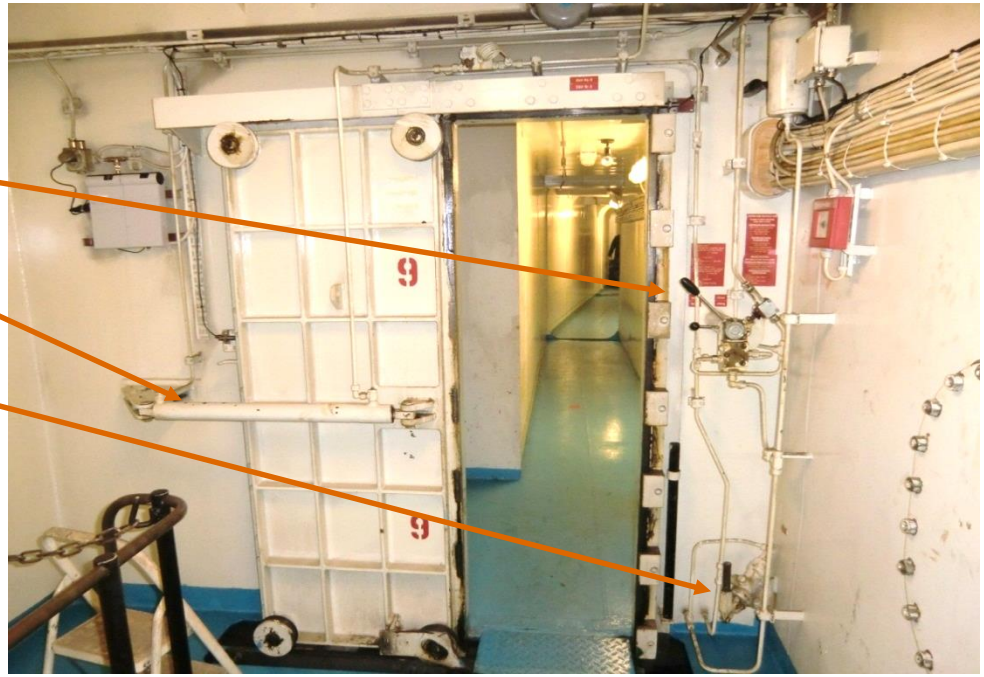
CCTV *Digital Control Systems*

Power operated watertight sliding doors

Typical door and location

RoRo and
RoPax ferries

Local operation handle and instruction for use.
Hydraulic cylinder for closing
Emergency operation handle and pump



Power operated watertight sliding doors

Typical location

Large passenger vessel

Modern type doors below the bulkhead deck.
Typical working areas for crew, galley, laundry etc.

Regulators may allow for certain pre-defined **watertight doors to be opened while at sea.**

Such considerations would be if the door:

- is essential to the safe operation of the machinery
- or to permit passage of passengers and crew
- or to permit work in the immediate vicinity

Dimensions: 1.2 x 2 meter

- horizontal stiffeners, for strengthening the door
- flush-type, thus no obstruction for the users

Dimensions: 0.9 x 2 meter

- mounted in corridor of crew cabins
- upper handle is for emergency operation
- lower handle is for normal operation
- flush-type

Power operated watertight sliding doors

Typical location

Container ships

- Fore and aft passageways under deck and in engine room bulkheads leading to pipe- and shaft-tunnels.

Source: www.telegraph.co.uk

Offshore vessels and units

- Below cargo deck on offshore service and construction vessels, special purpose vessels, crane vessels, oil exploration vessels.
- In lower part of pontoons in offshore units.

Power operated watertight sliding doors

Water tightness

For water tightness the doors may use a rubber **O-ring** type of packing or a wider **rubber-lip** type packing

.. or may seal by being wedged into the door frame **“steel to steel”**

Power operated watertight sliding doors

Sliding on wheels and rails

The watertight sliding doors slide sideways on wheels running on a set of rails.

Door function might be compromised by worn wheels or rails.

Power operated watertight sliding doors

Movement and closing power

Either by **hydraulic power**
normally a **2 ton** cylinder

.. or **electric power**
normally a **1 ton** electric motor

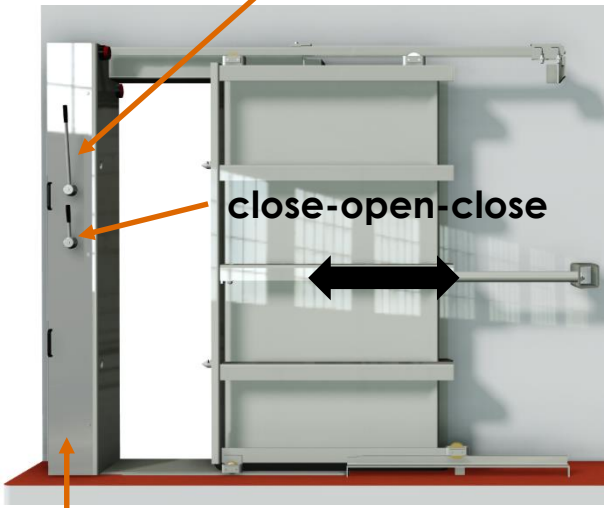
The regulations do not specify the power to be used

only under what circumstances the door should be able to close

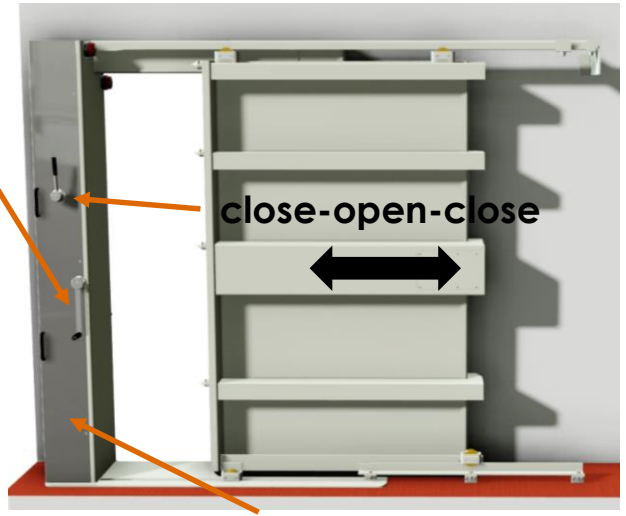
Power operated watertight sliding doors

Back-up power

3 movements of the door in case of black-out
and **hand-powered generator** for local emergency operation



Backup power stored in
hydraulic accumulator

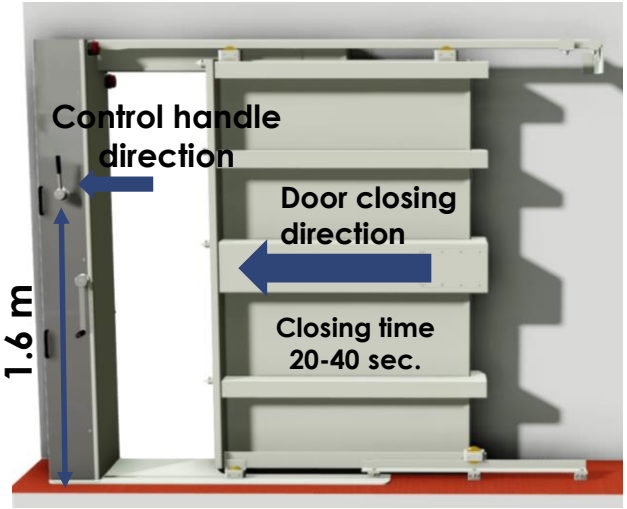


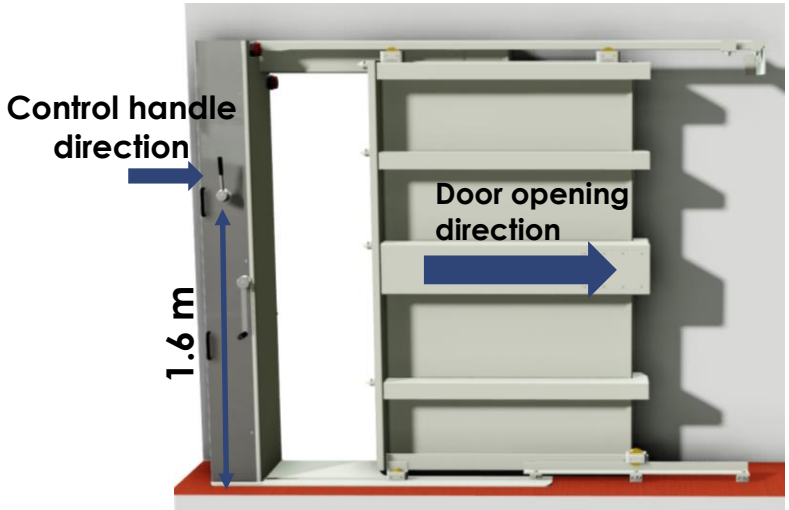
.. or **electric battery**
and emergency switchboard

Power operated watertight sliding doors

Normal local operation

- The doors have individual control handles on each side of the door.
- The **Opening** and **Closing** of the door shall be in the direction of the door movement and shall be clearly marked on the control handles.
- The closing time shall be between 20-40s.
- The control handles are located at least 1.6m above the floor on passenger ships.



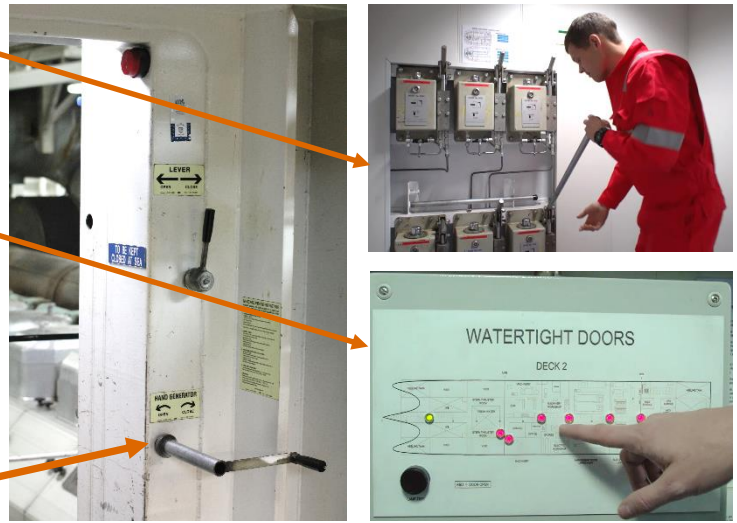


Hold both handles in the open position while passing through!

Power operated watertight sliding doors

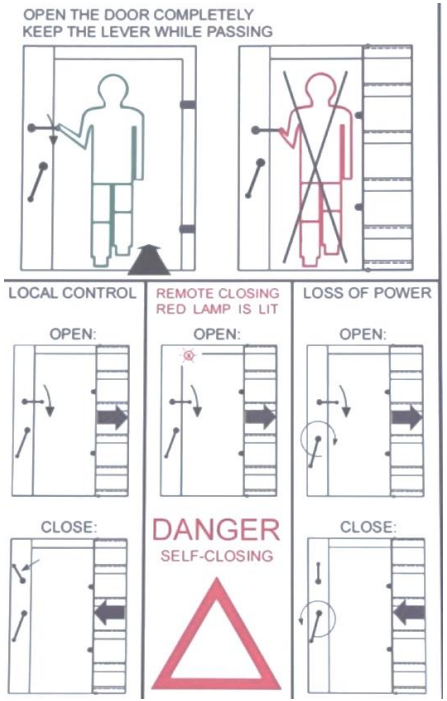
Emergency operation locally and above the bulkhead deck

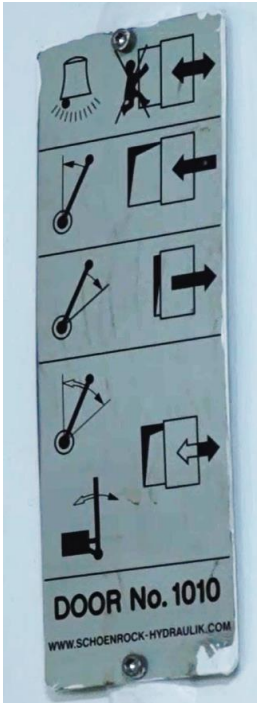
- For passenger ships, it is also required to be able to **close** the doors from an accessible **position above the bulkhead deck**.
- This remote location is to have **means of indicating** whether the doors are **open** or **closed**.
- The time necessary for the complete **closure of the door by hand gear is not to exceed 90s** with the ship in an upright position.
- The doors must be able to be **operated using a hand-operated generator** locally by the door.



Power operated watertight sliding doors

Instructions for use - Local control, remote control and emergency operation





If the door moves, you do not!

Power operated watertight sliding doors

Typical location onboard

Engine room bulkhead door

A wide door may close with a higher speed than a narrow door.

Instructions for use partly painted over.

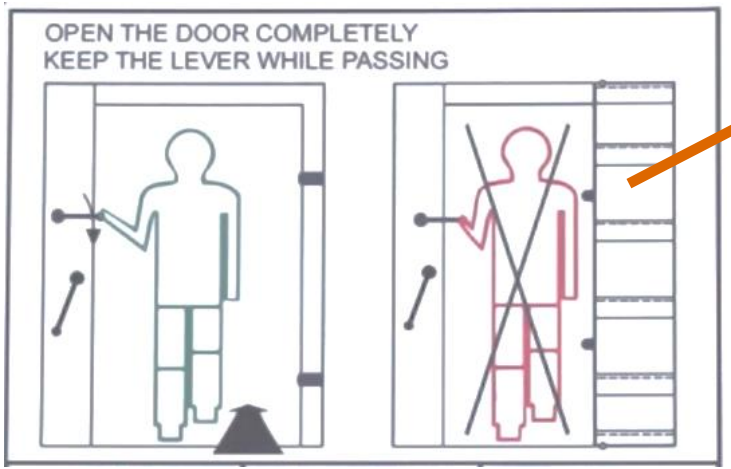
Power operated watertight sliding doors

The dangers during local operation

It is essential that crew feel confident when manually operating and passing a power operated watertight door, so that the risk of injury is avoided

Low risk

High risk will be observed



Power operated watertight sliding doors

Investigations after personnel injuries

Root cause investigations:

- Door not fully opened before passing through.
- Door alarm and light found not working.
- Door closing to fast.
- Door has not been maintained and tested.
- Door not complying with the regulations.
- Door handle was installed incorrectly.

Most accidents to personnel happen when the doors are in bridge control, "doors closed" mode.

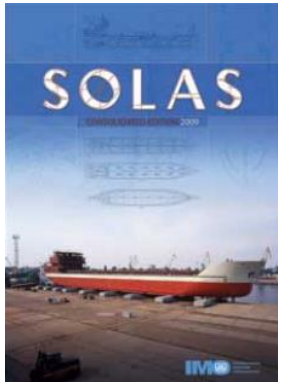
Watertight integrity

Requirements for internal openings in the watertight bulkheads

Passenger- and cargo ships

"The number of openings in watertight bulkheads shall be reduced to the minimum compatible with the design and proper working of the ship"

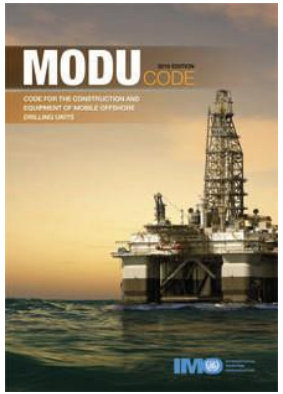
SOLAS Ch. II-1, Part B-2 Reg. 13 and 13.1



Mobile offshore units

"The number of openings in watertight subdivisions should be kept to a minimum compatible with the design and safe operation of the unit"

MODU Code Ch.3 Reg. 3.6.1



Watertight integrity

Bridge control

Cargo ships

Doors which are used while at sea must be:

- *capable of being **remotely closed** from the bridge*
- ***indicators are to be provided** at the control position showing whether the doors are open or closed*
- ***an audible alarm** is to be sounding when doors are closing.*

SOLAS Ch. II-1, Part B-2 Reg. 13.1.3

Mobile Offshore Units

Doors which are used during the operation of the unit while afloat should be:

- ***remotely controlled** from the central ballast control station*
- ***open/shut indicators should be provided** at the control station*
- *and be provided with **an alarm system (e.g., light signals)***
- *the remote operated doors should also meet SOLAS Ch. II-1, Part B-2 Reg. 13.1*

MODU Code Ch.3 Reg. 3.6.5

Source: www.oilandgasinvestor.com

Watertight integrity

Bridge control

The bridge control on passenger ships:

- close all doors simultaneous from the bridge in 60 seconds
- diagram showing the location of all doors
- **red** light for fully **open** and **green** light for fully **closed**
- "master mode switch" for "local control" mode and "doors closed" mode
- local audible alarm distinct from any other alarm in the area
- sounding whenever the door is closed remotely, at least 5 seconds, but not more than 10 seconds before the door begins to move
- shall sound until the door is fully closed
- may be supplemented by visual signal at the door

SOLAS Ch. II-1, Part B-2 Reg. 13.5.1, 13.6, 13.7, 13.8

Note: *Passenger ships built before 01.02.1992 have no definitions for red and green functions, and may have push buttons instead of a "master mode switch" and there is no such requirement for cargo ships and mobile offshore units.*

Bridge central operating console

Modern offshore supply vessel

Master mode switch

Local control

- Will allow any door to be locally opened and closed.
- Doors will stop moving when the local operating lever is released locally at the door.
- **To be used during normal operations**.

Doors closed

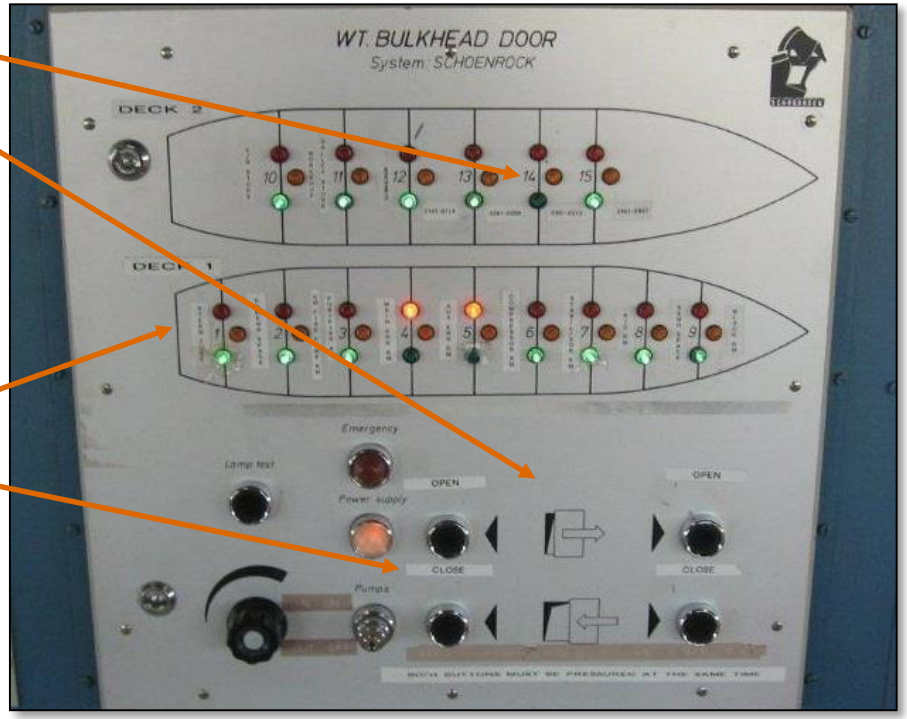
- Will close all open doors, after a 5-10 second delay with audible alarm sounding and in some cases warning light flashing.
- Doors may still be opened but will close automatically if the operating lever is released locally at the door.

DOORS CLOSED
Shall only to be used in an emergency or for testing purposes

Bridge central operating console

RoPax ferry from 1981

- Damaged light door 14?
- Doors can be closed and **opened from the bridge!**
- No **“master mode switch”** for changing between bridge and local control.
- No definition of red and green indicators.
- The push buttons for closing and opening doors are all black.



Operational issues

Example of incorrect priorities concerning the safety of the ship

This watertight door has;

- Instructions stating: "The door is to be closed before leaving quay side".
- The door operation handle is locked inside a cabinet.
- **The key to the cabinet is kept on the bridge!**
- The door is an emergency exit.

How to close the door locally in case of water ingress or escape in case of emergency?

Operational issues

Example of issue concerning the safety of the ship

Watertight doors in a crew corridor was found left permanently open by manipulating magnet switches in the coaming.

Witnessed during an inspection of
a cruise ship August 2012.

The audible bell and light alarms will not work and doors will indicate as closed on the bridge!

Operational issues

Passenger ships – doors which may be opened during navigation

IMO circular MSC.1/Circ.1380

- The circular categorizes these doors into: A, B, C and D doors.
- A, B and C doors, although allowed to be opened, should be kept closed in certain situations.
  - The limitations are to be included on the damage control plan.
  - The actual categorization shall be posted on each side of the door.

The recommendations leave room for individual interpretations.

- may reduce the needed respect for essential doors to be kept closed at sea.
- confusing for crew to have four different categories of watertight doors.

Hence effective training and familiarization is very important.

Operational issues

Challenging conditions

General rule:

Keep the doors closed while at sea!

Above all when navigating:

- with restricted visibility
- in areas of high traffic density
- in congested waters
- near coastal waters
- in heavy weather
- in icy waters
- shallow water
- when the Master feels that the conditions are risky and dangerous.

Operational issues

Emergency preparedness

- **Drills and inspections:**
  - shall take place every week and entered in the log-book with explicit record of any defects which may be disclosed.
- **The doors should be:**
  - checked before leaving port.
  - operated daily during the safety rounds.
  - able to operate from both local and remote places. I.e. bridge and ship control center.

Maintenance issues

Power operated watertight sliding doors

Safety critical equipment containing:

- structural parts
- means of tightness
- mechanical parts
- hydraulic parts
- electric parts

to be maintained and controlled in accordance with the manufacturer's instructions.

Work orders:

Recent inspections have revealed that planned maintenance work orders only referred to makers instructions, with **no specific instructions at all.**

Maintenance issues

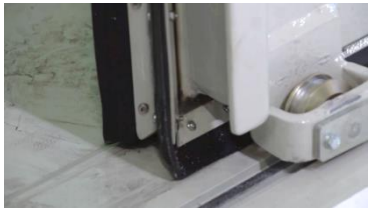
Important items to be checked

Work order templates have been prepared

- **Inspect for structural damage**, frame and surrounding steel structure (cracks, indentations, corrosion).
- **Inspect the watertight integrity** (gaskets, electrical components, penetrations of pipes and leads).
- **Ensure the hand crank for emergency operation** is easily available.
- **No loose or unsecured items in the vicinity of the door**, such as loose floor plates, trolleys, pallet jacks etc.
- **Operating instructions** are posted clear and easy to see.
- **Test of local and remote operation and alarms** (remote closing and emergency power with 3 movements on stored power).
- **Vessel specific instructions** are posted and mention under which conditions the door may be open.

Maintenance issues

Service by the manufacturers



Summary and recommendations

Main learning points

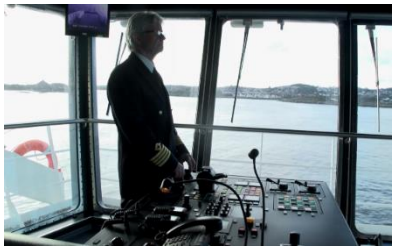
Crew preparedness

- Ask for onboard training on the function and operation of a watertight door.
- Keep doors closed while at sea.
- Open the door fully before passing through.
- Beware when the master mode switch has been set to “doors closed” mode.
- Participate in the regular drills.
- **Keep situational awareness when passing through these doors.**

Main learning points

Management contribution

- Promote keeping watertight doors closed while at sea.
- Use the “doors closed” mode is only in an emergency or for testing purposes.
- Host regular onboard training and drills for crew preparedness.
- Implement the proper maintenance procedures for the watertight doors.
- Improve monitoring to quantify impact of watertight doors explicitly.
- Make sure the current and upcoming regulatory requirements are applied.
- Consider going beyond minimum regulatory compliance.
- **Motivate a prudent culture onboard for the proactive and safe use of watertight doors.**



Main learning points

Industry contribution

Manufacturers, class society and Flag Administration representatives should:

- Verify that critical door functions are tested regularly.
- Verify that doors are maintained by competent personnel, e.g manufacturer or trained company personnel.
- Verify that onboard training program is available to the crew.
- Verify that that watertight doors are identified as safety critical equipment.
- Improve design guidelines for expedient pass through and safe operation.
- **Assess the watertight doors impact on vessels stability and safe return to port in case of accidents or during internal flooding.**

For further guidance…

Publications of relevance

IMO

Guide on watertight doors on passenger ships which may be opened during navigation - **MSC.1/Circ.1380 guidelines**

Draft amendments to SOLAS regulation II 1/22 and draft MSC Circular on guidance on watertight doors on passenger ships which may be opened during navigation - **SDC, 2nd session, 16-20 February 2015**

EMSA

Study assessing the acceptable and practicable risk level of passenger ships related to damage stability, undertaken by DNVGL - www.emsa.europa.eu/damage-stability-study

DNV-GL & RCCL

Technical note on stability barrier management for large passenger ships - Ocean Engineering125(2016)342–348

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Thank you for your attention!

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