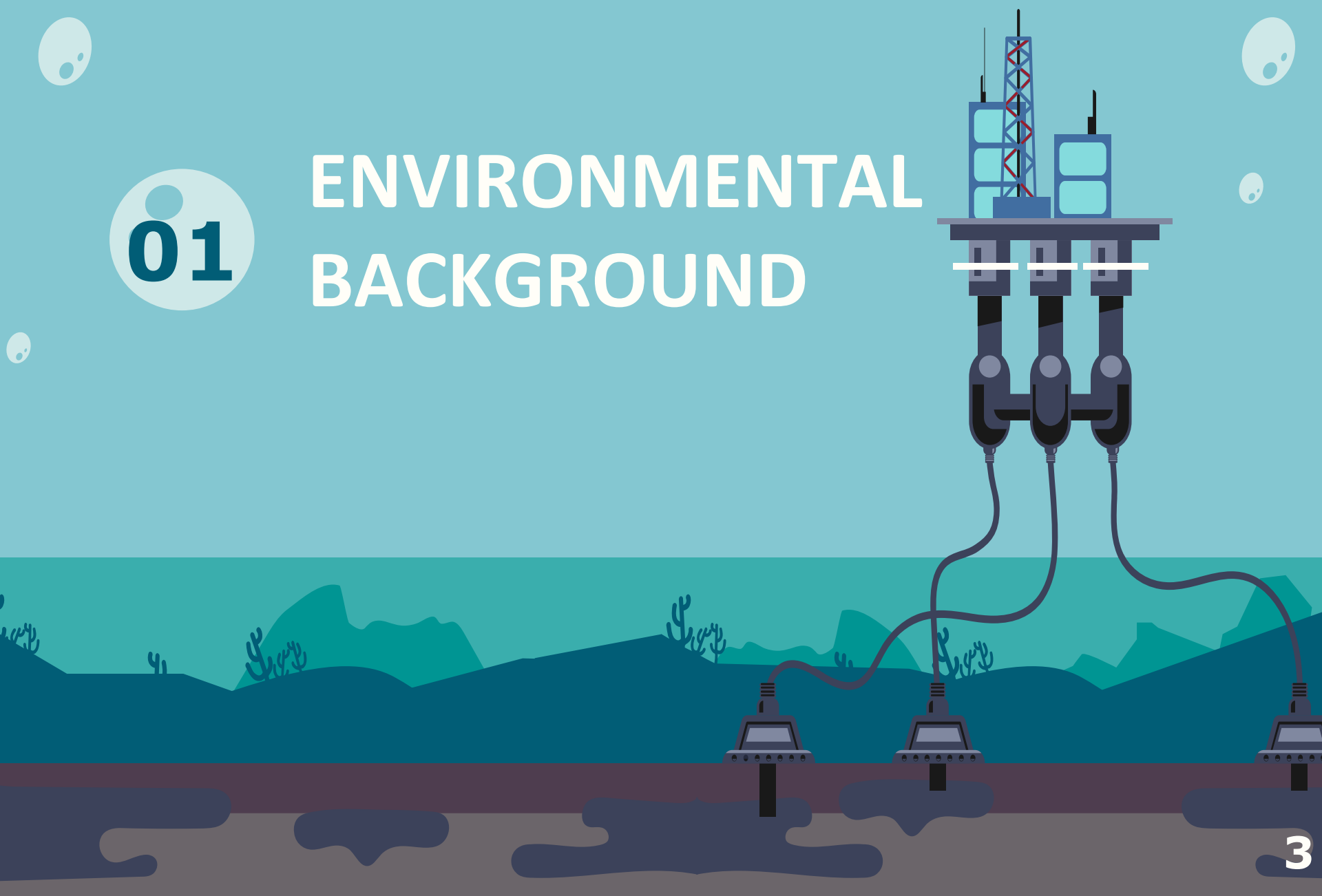
AMMONIA
FUELLED SHIPS
PROJECT PROPOSAL

TEAM AMMONUTION

TABLE OF CONTENTS

01 ENVIRONMENTAL BACKGROUND



AIR POLLUTION PREVENTION

1991 — IMO General Assembly

Adoption of Resolution "Air Pollution Prevention from Ships"

1992 — UNFCCC (UN Climate Change Convention)

Adoption of Agenda "Air Pollution Prevention"

1997 — Kyoto Protocol

Recognition of high levels of GHG emission

2000 — 1st IMO GHG Study

Ship GHG emission study for GHG reduction in the shipping sector

2015 — Paris Agreement

Readoption of Agenda "Air Pollution Prevention from Ships"

2018 — Initial IMO Strategy on reduction of GHG emissions from ships

Credits: IMO - Our Work - Maritime Environment

MARPOL Annex VI

(International Convention for the Prevention of Marine Pollution from Ships)

International Convention for the Prevention of Marine Pollution from Ships (MARPOL) Annex VI 'Prevention of Air Pollution from Ships'

- Limits on air pollutants such as SOx, NOx, Ozone Depleting Substances (ODS)

Credits: IMO - Conference Meetings - MARPOL

The P2G System

P2G (Power to Gas)

- Surplus power produced by renewable energy can be converted into hydrogen fuel/energy and stored

Current Problem of P2G

- Storage capacity per volume per of hydrogen is too small
  - Economically difficult to store large amounts and transport long distances

A hydrogen carrier capable of increasing storage capacity and reducing economic costs??

Credits: “Ammonia as a Marine Fuel Safety Handbook” Green Shipping Programme

AMMONIA

1

Used for Storage & Transportation

- As a hydrogen energy carrier
- As an internal source of hydrogen

2

Cheaper development costs compared to other carbon-neutral fuels

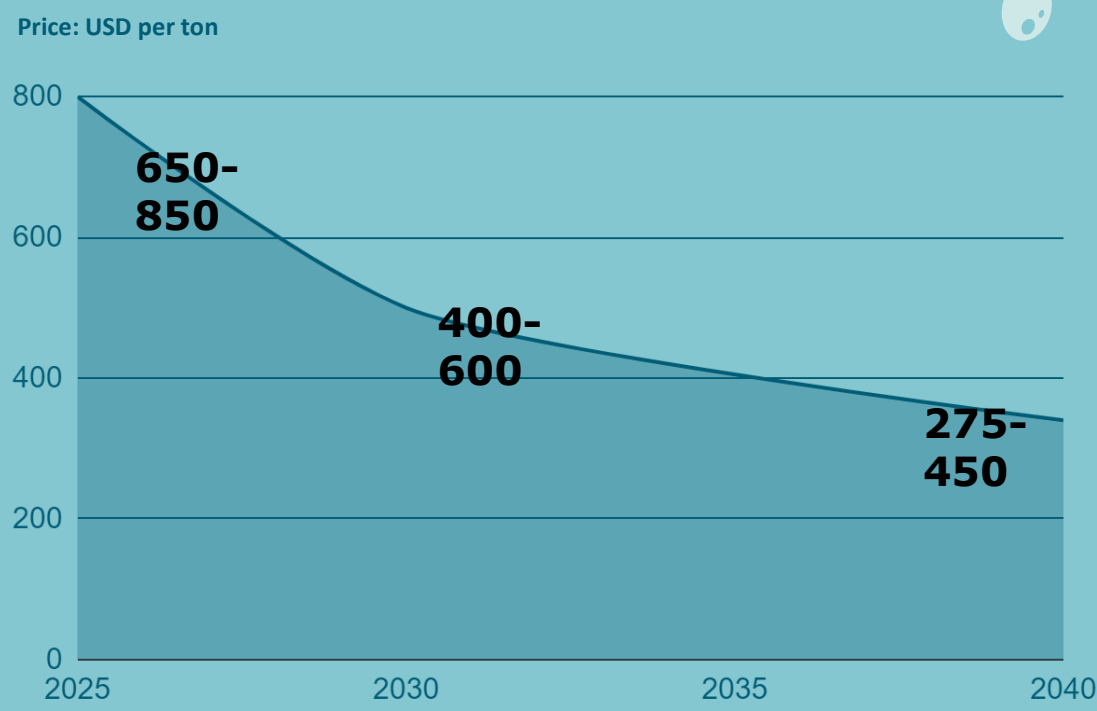
Credits: “Ammonia as a Marine Fuel Safety Handbook” Green Shipping Programme

GREEN AMMONIA

Using renewable energy

Electrically synthesize energy from the air (nitrogen)

Can replace the Haber-Bosch process in the future



ANTICIPATED PRODUCTION COST OF GREEN AMMONIA

Credits: “Ammonia as a Marine Fuel Safety Handbook” Green Shipping Programme

ECO-FRIENDLY SHIP

"Ammonia Ready" Ship

Ammonia can utilize the **existing land LPG infrastructure**, and it is expected to be put into **practical use** as soon as possible due to the existence of **transportation and storage performance** through ships.

Credits: “Ammonia as a Marine Fuel Safety Handbook” Green Shipping Programme

STATUS QUO IN KOREA

한국조선해양 Korea Shipbuilding & Marine Engineering (현대미포조선 Hyundai Mipo Shipbuilding) has obtained the basic certification (AIP) of Lloyd's (British Shipbuilding) for ammonia-powered ships.

대우조선해양 Daewoo Shipbuilding & Marine Engineering has obtained basic certification (AIP) of Lloyd's Shipping (UK Shipping) for ammonia-promoted super-large container ships (2.3 million TEU-class), and will commercialize in 2025('20.10).

삼성중공업 Samsung Heavy Industries announced that it has obtained basic approval (AIP) certification for the basic design of the "Ammonia Ready" super-large crude oil carrier (VLCC) from Norwegian shipping company DNV.

Credits: 그린뉴딜, 탄소중립을 위한 친환경선박 중장기 계획 수립- 해수부ㆍ산업부, 제1차 친환경선박 개발ㆍ보급 기본계획('21-'30) 〈발표 -, 해양수산부, 2020. 12. 22.

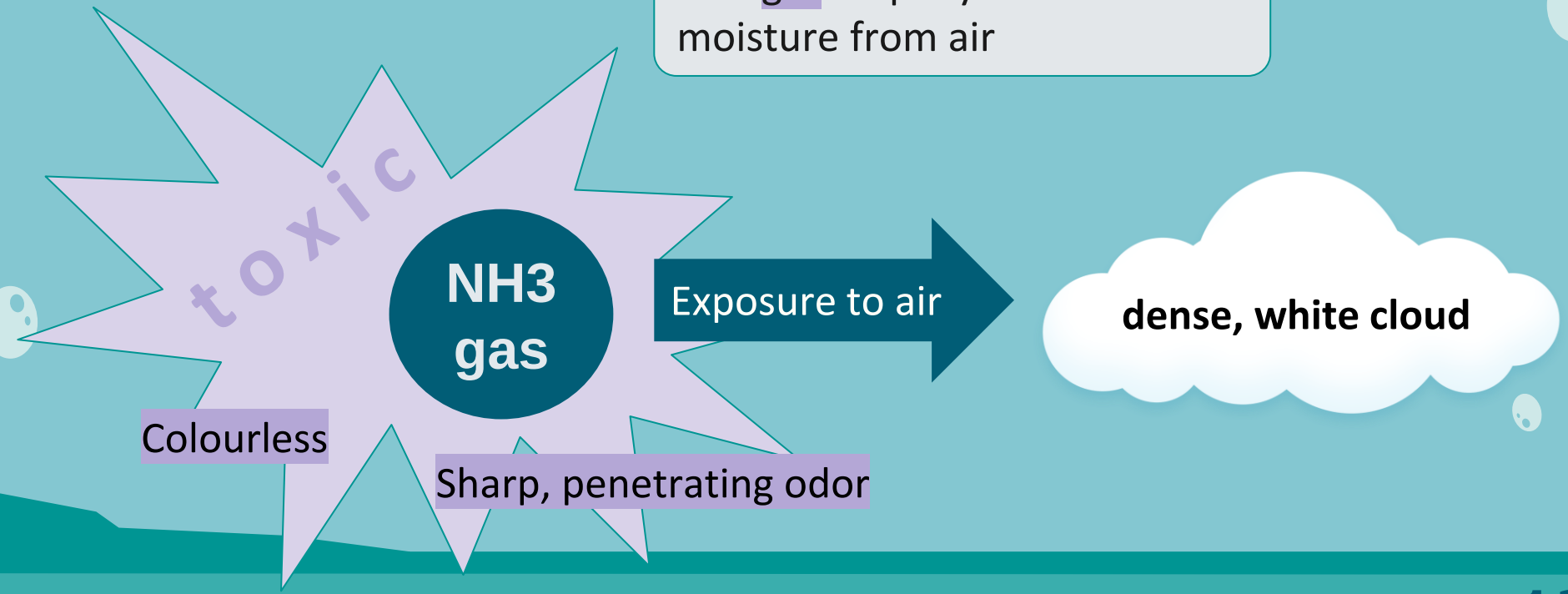
02 SAFETY HAZARDS

GENERAL CHARACTERISTICS

In pure form: ammonia is

- **Anhydrous** 'without water'
- **Hygroscopic** 'has a high affinity for water'

As a gas: Rapidly absorbs moisture from air



Credits: "Ammonia as a Marine Fuel Safety Handbook" Green Shipping Programme

AMMONIA'S PROPERTIES

TOXIC

Can lead to severe irritation of eyes and the respiratory system
In higher concentrations, can be lethal

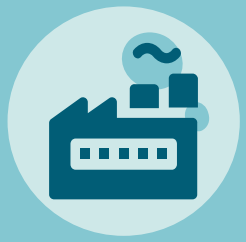
FLAMMABLE BUT DIFFICULT TO IGNITE

Anhydrous vapour:
possibly cause fire hazards in a confined space, especially with oil and other combustible materials

AMMONIA'S PROPERTIES

EASILY DISSOLVES IN WATER

Creates ammonium hydroxide (NH3-H2O) when dissolved in water,
→ a **caustic** solution capable of **burning and eroding skin**



CORROSIVE TO METALS

Alkaline, corrosive to galvanized metals, cast iron, copper, brass, copper alloys, etc.
→ **safe materials** such as stainless steel should be considered for tanks & containers

Credits: "Ammonia as a Marine Fuel Safety Handbook" Green Shipping Programme

03 SAFETY REGULATIONS

SOLAS Convention

"International Convention for the Safety of Life at Sea"

IGF Code

"Safety standards for Ships using **Gases as Fuel or Low Flashpoint Fuels"**

IGC Code

"Construction and equipment of Ships Carrying **Liquified Gases in Bulk"**

Credits: IMO - Conference Meetings - SOLAS

IGF Code

Outlines international standards for **the safety of ships using gases as fuel**

Specific **functional** requirements **for all fuel types**

Specific **design** requirements **only for LNG fuel**

Does Ship Design comply with IGF Functional Requirements?

Credits: IMO - Conference Meetings - IGF Code

IGC Code

Outlines international code for **the construction and equipment of ships carrying liquified gases**

- Specifies liquefied gases **in bulk**
- **Use of cargo as fuel** is mentioned

However, the cargo of toxic products such as **ammonia** are **not permitted**

Credits: IMO - Conference Meetings - IGC Code

SOLAS Convention

"International Convention for the Safety of Life at Sea"

IGF Code

"Safety standards for Ships using **Gases as Fuel**"

Utilize for New Design Regulations

IGC Code

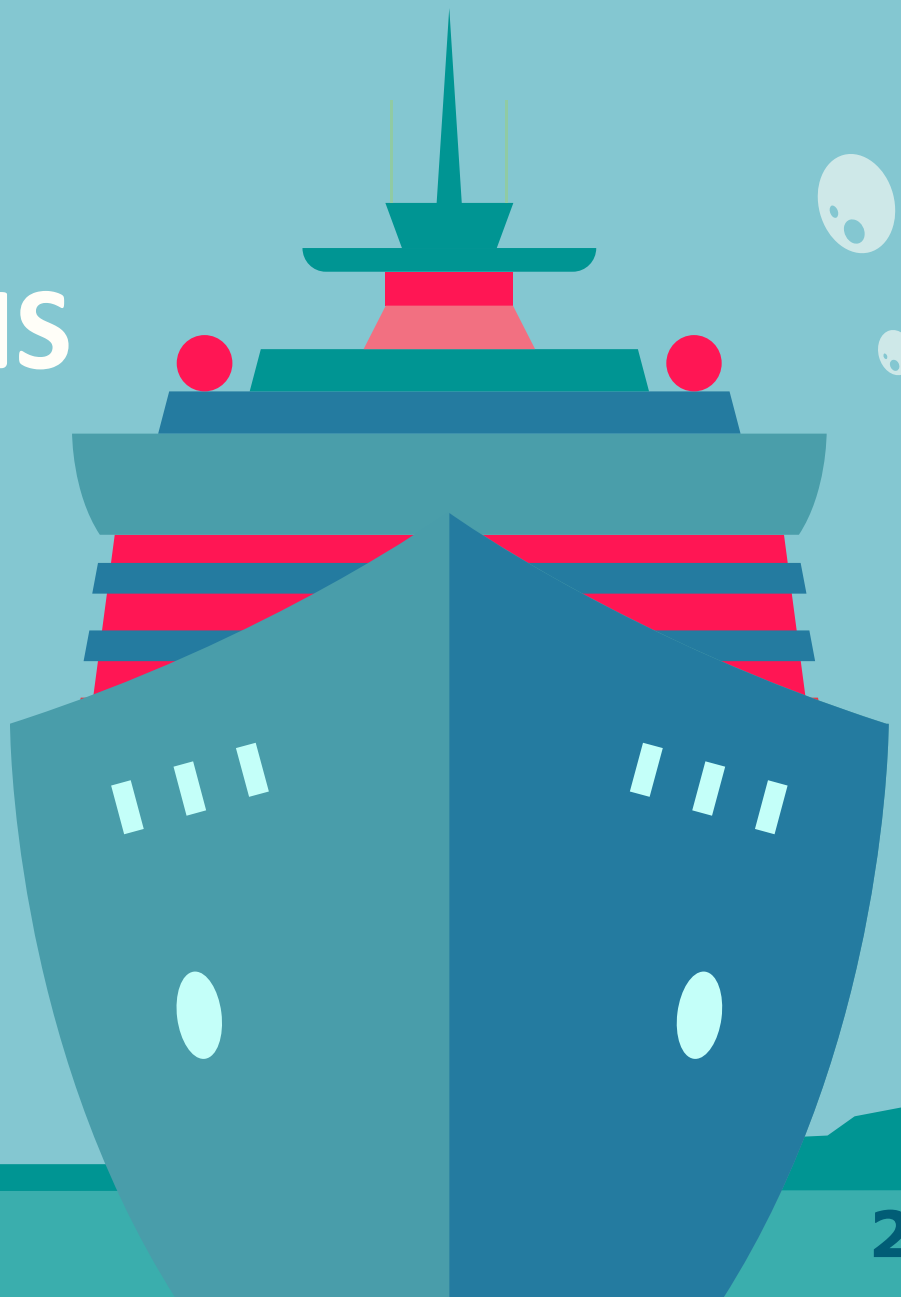
"Construction and equipment of
Ships Carrying **Liquified Gases in Bulk**"

Applies to Ammonia

Does not Apply

Credits: IMO - Conference Meetings - SOLAS

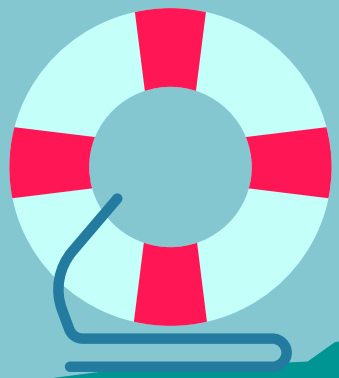
04 SOLUTIONS



PREVIOUS REGULATIONS

The IGF Code for LNG-fuelled ships include:

- **Access to Tank Connection Space (TCS) through a bolted hatch**
- **Drip tray system as the sole method of leakage isolation**
- **PPE only in certain regions**
- **X mention of equipping first aid treatment**



Credits: “Ammonia as a Marine Fuel Safety Handbook” Green Shipping Programme

SAFETY REQUIREMENTS

1

Segregation

Keeping the installation away from areas where it may be mechanically damaged and protecting the installation from external events is equally important.

2

Isolation of Leakages

In case of a leakage scenario, it is essential to isolate the leakage when it occurs and away from harm, without human intervention.

Credits: “Ammonia as a Marine Fuel Safety Handbook” Green Shipping Programme

VESSEL DESIGN

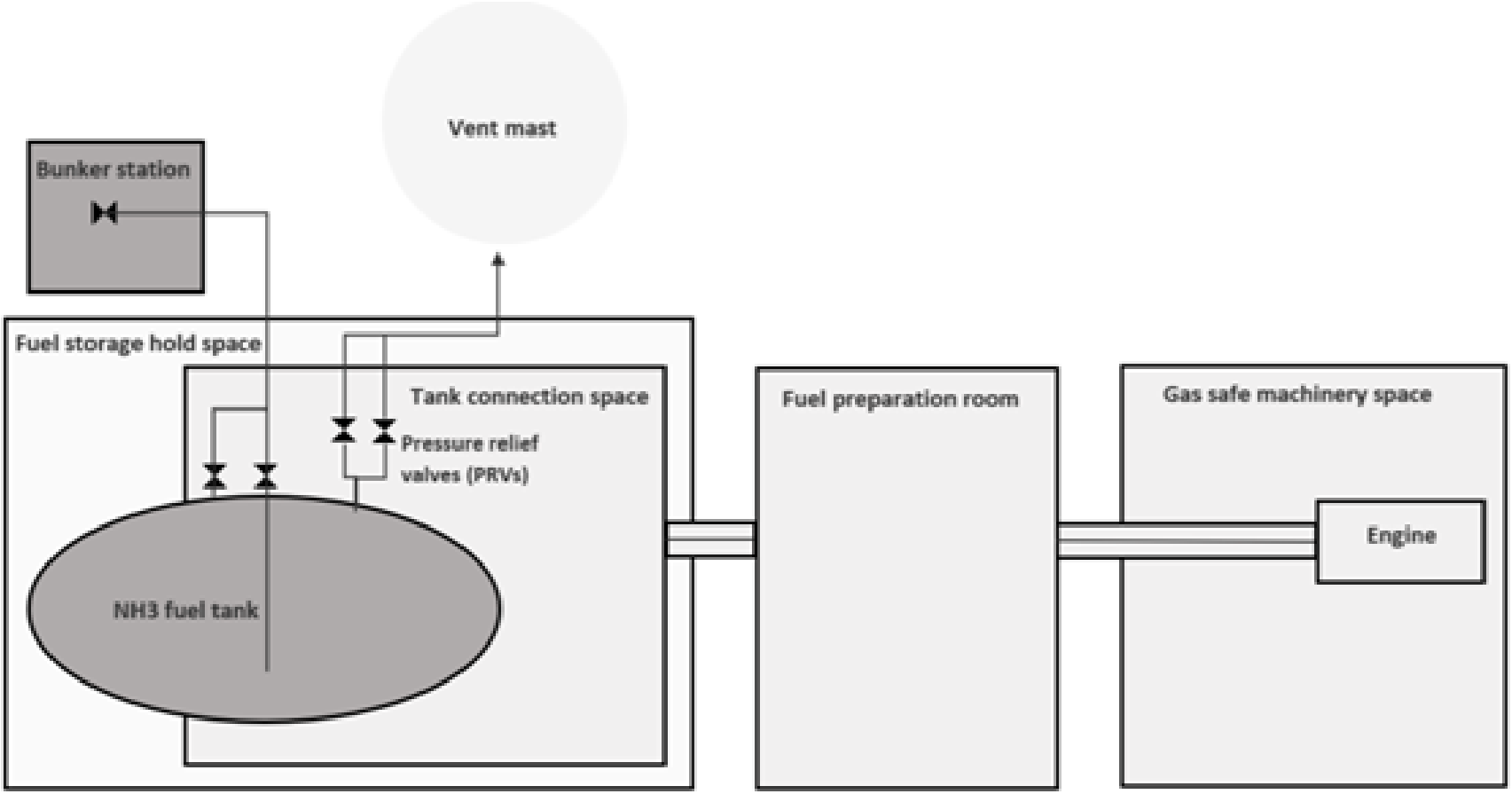
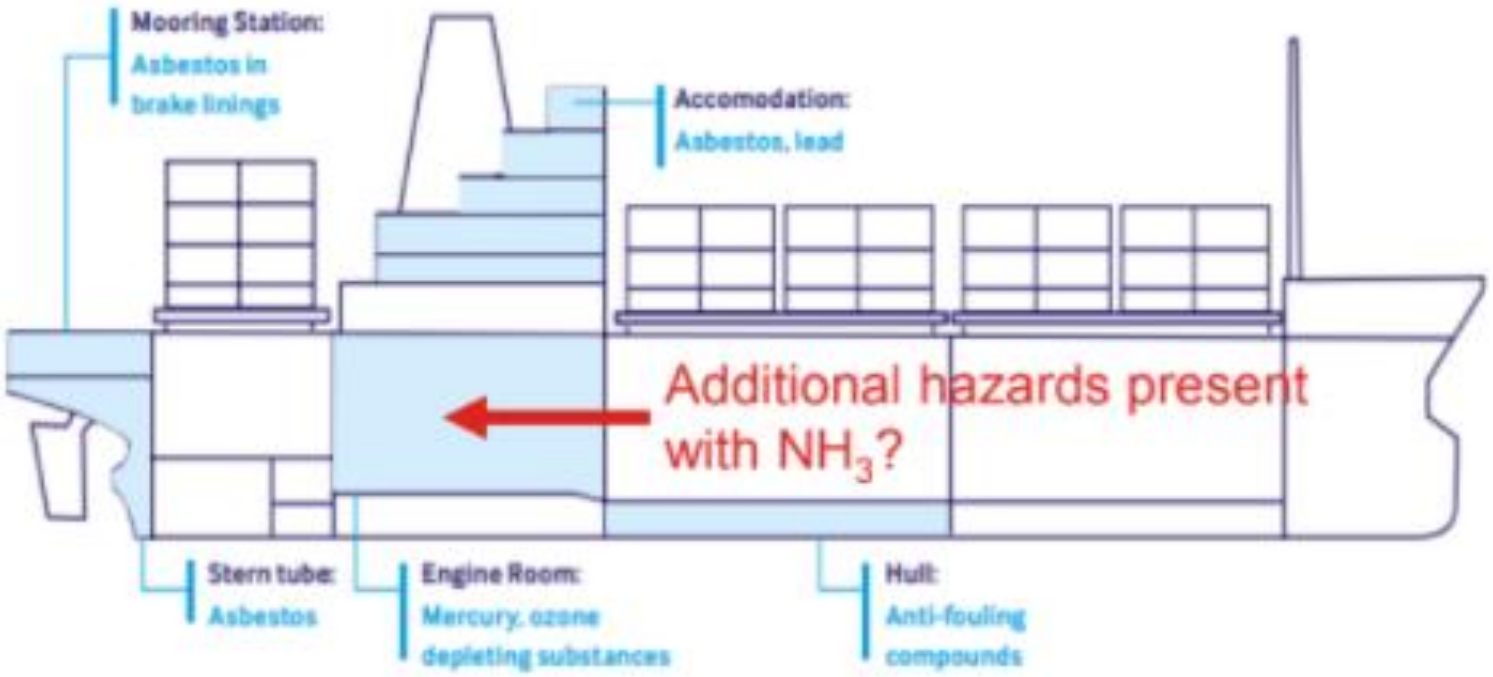


Figure 6-1 Principle diagram ammonia fuelled installation (DNV GL).

Credits: “Ammonia as a Marine Fuel Safety Handbook” Green Shipping Programme

VESSEL DESIGN

Examples of hazardous materials and where they could be found:



Source: [Adapted from] (2) Ship Owners Club (2020)

ACCESS TO COMPARTMENTS

IGF Code

5.11 Regulations for arrangement of entrances and other openings in enclosed spaces

5.11.1 Direct access shall not be permitted from a non-hazardous area to a hazardous area. Where such openings are necessary for operational reasons, an airlock which complies with 5.12 shall be provided.

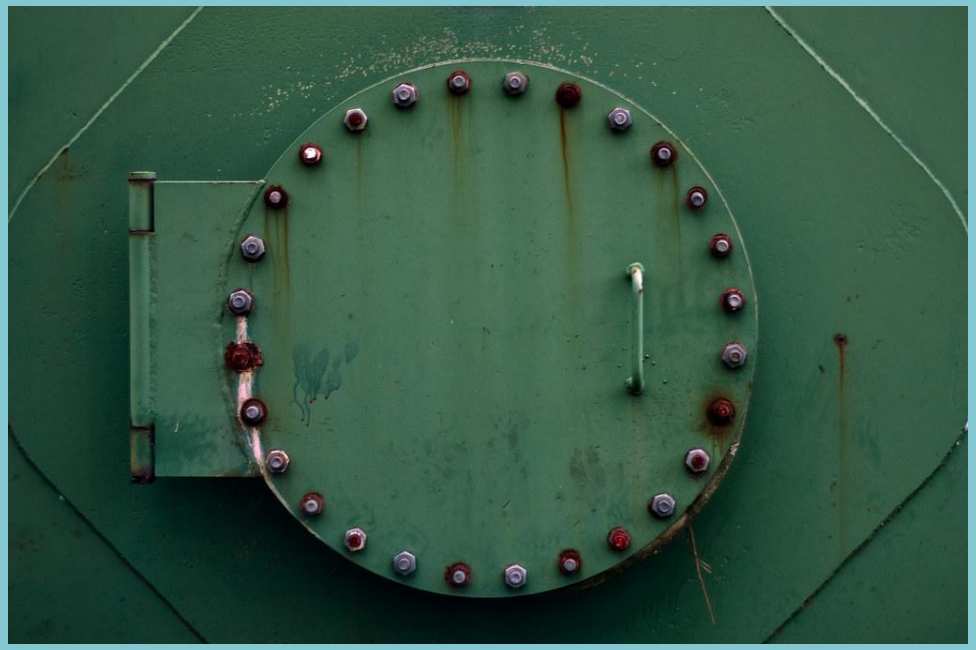
5.11.3 Unless access to the tank connection space is independent and direct from open deck it shall be arranged as a bolted hatch. The space containing the bolted hatch will be a hazardous space.

5.11.5 For inerted spaces access arrangements shall be such that unintended entry by personnel shall be prevented. If access to such spaces is not from an open deck, sealing arrangements shall ensure that leakages of inert gas to adjacent spaces are prevented.

ACCESS TO COMPARTMENTS

Initially, LNG-fuelled ships gained access to Tank Connection Space (TCS) through a **bolted hatch**.

- Important to maintain gas tightness of boundaries



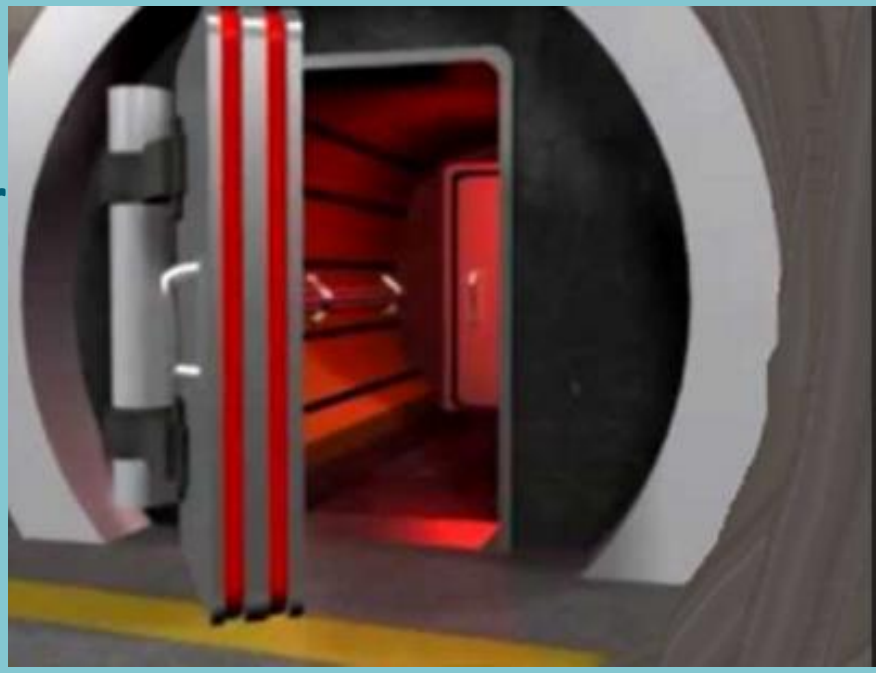
https://flic.kr/p/6mpC56

ACCESS TO COMPARTMENTS

However, ammonia-fuelled ships face difficulty in restoring gas tightness without releasing ammonia outside.

Using an **airlock access** would:

- **Seal the TCS without danger of exposure to ammonia**
- **Make it easier to evacuate and retrieve injured people in cases of emergencies**



https://5.imimg.com/data5/GJ/TV/GLADMIN-4974549/airlock-inflatable-seal-500x500.png

ACCESS TO COMPARTMENTS

IGF Code

5.11 Regulations for arrangement of entrances and other openings in enclosed spaces

5.11.3 Access to the tank connection space, unless independent and direct from open deck, **shall be arranged with an airlock which complies with 5.12.** If access to the tank connection space is independent and direct from open deck, it shall be arranged as a bolted hatch. The space containing the bolted hatch will be a hazardous space.

POSSIBLE LEAKAGE

IGF Code

5.10 Regulations for drip trays

5.10.1 Drip trays shall be fitted where leakage may occur which can cause damage to the ship structure or where limitation of the area which is effected from a spill is necessary.

5.10.4 Each tray shall be fitted with a drain valve to enable rain water to be drained over the ship's side.

5.10.5 Each tray shall have a sufficient capacity to ensure that the maximum amount of spill according to the risk assessment can be handled.

SOLUTIONS FOR AMMONIA : LEAKAGE

NH3
Anhydrous Ammonia
hygroscopic

+ H2O
Water Curtains

=
NH3-H2O
Ammonia
Contained inside Water

Credits: “Experimental Research on Water Curtain Scavenging Ammonia Dispersion in Confined Space”, MDPI

DRIP TRAY

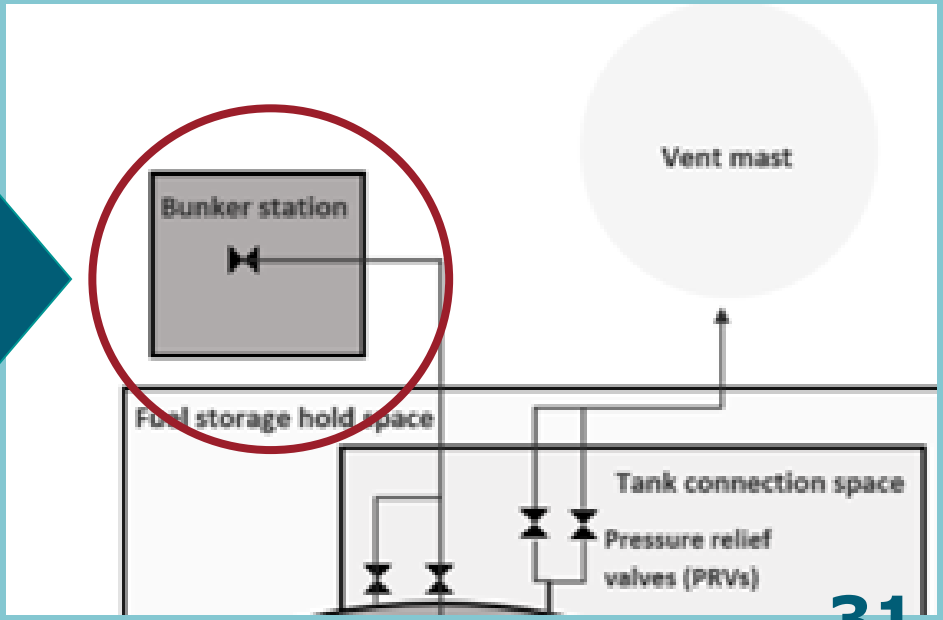
NH3
Anhydrous Ammonia
hygroscopic

+ H20
Waterspray and Water Curtains

=
NH3-H2O
Ammonia Contained inside Water

UNDERNEATH:

Collect Ammonia-Trapped Water



Credits: “Ammonia as a Marine Fuel Safety Handbook” pg. 16, Green Shipping Programme

WATER CURTAIN

Reduce toxic gas concentration

Above bunkering manifold

Outside entrance of Refrigeration machinery spaces

Credits: “Water Spray System / Drencher System” Iljin AND Co., Ltd.

POSSIBLE LEAKAGE

IGF Code

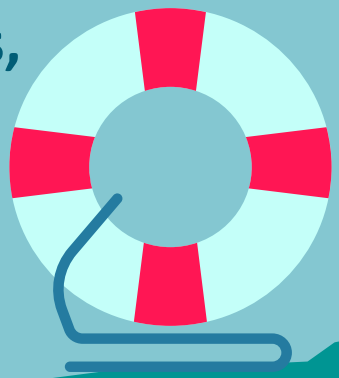
5.11 Regulations for arrangement of entrances and other openings in enclosed spaces

5.11.6 For enclosed spaces, water curtain systems shall be applied to the entrances and other openings to such spaces. Through the isolation of leakages within the enclosed space, the outer concentration of toxic gases in cases of exposure of toxic materials will be reduced.

PERSONAL PROTECTIVE EQUIPMENT (PPE)

Personal Protective Equipment include:

- **Special gloves with long sleeves,**
- **Large aprons that cover the anterior part of the body,**
- **Footwear such as boots that cover the calves,**
- **Tight-fitting goggles,**
- **Face shields.**

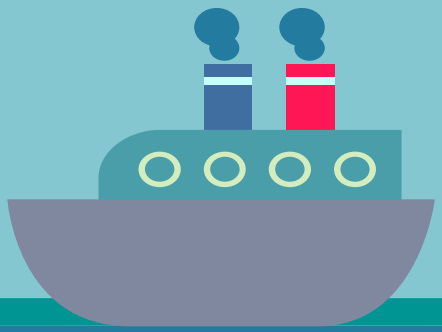


Credits: “Ammonia as a Marine Fuel Safety Handbook” Green Shipping Programme

First Aid Treatment

First Aid Treatment include:

- **Emergency showers,**
- **Eyewashes**
- **Decontamination shower**



https://www.medicalexpo.com/prod/hemco/product-108014-746992.html

PPE Locations

People involved in bunkering operations

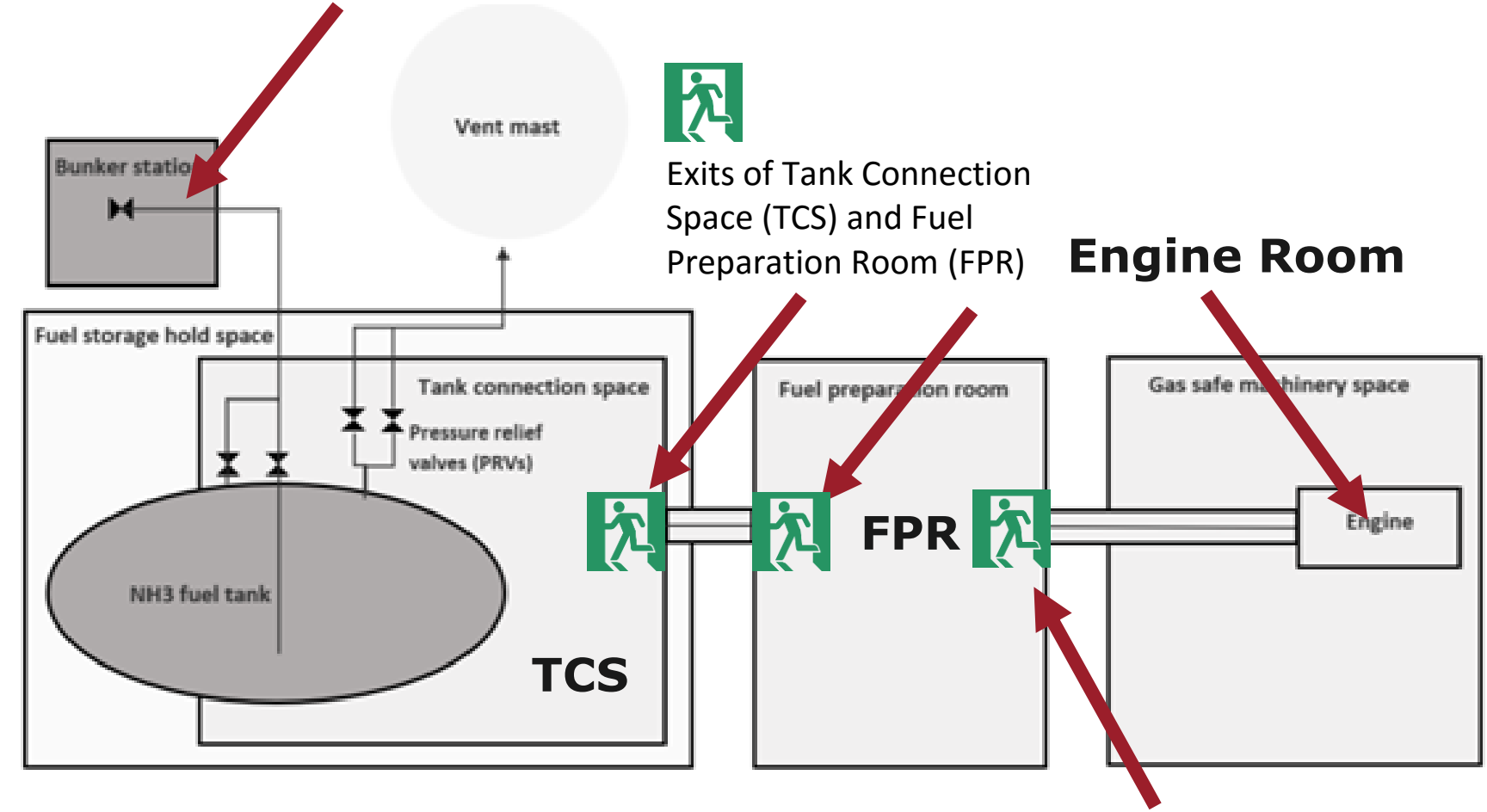


Figure 6-1 Principle diagram ammonia fuelled installation (DNV GL).

SAFETY REGULATIONS (GENERAL)

IGF Code

15.3 Control, Monitoring and Safety Regulations

15.3.1 Suitable instrumentation devices shall be fitted to allow a local and a remote reading of essential parameters to ensure a safe management of the whole fuel-gas equipment including bunkering.

15.3.2 A bilge well in each tank connection space of an independent liquefied gas storage tank shall be provided with both a level indicator and a temperature sensor. Alarm shall be given at high level in the bilge well. Low temperature indication shall activate the safety system.

15.3.3 For tanks not permanently installed in the ship a monitoring system shall be provided as for permanently installed tanks.

15.3.4 The allocation of PPE shall be widespread in machinery spaces, preparation rooms, and other enclosed spaces that are vulnerable to the exposure of toxic substances.

SAFETY REGULATIONS (GENERAL)

IGF Code

15.3 Control, Monitoring and Safety Regulations

15.3.5 In terms of first aid treatment, the following mandatory equipment shall be provided in convenient locations, including the entrances, other openings of enclosed spaces, and the vicinity of bunkering stations:

.1 emergency showers;

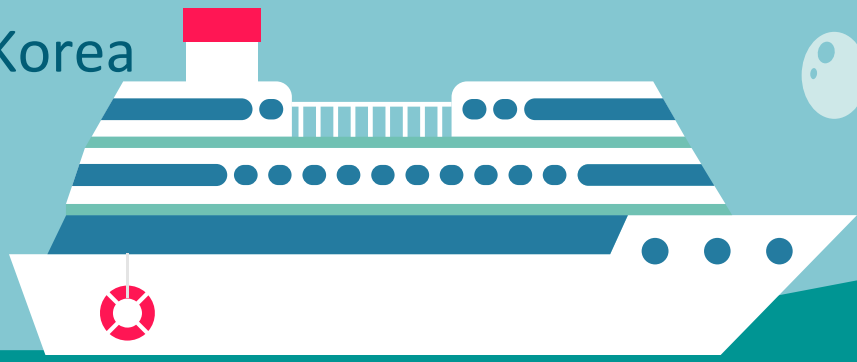
.2 eyewashes;

.3 decontamination showers.

VESSEL DESIGN

Through utilizing ship design, we aim to:

- **Work in correspondence with** the 2022-2023 biennial agenda of the CCC Sub-Committee
- **Lead the discussion in** ensuring the safety of ships using ammonia as fuel
- **Encourage R&D projects** such as the CCC 7/INF.8 ***"Forecasting the alternative marine fuel: ammonia"*** submitted by the Republic of Korea



Credits: IMO - MSC-MEPC.1/Circ.5/Rev.2, MEPC.304 (72), MSC 104-15-9, CCC 7/INF.8

THANK YOU.

RESOURCES

PHOTOS

- 3d windmill project
- 3d windmill project
- Woman working at environment project
- Smiley young person waving in the streets
- Smiley pregnant woman at home holding glass of water

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VECTORS

- Flat marine engineer machine
- Pollution concept
- Flat marine engineer machine
- Global environmental problems infographic template
- Pollution on human body infographic
- Global environmental problems infographic flat style
- Flat recycling symbol with green fields
- Flat design platform marine engineering concept
- Flat design marine engineering concept