European Maritime Safety Agency

# Guidance for Safe Bunkering of Biofuel

## GUIDANCE DOCUMENT AND CHECKLISTS: PRE-BUNKERING, CONNECTION, TRANSFER, DISCONNECTION, SIMOPS

Rev.3.1

**Date: 06/12/2024**

EMSA

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# Document History

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|---|---|---|---|---|
| 1.0 | 05/09/2024 | First issue | RAJIV | ASAHOE |
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# List of Abbreviations and Definitions

| Terms | Abbreviation |
|---|---|
| Biodiesel | Generic term for bio-based fuel with properties similar to diesel or diesel containing bio-blends. “Biodiesel” is often used to describe fatty acid methyl ester (FAME), but it is not exclusive to describe FAME or fuel containing FAME (ISO, 2024). |
| Biofuel | Fuel produced directly or indirectly from biomass (ISO, 2024). |
| Biomass | Material of biological origin excluding material embedded in geological formation and/or fossilized (ISO, 2024). |
| BV | Bunkering vessel |
| BTL | Biomass to Liquid |
| CFPP | Cold Filter Plugging Point |
| CP | Cloud Point |
| Cold flow properties | The cold flow properties of fuels refer to their behaviour and performance under low-temperature conditions. Important cold temperature metrics for marine distillate fuels are cloud point (CP), pour point (PP) and cold filter plugging point (CFPP). |
| CTL | Coal to Liquid |
| DM | Distillate marine fuel grades |
| DME | Dimethyl Ether |
| ECHA | European Chemicals Agency |
| ECS | European Committee for Standardisation |
| FAME | Fatty Acid Methyl Ester (often referred to as biodiesel) |
| FL | Filling limit (FL) means the maximum liquid volume in a tank relative to the total tank volume when the liquid cargo has reached the reference temperature. |
| FOGs | Fats, Oils and Grease (feedstock for biofuel production) |
| FT-diesel | Fischer-Tropsch diesel |
| GHG | Greenhouse gas |
| GTL | Gas to Liquid |
| HFO | Heavy Fuel Oil |
| HVO | Hydrotreated Vegetable Oil (sometimes referred to as paraffinic diesel) |
| IDLH | Immediately Dangerous to Life or Health |
| IBC Code | International Code for the Construction and Equipment of Ships carrying Dangerous Chemicals in Bulk |
| IGC Code | The International Code for Construction and Equipment of Ships Carrying Liquefied Gases in Bulk |
| IGF Code | International Code of Safety for Ship Using Gases or Other Low-flashpoint Fuels |
| IMO | International Maritime Organization |
| ISGOTT | International Safety Guide for Oil Tankers and Terminals |
| KPI | Key Performance Indicators |
| JPBO | Joint Plan of Bunker Operations |

| Terms | Abbreviation |
|---|---|
| LEL | Lower Explosive Limit |
| LHV | Lower Heating Value |
| LL | Loading limit (LL) means the maximum allowable liquid volume relative to the tank volume to which the tank may be loaded. |
| LNG | Liquefied Natural Gas |
| LPG | Liquefied Petroleum Gas |
| LSA | Life-saving appliances |
| MARPOL | The International Convention for the Prevention of Pollution from Ships |
| MGO | Marine gas oils |
| OEL | Occupational Exposure Limit |
| OCIMF | The Oil Companies International Marine Forum |
| PIC | Person in charge |
| POAC | Person in overall advisory control |
| PPE | Personal Protective Equipment |
| ppm | Parts per million (commonly used unit for very small concentrations of a solution) |
| PSM | Process Safety Management |
| PTS | Port to Ship |
| REACH | Registration, Evaluation, Authorisation and Restriction of Chemicals |
| RV | Receiving Vessel |
| SAF | Sustainable Aviation Fuels |
| SDS | Safety Data Sheet |
| SIGTTO | The Society of International Gas Tanker and Terminal Operators |
| SIMOPS | Simultaneous Operations |
| SMPEP | Shipboard Marine Pollution Emergency Plan |
| SOPEP | Shipboard Oil Pollution Emergency Plan |
| SMS | Safety Management System |
| SSL | Ship Shore Link |
| STS | Ship to Ship |
| TTS | Truck to Ship |
| UEL | Upper Explosive Limit |
| VRP | Vessel Response Plan |
| % v/v | Percent concentration by volume (volume/volume) |

# 1. Introduction

## 1.1 Background

The maritime industry is increasingly considering biofuels to cut carbon emissions in order to adhere to the International Maritime Organisation's (IMO) greenhouse gas reduction strategy. Understanding the risks of biofuels is essential before those are widely used. As ships transition from traditional fuels to fuels with other safety characteristic (such as fuels with origin in biomass), significant changes in ship design, operation, and fuel logistics are expected, introducing new safety challenges. It is crucial to manage these changes safely to protect lives, the environment, and assets. Despite the current limited application of biofuels in shipping, knowledge gaps remain concerning their safe operation.

The selection of biofuels for this study, identified through a recent EMSA study on the potential of biofuels in shipping, is focusing on the following five biofuels:

- Bio-methanol,
- Bio-Dimethyl Ether (DME),
- Fischer-Tropsch (FT) diesel,
- Hydrotreated Vegetable Oil (HVO), and
- Fatty Acid Methyl Ester (FAME).

This guidance document is intended to provide information to a broad range of stakeholders, including, but not limited to, ship operators, bunker suppliers, and regulators. It addresses a wide variety of topics to be tailored to the diverse interests and needs of these stakeholders. The checklists under the appendices are intended as more of a guide to develop and customise a checklist that needs to be adapted to ship type/ organisational procedures. It covers a collection of topics and items that should be considered for bunkering of biofuels being discussed. However, for sake of simplicity, it is being referred to as a checklist.

## 1.2 Objective

The objective is to develop a guidance document for bunkering operations with the selected biofuels, based on the analysis performed in previous tasks of the EMSA's *Study on the Safe Bunkering with Biofuels* (Task 1 – Literature review of rules and regulation, comparisons and fuels characterisation, and the results of Task 2 - Risk assessment of bunkering of biofuels).

## 1.3 Scope and limitations

The scope is limited to the five pre-selected biofuels, Bio-methanol, Bio-Dimethyl Ether (DME), Fischer-Tropsch (FT) diesel, Hydrotreated Vegetable Oil (HVO), and Fatty Acid Methyl Ester (FAME). Based on the work carried out in Task 1, HVO, FT-diesel and FAME is bundled together in this study as *biodiesels* due to their similar characteristics, whereas bio-methanol and DME is treated separately.

Three configurations for fuel supply modes are considered in this study: Port-to-Ship, also referred to as Shore to Ship (STS), Truck-to-Ship (TTS) and Ship-to-Ship (STS). The boundary limits of the fuel transfer operations are the same limits as presented in the risk assessment in Task 2 of the reference study; from the presentation flange of the supplier, through the bunker hose, ship's bunker flange, piping all the way to the tank, as illustrated in Figure 1-1.

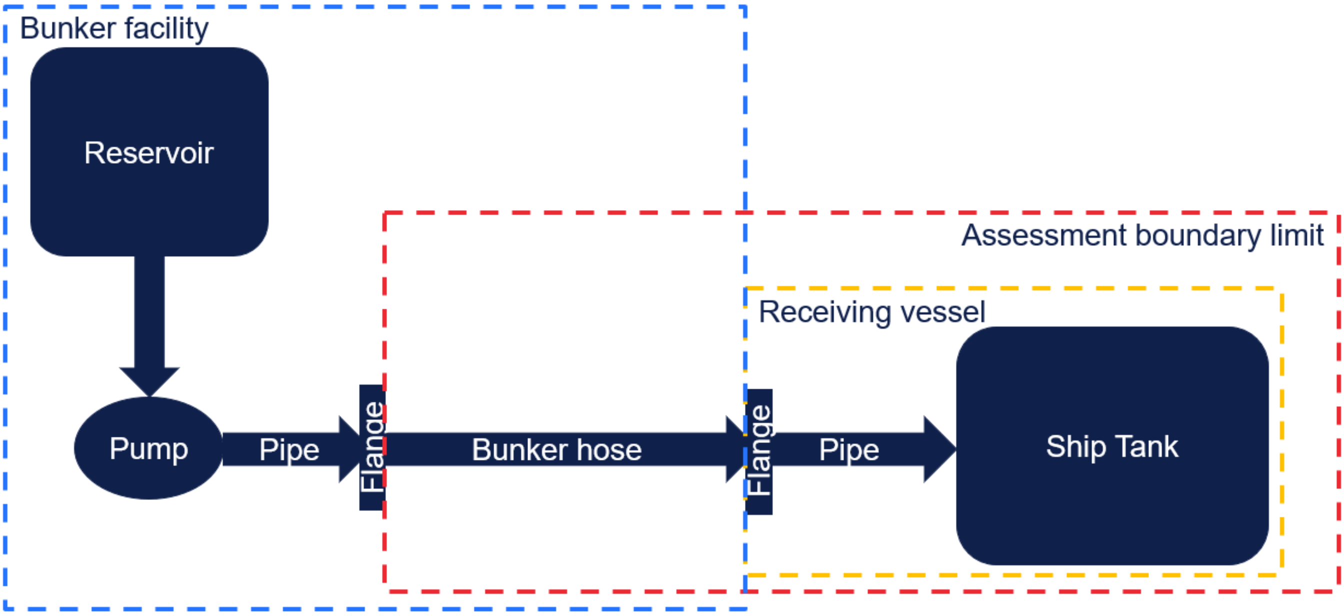


Figure 1-1 Physical boundary limit for assessment of bunker operation.

As this work is based on the findings of the risk assessment, the same assumptions apply:

- The receiving vessel is appropriately approved by Classification Society and Flag Administration to use the fuel intended for bunkering.
- If the fuel is supplied from a bunker vessel, it is assumed that the vessel in question also has the necessary applicable approvals to conduct a safe bunkering operation.
- Arrangements for bunker supply (all configurations) are approved by applicable authorities (port/national).
- Location in the port, for bunkering operation is approved by applicable authorities (port/national) if required.
- The bunker supplier has obtained the necessary approvals from relevant national authorities to provide bunkering services.
- Personnel involved in the bunkering delivery operation are adequately trained and equipped with Personal Protective Equipment (PPE) that is fit for purpose.
- The receiving vessel has an approved bunkering procedure, adequately trained crew involved in bunkering operations, and adequate PPE.
- FT-diesel can have a flashpoint just below 60°C, but it is assumed all FT-diesel delivered as a marine fuel will have a flashpoint above 60°C.
- It is assumed that the case of 100% biofuel is the “worst-case” scenario for bunkering of biofuels; hence, blends of biofuels represent an equal or lower risk than pure biofuels.

## 1.4 Validation process

After a first draft was developed, the guidance document was sent out to project stakeholders representing both shipside, shoreside and regulatory entities. 16 stakeholders responded with comments which were further evaluated and implemented into the final draft.

## 1.5 Summary of preliminarywork

### 1.5.1 Task 1: Characteristics, Regulatory Landscape, and Safety Assessment

Based on the identified characteristics, biodiesels such as FT-diesel, HVO, and, to a certain extent, FAME have similar chemical and physical properties as conventional marine distillates. Consequently, these biodiesels can be compared with MFO when identifying certain risks relevant for bunkering.

Bio-methanol, being chemically identical to fossil methanol, can leverage existing practices and regulations, as fossil methanol is currently utilised as a marine fuel.

DME, being gaseous under standard ambient temperature and pressure conditions, exhibits similarities with Liquefied Petroleum Gas (LPG) fuels, enabling the possible utilisation of LPG infrastructure. This opens the possibility of drawing inspiration from or aligning with established guidelines and regulations developed for LPG.

The chosen biofuels are distinct when it comes to regulatory coverage and industry best practices for their safe bunkering. Bio-methanol stands out as the most mature, as it is identical to its fossil-based counterpart. The industry has more experience with methanol used as a marine fuel and, by extension, its bunkering, which has led to the development of specific procedures, technical requirements, and a regulatory framework. Thus, best practices regarding the safe bunkering of bio-methanol are more mature compared to the other biofuels. For HVO, FAME and DME, there are no specific best practices or guidelines regarding their safe bunkering. FT-diesel has the least regulatory coverage among the selected biofuels. Despite their comparable chemical characteristics to conventional fuels a risk-based approach to the safe bunkering of biofuel seems the most appropriate until their use matures, to account for properties not seen in their conventional counterparts (such as microbial growth).

Task 1 of the reference study reviewed incidents and accidents in land-based industries dealing with biofuels, identifying incidents related to the bunkering of the selected biofuels. The scope excluded accidents rooted in manufacturing processes or equipment specific to biofuel production and other industrial uses. Similarly, transportation accidents where biofuel cargo did not impact the root cause were deemed irrelevant. A recurring issue involved hot work around fuel infrastructure leading to ignition and explosion, along with general equipment failure, which may, in part, be attributed to inadequate maintenance procedures. Some accidents also occurred during maintenance activities, suggesting that the maintenance procedures themselves may not have been sufficiently robust.

The appropriate level of PPE depends on the situation and the preceding risk assessment performed before fuel handling. Both the exposure risk and the classification of the substance to be bunkered play a role in determining the appropriate PPE for each crew member. Recurring PPE needs for all biofuels include safety glasses, chemical-resistant gloves, as well as body- and respiratory protection based on the exposure risk. It is imperative to strictly adhere to the PPE guidelines outlined in the respective Safety Data Sheets.

### 1.5.2 Task 2: Risk assessment of biofuel bunkering and operation

A three-day Hazard Identification (HAZID) workshop was conducted from March 11th to 13th, 2024, as part of the process on safe bunkering with biofuels. The workshop focused on the five biofuels:

- Bio-methanol,
- Bio-Dimethyl Ether (DME),
- Fischer-Tropsch (FT) diesel,
- Hydrotreated Vegetable Oil (HVO), and
- Fatty Acid Methyl Ester (FAME).

The liquids, HVO, FT-diesel, and FAME were grouped together for assessment based on their characteristics. The two other, Bio-methanol and DME, were assessed individually due to significant differences in their properties. The workshop aimed to identify hazardous situations during bunkering and recommend additional measures or safeguards that could help reduce the risk involved with the operation. After the workshop, a qualitative risk ranking of each identified hazard was set based on a review of similar studies carried out in the past.

The HAZID workshop identified hazards primarily tied to the fuel transfer phase. Two key safeguards were found crucial to ensure safe bunkering operations: conducting a thorough compatibility assessment and following sound bunkering procedures. Bunkering bio-methanol and DME is associated with a higher risk, in terms of the potential severity of an accidental event, compared to bunkering of drop-in biofuels (such as HVO, FT-diesel, and FAME).

Regulations for the bunkering and handling of bio-methanol and DME are more rigorous than for the other assessed biofuels, requiring adherence to the *International Code of Safety for Ships Using Gases or other Low-flashpoint Fuels* (IGF Code), and relevant interim guidelines (MSC/Circ. 1621) in the case of bio-methanol. According to the IGF code, vessels fuelled by gases and low flashpoint fuels are required to have a separate risk assessment considering potential onboard hazards, which should include bunkering scenarios as well.

Specifically, for DME, it is essential to consider thermal expansion when setting DME filling limits, and adhere to the tank loading limit and filling limit to prevent the tank from becoming liquid-full. Additionally, the refrigeration system of the receiving ship may not be able to sufficiently cool the transferred fuel if the delivery temperature is too high. DME supplied at low temperatures could lead to overflowing in the receiving ship as the liquid DME expands. Additionally, the capacity of a refrigerated receiving ship's reliquefication system could be exceeded if DME is supplied at ambient temperature. While no additional safety risks were identified for HVO, FT-diesel, and FAME, operational risks may exist due to their potential shorter longevity compared to conventional fuels. Proper storage practices are crucial to avoid biodiesel deterioration or contamination.

A total of 59 recommendations were made across the assessed biofuels (bio-methanol, DME, HVO, FT-diesel and FAME), whereof several may already be covered by current bunkering best practices, yet still recorded as they were addressed during the HAZID.

# 2. Biofuels characteristics

The following chapter covers the key characteristics of the biofuel types as described in the Task 1 report, *Bunkering of Biofuels in Maritime: Characteristics, Regulatory Landscape, and Safety Assessment*. For a more detailed description of fuel characteristics, please refer to the Task 1 report.

## 2.1 Definition of relevant fuel characteristics

Table 2-1 provides a description of key fuel characteristics covered in this chapter, that may have implications for biofuel bunkering operations. Each fuel characteristic has been categorised into those relating to *flammability* of a fuel and its *storage, handling, release, and dispersion*.

Table 2-1: Description of relevant characteristics of fuels. Each description has been adapted from (DNV, 2022) and other sources.

| Category | Fuel characteristics | Description |
|---|---|---|
| Flammability | Flashpoint (Not applicable for gases and gas mixtures) | The flashpoint is used as a main indicator of the flammability of a liquid product. It is defined as the lowest temperature at which there will be enough vapour from the liquid to produce a flammable mixture with air that can be ignited. |
| | Lower & upper flammability limit (LEL and UEL) (% vol. fraction) | Flammability limits refer to the range of gas or vapour concentrations in air which will burn in the presence of an ignition source. Flammability limits are usually given as the percent by volume of the gas or vapour in air. |
| | Minimum ignition energy (mJ) | The minimum ignition energy (MIE) determines the ignition capability of fuel-air mixtures, where the fuel may be a combustible vapour or gas. It is defined as the minimum electrical energy stored in a capacitor, which, when discharged, is sufficient to ignite the most ignitable mixture of fuel and air under specified test conditions. The MIE value is used to assess the likelihood of ignition during processing and handling. |
| | Auto-ignition temperature (°C) | Also known as self-ignition temperature, the auto-ignition temperature of a substance indicates the lowest temperature at which it may spontaneously ignite without the presence of an ignition source such as a flame or spark. At the auto-ignition temperature, the temperature alone provides sufficient energy to induce combustion. The auto-ignition temperature depends on pressure and availability of oxygen, and is typically given at standard pressure and temperature, with ideal oxygen concentration. Since the auto-ignition temperature is given at idealized conditions, higher temperatures would be needed for ignition in most realistic scenarios. |
| | Laminar burning velocity (m/s) | Burning velocity is the speed at which a flame front propagates relative to the unburned gas. As such, the burning velocity indicates how fast a flame travels through a flammable air-fuel mixture. The laminar burning velocity is the speed at which a laminar (planar) combustion wave propagates relative to the unburned gas mixture ahead of it. For most hydrocarbons the laminar burning velocity is measured in cm/s. Indirectly, laminar burning velocity can indicate the severity of an explosion. |
| Storage, handling, | Normal Boiling point (°C) | The boiling point of a liquid is the temperature at which its vapour pressure is equal to the surrounding pressure and the liquid changes into a vapour. |

| Category | Fuel characteristics | Description |
|---|---|---|
| release, and dispersion | Toxicity | Toxicity is a chemical substance’s ability to damage an organism. Toxicity is dose-dependent; even harmless substances, such as water, can lead to intoxication if taken in too high a dose, while very poisonous substances can be harmless if the dose is negligible. |
| | Odour threshold | Limit for air concentration for which the odour is detectable and unpleasant. This can imply stricter control for fuel slip and leakages than toxicity limit on passenger ships and crew areas. |
| | Specific gravity (or relative density) (Air/water:1) | Specific gravity for gases is defined as the ratio of the density of the gas to the density of air at a specified temperature and pressure. If a gas has lower specific gravity than air (<1), it is said to be “lighter” than air, and if it has a higher specific gravity it is said to be “heavier” than air (>1).<br>Similarly, specific gravity for liquids is defined as the ratio of the density of the liquid to the density of water at a specified temperature and pressure. |
| | Corrosion | A process where metal deteriorates, due to chemical, electrochemical and other reactions of the exposed material surface with the surrounding environment. |
| | Kinematic viscosity ($mm^2/s$ or cSt) | Kinematic viscosity measures a fluid’s internal resistance to flow under gravitational forces. Commonly used to characterize flow behaviour of fuels at a given temperature. |
| Storage, handling, release, and dispersion | Density ($kg/m^3$) | The amount of mass in a specific volume. |
| | Vapour pressure (mbar) | The pressure exerted by the vapour present above a liquid. It is a measure of how readily a substance evaporates into vapour or gas at a given temperature. It indicates the substance's volatility; in practical terms, the higher the vapour pressure, the more easily the substance evaporates and turns into vapour at a given temperature. |
| | Cold flow properties | Cold flow properties indicate the low-temperature operational ability of a fuel during cold weather. For example, while one fuel at very low temperatures may remain fluid, another of a similar grade may either stop flowing or result in the deposition of wax crystals at the filters. |
| | Cloud point (°C) | Related to a fuel’s cold flow properties, indicating low-temperature operation ability. The cloud point (CP) is defined as the temperature of a liquid specimen when the smallest observable cluster of wax crystals first appears upon cooling under prescribed conditions. |
| | Cold Filter Plugging Point (°C) | Related to a fuel’s cold flow properties, indicating low-temperature operation ability. The Cold Filter Plugging Point (CFPP) is defined as the lowest temperature, at which a given volume of diesel type of fuel still passes through a standardized filtration device in a specified time when cooled under certain conditions. |
| | Water solubility (g/L) | Water solubility refers to the ability of a substance to dissolve in water. If a substance is water-soluble, it means that it can effectively mix with and dissolve in water, forming a homogeneous solution. High water solubility means easier dissolving in water. |

## 2.2 Summary of fuel characteristics

In Table 2-2, an overview of fuel properties relevant for the five biofuels examined in this study is presented. The properties listed in the table lack footnotes, and specific conditions relevant to each characteristic may apply. For further details, refer to the respective sections for more information, including references. It should be noted that this summary is based on a selection of fuel products, and exclusively includes the neat biofuels and does not account for any blends.

Table 2-2: Summary of fuel characteristics. For further details see the Report from Task 1, "*Bunkering of biofuels in the maritime: Characteristics, regulatory landscape and safety assessment*".

| Fuel property | Unit | MGO | Bio-methanol | Bio-FT-diesel | DME | HVO | FAME |
|---|---|---|---|---|---|---|---|
| Flashpoint | °C | ≥ 60 | 9.7[2] | 59[3] | -41[4] | 61[5] | ≥120 - <180[6] |
| LFL and UFL | % v/v | 0.5-7.5 | 5.5-44 | Not available | 3.4 - 27 | 0.8 – 5.4 | - |
| Minimum ignition energy | mJ | - | 0.14 | - | 0.29 | - | - |
| Auto-ignition temperature | °C | 240-350 | 455 | 208 | 350 | 204 | ≥256 - ≤266 |
| Laminar burning velocity | m/s | - | 0.48 | - | 0.54 (max) | - | - |
| Normal Boiling point | °C | 160-400 | 64.7 | 158-351 | -24.8 | 180 – 390 | ≥302.5-≤570 |
| Specific gravity (Air = 1) | - | > 1 | 1.11 | >1 | 1.59 (G) | > 1 (V) | > 1 (V) |
| Specific gravity (Water = 1) | - | < 1 | 0.79-0.80 (20°C) | <1 | 0.61(L) | 0.77– 0.79 | 0.87-0.89 |
| Toxicity IDLH | ppm | - | 6000 | - | Not available | - | - |
| Odour threshold | ppm | 0.11 | 3.1-5960 | Not available | Not available | - | - |
| Vapour pressure | mbar | <0.4 (20°C) | 169 (25°C) | Not available | 5333 (20°C) | 0.4 (20°C) | ≥2 - ≤6 |
| Density (15°C) | kg/m³ | 800-910 (15°C) | 791 (25°C) | 770 (15°C) | 661 (20°C, L) | 765 – 800 | 878-895 |
| Kinematic viscosity (40°C) | mm²/s | ≥ 1.4 (40°C) | 0.54-0.59 (20°C) | <7 | <1 (L) | 2.6 | 3.8 – 5.0 |
| Cloud point | °C | ** | - | ** | - | -10 – -34 | ** |
| CFPP | °C | ** | - | ** | - | - | ** |
| Oxidation stability | [g/m³] or [h] | Max 25 g/m³ | - | Not available | - | Max 25 g/m³ | Min 8 h |
| Water solubility | g/liter | Negligible | 1000 (20°C) | Non-soluble | 24-353 | Non-soluble | Negligible |
| **Remarks:**<br>** See ISO 8217 for specification. | | | | | | | |
| **IDLH** = Immediately Dangerous to Life or Health Concentrations specified by the United States National Institute for Occupational Safety and Health (NIOSH), **L** = liquid, **G** = gas, **V** = vapour | | | | | | | |

[2] Source of data is Methanol Safety Data Sheet by Sigma-Aldrich
[3] Source of data is BP Distillates (Fischer-Tropsch), C8-26, branched and linear Safety Data Sheet
[4] Source of data is Sigma-Aldrich Safety Data Sheet Dimethyl ether
[5] Source of data is BP HVO Safety Data Sheet
[6] Source of data is REG Safety Data Sheet for REG Eco Premium Biodiesel/Biodiesel B99.9

## 2.3 Summary of critical conditions

This section presents a high-level overview of what can be identified as critical conditions and fuel properties for the selected biofuels in relation to the foreseen conditions during bunkering. These conditions can play a crucial role in ensuring safe and efficient bunkering operations, meeting regulatory requirements, and preserving the fuel's integrity during storage and transfer processes. The outlined conditions are based on the pure biofuel intended for maritime use, while blends, if applicable, typically exhibit characteristics that fall between the pure biofuel and the fuel being blended.

Table 2-3: Summary of critical conditions and the most crucial fuel properties for the five biofuels, in consideration of the anticipated conditions during bunkering.

| Fuel | Critical conditions |
|---|---|
| Bio-methanol | **Temperature**<br>▪ Methanol has a lower flashpoint (9.7 °C) compared to traditional marine fuels (≥ 60 °C), requiring careful additional safeguards to mitigate the risk of fire and explosion hazards.<br>▪ Methanol's normal boiling point is about 65 °C. This temperature is considered out of range for normal bunkering operations.<br>**Material compatibility**<br>▪ Methanol can be corrosive to some materials (e.g., aluminium, copper, titanium, and polyvinyl chloride). Corrosion is prevented through the selection of materials in contact with methanol or the application of appropriate coating.<br>**Miscibility and contaminants**<br>▪ Methanol has a high solubility in water. Even solutions of methanol containing up to 74% water may be flammable.<br>**Toxicity**<br>▪ The Immediately Dangerous to Life or Health concentration (IDLH) of methanol is 6000 ppm. The primary risks related to methanol toxicity are through ingestion of the substance in its liquid state, but vapour inhalation and contact/absorption through the skin can also have harmful impact. |
| Bio-FT-diesel | **Temperature**<br>▪ Bio-FT-diesel may have a lower flashpoint than 60°C. As such, the IMO IGF Code could be mandatory, depending on the specified flashpoint of the bio-FT-diesel product. In this study it is assumed all FT- diesel delivered as a marine fuel will have a flashpoint above 60°C. |
| DME | **Temperature**<br>▪ DME is a flammable gas under normal ambient conditions necessitating additional safeguards to avoid the risk of fire or explosion. The presence of surfaces above the autoignition temperature of DME (350 °C) is not considered credible during bunkering operations. However, sources of ignition still pose a risk.<br>▪ DME will liquefy if cooled (below boiling point at -24.8 °C at 1atm) or pressurised (above the vapour pressure at 5.3 bar at 20 °C).<br>▪ The freezing point of DME (-141.5 °C) is considered irrelevant for bunkering operations.<br>**Pressure**<br>▪ If the pressure drops below 5.3 bar at 20 °C, dimethyl ether (DME) vaporizes. Due to the relative vapor density of DME (1.59) compared to air (1.0), it becomes heavier than air and can pose a risk of distant ignition or inhalation in confined spaces as it travels along the ground or water surface. |
| HVO | **Temperature**<br>▪ HVO share the same flashpoint specification as distillate marine fuels (≥ 60 °C), requiring similar flammability precautions.<br>▪ Some HVO fuels, without additional cold flow processing, may exhibit poorer cold flow properties than MGO. |

<table>
<tr><th>Fuel</th><th>Critical conditions</th></tr>
<tr><td></td><td></td></tr>
<tr><td>FAME</td><td>Temperature<ul><li>Cold temperatures can cause fuel degradation, clogging and reduced flow capabilities. Cold flow properties differ among biodiesels, with the cloud point for B100, for instance, ranging from -5 to 20°C. Biodiesels typically lower tolerance to cold temperatures than MGO.</li><li>B100 flashpoint (≥ 101 °C) exceeds that of MGO (≥ 60 °C), signifying lower flammability. The flashpoint of FAME is not considered a credible risk during bunkering.</li></ul>Contamination<ul><li>FAME is more contamination-sensitive than MGO. Prevent water, oxygen, dirt, and rust introduction to maintain fuel quality. Exposure to water can facilitate for microbial growth and/or hydrolysis which may cause corrosion and formation of sediments.</li></ul>Material compatibility<ul><li>B100-compatible materials: carbon steel, aluminium, stainless steel, Teflon, Viton, Nylon, fluorocarbon, carbon filled acetal, fibreglass.</li><li>Materials not recommended for use with B100: copper, bronze, brass, zinc, lead, tin, galvanized metal, nitrile rubber, butadiene, Hypalon, natural rubber, neoprene, chloroprene, styrene-butadine rubber, butadine rubber, Polyvinchloride, Polypropylene, Polyurethane, Polyethylene (CONCAWE, 2009) (McCormick & Moriarty, 2023) (CIMAC, 2024).</li></ul></td></tr>
</table>

# 3. Bunkering supply modes, facilities and equipment

## 3.1 General bunkering procedure

Bunkering is a safety-critical operation because it involves handling hazardous biofuels, which pose significant risks for toxicity, fire, spills, environmental damage, and operational hazards if not managed safely. While conventional fuel bunkering benefits from extensive industry experience and well-established procedures, additional guidance is necessary for alternative fuels like biofuels. For this guidance document, the principles of the LNG bunkering process can serve as a valuable example of operational procedures with proven industry experience. LNG bunkering incorporates many of the safety and operational principles applicable to the bunkering of certain biofuels, such as methanol and bio-DME. These practices are described in the *International Safety Guide for Oil Tankers and Terminals* (OCIMF, 2020), which outlines a typical LNG bunkering procedure as the following:

1. Planning phase
   - Risk assessment: Safety and risk assessment phase
   - LNG bunkering management plan: Safety and risk assessment conclusions undertaken
   - Compatibility assessment: Safety and risk assessment applied

2. Operational phase
   - Set-up of safety zone, if required
   - Pre-bunkering phase: Preparation for safe bunkering[7]
   - Connection: Inserting, coupling and testing
   - Bunkering phase: Monitoring and management of the LNG transfer
   - Disconnection: Draining, purging, disconnection and safe storage of the LNG transfer system

3. Post bunkering phase:
   - End of bunkering operation: Documentation

## 3.2 Bunkering biofuel

Biofuel brings about a new set of challenges when it comes to bunkering, mainly due to a lack of industry experience, the variety of biofuels and their ability to be blended with conventional fuel. Differences in bunkering can mainly be attributed to the differences in fuel properties. Some of the main considerations to be taken are regarding the compatibility between the biofuel and vessel systems, considering the possible blend ratio.

Risk assessment on the bunkering of biofuels, conducted for the purpose of this study, showed that bunkering bio-methanol have the same hazards as conventional methanol.

The main concern with DME lies in storage compatibility, vessels bunkering DME need to ensure they have carried out a compatibility assessment. Parallels in bunkering DME can be drawn from bunkering LPG due to their similarity in handling.

HVO, FT-diesel and FAME are very similar to conventional fuels in terms of bunkering. With their main concerns related to fuel degradation and material compatibility over longer periods (EMSA, 2024).

[7] Ensure all safety protocols and equipment checks are in place

## 3.3 Supply modes

Bunkering involves various methods and parties. These parties include the fuel receiver and the supplier.

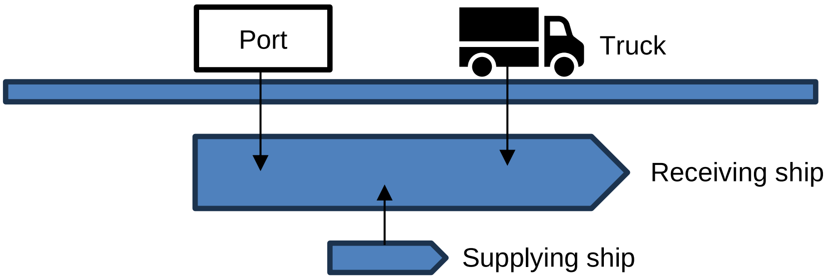


Figure 3-1 showing the differing supply modes for bunkering

Supplying bunkering fuel can be done through different supply modes, such as Port-to-Ship, Truck-to-Ship, and Ship-to-Ship (Suistainable World Ports, 2024). These different supply modes (shown in Figure 3-1) all have their own risks, advantages and disadvantages and differ in terms of feasibility and maturity when it comes to bunkering biofuels.

Table 3-1 advantages and disadvantages of each supply mode

| Supply Mode | Advantages | Disadvantages |
|---|---|---|
| **Port-to-Ship** | - Permanent infrastructure allows for larger capacity and faster bunkering rates | - Restricted access to terminal location<br>- Limited berthing for larger vessels |
| **Truck-to-Ship** | - Flexible and low upfront investment | - Low capacity and flow rates<br>- Physical presence of truck can hinder cargo/simultaneous operations |
| **Ship-to-Ship** | - Flexible positioning (quaysides, anchor points, open sea).<br>- Allows for simultaneous operations | - Potential hazards like vapour/gas release and collision during approach |

### 3.3.1 Port-to-Ship

Port-to-Ship bunkering entails bunkering from the port, directly to a receiving vessel. This is often achieved via a bunkering terminal or directly from an import/export terminal. Pipelines and loading arm arrangements used here are permanent infrastructure

#### 3.3.1.1 Feasibility

*Bio-methanol:* Bunkering methanol via the Port-to-Ship supply mode is currently feasible, but there should be an appropriate ship-to-shore link (SSL) available. This link should include an automatic and manual emergency shutdown of the bunkering operation if problems arise. Facilities to bunker methanol from Port-to-Ship are lacking in availability, so while technical feasibility is at the level required, bunkering opportunities for bio-methanol Port-to-Ship are severely limited.

*DME:* Like bunkering methanol, bunkering DME Port-to-Ship is possible. However, facilities able to do this, from a technical point, are not available. If parallels are drawn with LPG bunkering, then most bunkering is done by LPG carriers themselves at terminals, so this may be the direction DME will also take. There are currently no DME-specific bunkering terminals. Considering DME's similarity to LPG it would benefit from a SSL here too.

*FT-diesel, HVO & FAME:* Bunkering biodiesel Port-to-Ship, is currently feasible due to its similarity with conventional fuels, although terminals that currently facilitate this are lacking.

### 3.3.2 Truck-to-Ship

Truck-to-Ship bunkering entails bunkering from a truck directly to a vessel. This occurs by attaching a flexible hose from a truck on the quay to the receiving vessel.

#### 3.3.2.1 Feasibility

*Bio-methanol:* Bunkering methanol via the Truck-to-Ship supply mode is currently feasible. The Fastwater project[8] outlines four Truck-to-Ship methanol bunkering real-world examples. With the dual-fuelled Stena Germanica example routinely bunkering methanol via truck (Fastwater, 2021).

*DME:* There are no reported instances of vessels being bunkered with DME via truck. DME fuelled trucks are currently in prototype phase, so there is reason to believe that bunkering DME via truck should be feasible in the future. Additionally, when drawing parallels with LPG, bunkering DME via truck should be feasible in the future.

*FT-diesel, HVO & FAME:* Bunkering biodiesels, Truck-to-Ship, are currently feasible and commercially available.

### 3.3.3 Ship-to-Ship

Ship-to-Ship bunkering entails bunkering from one vessel to another, usually occurring via a supplying vessel (bunkering barge) moored alongside the receiving vessel. Ship-to-Ship bunkering is flexible when it comes to positioning and can occur at various locations, such as quaysides, anchor points, or open sea. Bunkering vessels, with capacities ranging from 1,000 to 10,000 $m^3$, will moor alongside, and bunker, receiving ships. This method offers flexibility and can allow for simultaneous operations, for example cargo operations on the quayside while bunkering from the sea facing side.

The Ship-to-Ship Transfer Guide highlights what should be covered in a risk assessment before conducting a Ship-to-Ship transfer and provides an overview of the pre-requisites to conducting such a transfer (CDI, ICS, OCIMF, SIGTTO, 2013). A Ship-to-Ship operation contains many of the same principles as a bunkering operation.

- **Ship Compatibility and Mooring Arrangements:** Assess whether the ships are compatible for the proposed operation, including evaluating mooring arrangements
- **Location Suitability:** Consider the suitability of the location for the specific operation
- **Properties:** Evaluate the properties of the substance to be transferred
- **Personnel Training and Qualifications:** Ensure personnel have the necessary training, experience, and qualifications
- **Ship Preparation and Control:** Adequately prepare ships for the operation and maintain control during the transfer
- **Navigational Processes:** Assess the adequacy of navigational processes
- **Personnel Assignment:** Determine the appropriate number of personnel assigned to control and perform the transfer
- **Communication:** Ensure effective communication between ships and responsible persons
- **Cargo Transfer Implications:** Consider implications related to differences in freeboard or ship listing during cargo transfer
- **Equipment and Environmental Conditions:** Evaluate equipment (including fenders and transfer hoses) and anticipate environmental conditions
- **Emergency Planning and Procedures:** Establish emergency plans and procedures

#### 3.3.3.1 Feasibility

*Bio-methanol:* Bunkering methanol via the Ship-to-Ship supply mode is currently feasible and has been demonstrated. With the Port of Rotterdam hosting the first methanol Ship-to-Ship bunkering operation in 2021 (Port

[8] Full report at: Deliverable 7.1 for download - Methanol supply, bunkering guidelines, and infrastructure available for download (fastwater.eu)

of Rotterdam, 2021) and the Port of Singapore hosting the first bio-methanol Ship-to-Ship bunkering operation in 2023 and SIMOPS in 2024 (SGS Inspire, 2024).

*DME:* There are no reported instances of vessels being bunkered with DME Ship-to-Ship. Again, when drawing parallels with LPG, bunkering DME via barge should be feasible in the future.

*FT-diesel, HVO & FAME:* Bunkering biodiesels, Ship-to-Ship, is currently feasible and commercially available.

### 3.3.4 Supply Mode Maturity

Bunkering biofuels is still relatively rare, the Maritime & Port Authority of Singapore (which has a relatively mature biofuel bunkering scene) saw approximately 288 thousand tonnes of biofuels and their blends bunkered in the first half of 2024, compared to 26,696 thousand tonnes of conventional fuels. Which means that around 1% of fuels bunkered in Singapore were a biofuel or biofuel blend (MPA Singapore, 2024). Rotterdam saw a higher ratio. In Q1 of 2024, approximately 12% of bunkered fuels at the Port of Rotterdam were bio-blended (Port of Rotterdam, 2024).

The relative low levels of biofuel and their blends being bunkered, is also reflected in the maturity of the available supply modes for bunkering biofuel. The technology for bunkering the various biofuels is mature enough to feasibly conduct the operation, however availability is more limited. There are currently, approximately, 10 methanol bunkering facilities worldwide, with bio-methanol specific bunkering terminals not specified (Bureau Veritas, 2024). Biodiesel bunkering is more widespread. With most major ports offering at least biodiesel blends. DME is significantly less available, with no recorded bunkering facilities providing DME.

In terms of supply modes. Ship-to-Ship bunkering appears the most mature, with most biodiesel and bio-methanol bunkering, in terms of volume, occurring via this supply mode. Truck-to-Ship sees less use, due to a lack of capacity, but is a commercially available option in some ports. Port-to-Ship bunkering is currently the least mature, as this supply mode requires a high upfront cost and is not as flexible as the other options.

## 3.4 Receiving vessel facilities and equipment

Bunkering biofuels often necessitates specific facilities and equipment for the receiving vessel, which can vary depending on the type of biofuel being handled. These variations arise due to differences in composition, viscosity, and handling requirements among the different biofuel types. The infrastructure for bunkering biofuels must align with the specific characteristics of each biofuel to ensure safe and efficient operations.

### 3.4.1 Bio-methanol

Bunkering bio-methanol is identical to bunkering pure methanol and thereby requires the same facilities and equipment. IMO’s interim guidelines covering ships using methyl/ethyl alcohol as fuel provides some specific guidance when it comes to methanol and its bunkering (IMO, 2020). It outlines the provisions for the facilities and equipment needed for bunkering operations specific to methanol for the receiving vessel. Including, but not limited to the following:

- *The bunkering station should have appropriate fire protection (e.g. A-60 class divisions and alcohol resistant foam)*
- *Sufficient ventilation for the bunkering station*
- *Suitable instrumentation devices for fuel equipment*
- *Overflow control for bunkering lines*
- *Bunkering control from a safe remote location*
- *Provisions for the detection of fuel leakages and subsequent emergency stop*
- *Sufficient means of communication*
- *Consideration to prevent electrical bonding*

Additionally, reference can be made to ISO 28460:2010 which sets out standards for the interfaces between ship and shore for the loading of LNG and is referred to in IMO’s interim guidelines for ships using methyl/ethyl alcohol (ISO, 2010). Similar facility and equipment considerations may be needed for methanol.

### 3.4.2 DME

As a gaseous substance under ambient conditions, DME requires more specialised facilities/equipment than conventional fuel oils. DME's similarity to propane indicates that comparable facilities and equipment should be used and should thereby follow similar bunkering requirements set out by MSC circular 1666 (IMO, 2023). This circular covers IMO's *Interim Guidelines for the Safety of Ships Using LPG Fuels*.

This circular highlights requirements for bunkering LPG, giving an indication as to what is needed for DME, notably:

- *The fuel transfer piping system must be designed to prevent any leaks that could endanger personnel, the environment, or the ship*
- *Bunkering systems must be compatible with the temperature, pressure, and all LPG compositions used on board*
- *Vapour management systems should be in place to handle vapour generated in the tank during bunker transfer. If such systems are not available on the ship, a vapour return connection should be installed at the bunkering manifold*

Additionally, the conducted risk assessment from Task 2 highlights some additional potential requirements for mitigating DME hazards:

- Ability to cool down fuel tanks and bunker piping
- Ability to inert and purge bunkering tanks/lines prior to gassing up should be possible
- Method for gas sampling
- Material compatibility
- Gas detection
- Emergency liquid relief valve
- ESD-based shutdown on too high pressures
- An emergency shutdown (ESD) link
- A drip tray with leakage detection
- The ability to conduct a dry breakaway
- A water curtain system installed for mitigating DME leaks

Experience with bunkering DME is limited, so facility and equipment needs are still evolving.

### 3.4.3 FT-diesel, HVO & FAME

Bunkering FT-diesel, HVO, FAME or derived blends thereof can be considered identical to conventional fuels and thereby can make use of the same facilities/equipment. However special care must be taken to ensure material compatibility and fuel degradation over longer periods of time.

# 4. Goal and functional requirements

This chapter aims to describe the overarching goal of the Guideline on safe bunkering of biofuel, while attempting to distinguish various biofuel types with a focus on specific functional requirements.

## 4.1 Overarching goal

The Guideline seek to develop guidance towards safe and environmentally sound design, construction, and operation of ships utilising biofuels for propulsion, auxiliary power generation, or other machinery systems. A primary objective is to mitigate risks associated with bunkering alternative (i.e. bio) fuels by ensuring thorough hazard assessments and implementing protective measures to safeguard personnel, the environment, and the ship.

## 4.2 Functional requirements (bio-methanol)

According to the *Interim Guidelines for The Safety of Ships Using Methyl/Ethyl Alcohol As Fuel* (MSC.1/Circ.1621), covers the functional requirements are described as relevant towards bunkering operations:

3.2.1 The safety, reliability and dependability of the systems should be equivalent to that achieved with new and comparable conventional oil-fuelled main and auxiliary machinery.

3.2.2 The probability and consequences of fuel-related hazards should be limited to a minimum through arrangement and system design, such as ventilation, detection and safety actions. In the event of fuel leakage or failure of the risk-reducing measures, necessary safety actions should be initiated.

3.2.4 Hazardous areas should be restricted, as far as practicable, to minimise the potential risks that might affect the safety of the ship, persons on board and equipment.

3.2.5 Equipment installed in hazardous areas should be minimised to that required for operational purposes and should be suitably and appropriately certified.

3.2.12 Suitable control, alarm, monitoring and shutdown systems should be provided to ensure safe and reliable operation.

3.2.14 Fire detection, protection and extinction measures appropriate to the hazards concerned should be provided.

3.2.16 The technical documentation should permit an assessment of the compliance of the system and its components with the applicable rules, guidelines, design standards used, and the principles related to safety, availability, maintainability and reliability.

Toxicity of methanol is significantly lower compared to substances like ammonia, which allows for less stringent exposure limits. To illustrate, ammonia has a long-term OEL[9] of 20 ppm, while methanol has 200 ppm. However, caution is necessary in situations where personnel may be exposed to high concentrations of methanol in enclosed/confined spaces.

## 4.3 Functional Requirements (DME)

DME, likely to be used as a liquified gas, has no specific standards or guidelines regarding its safe bunkering. Although there are no specific guidelines on the safe bunkering of DME, it could be considered that bunkering procedures would be similar to LNG or LPG bunkering. Owing to the similar characteristics and properties of these fuels, bunkering procedures would, thus, draw on the IGC and IGF codes. Other industry standards for LPG, such as the *National Fire Protection Association's (NFPA's) 58 – Liquefied Petroleum Gas Code*, and the US's *Code of*

[9] Occupational exposure limit - https://echa.europa.eu/oel

*Federal Regulations 33 Part 127 – Waterfront Facilities Handling Liquefied Hazardous Gas* could be considered when handling similar fuels, such as DME.

According to the *Interim Guidelines for The Safety Of Ships Using LPG As Fuel* (MSC.1/Circ.1666), the following functional requirements are described as relevant towards bunkering operations:

3.2.1 The safety, reliability and dependability of the systems should be equivalent to that achieved with new and comparable conventional oil-fuelled main and auxiliary machinery.

3.2.2 The probability and consequences of fuel-related hazards should be limited to a minimum through arrangement and system design, such as ventilation, detection and safety actions. In the event of gas leakage or failure of the risk-reducing measures, necessary safety actions should be initiated.

3.2.3 The design philosophy should ensure that risk-reducing measures and safety actions for the gas fuel installation do not lead to an unacceptable loss of power.

3.2.4 Hazardous areas should be restricted, as far as practicable, to minimize the potential risks that might affect the safety of the ship, persons on board and equipment.

3.2.9 Safe and suitable fuel supply, storage and bunkering arrangements should be made capable of receiving and containing the fuel in the required state without leakage. Other than when necessary for safety reasons, the system should be designed to prevent venting under all normal operating conditions, including idle periods.

3.2.10 Piping systems, containment and over-pressure relief arrangements that are of suitable design, construction and installation for their intended application should be provided.

3.2.11 Machinery, systems and components should be designed, constructed, installed, operated, maintained and protected to ensure safe and reliable operation.

3.2.12 Fuel containment system and machinery spaces containing source that might release gas into the space should be arranged and located such that a fire or explosion in either will not lead to an unacceptable loss of power or render equipment in other compartments inoperable.

3.2.13 Suitable control, alarm, monitoring and shutdown systems should be provided to ensure safe and reliable operation.

3.2.14 Fixed gas detection suitable for all spaces and areas concerned should be arranged.

3.2.15 Fire detection, protection and extinction measures appropriate to the hazards concerned should be provided.

3.2.16 Commissioning, trials and maintenance of fuel systems and gas utilisation machinery should satisfy the goal in terms of safety, availability and reliability.

3.2.17 The technical documentation should permit an assessment of the compliance of the system and its components with the applicable rules, guidelines, design standards used, and the principles related to safety, availability, maintainability and reliability.

3.2.18 A single failure in a technical system or component should not lead to an unsafe or unreliable situation.

DME is significant less toxic than, for example, methanol, having a long-term OEL of 1000 ppm in comparison to methanol's long-term OEL of 200 ppm. Hazardous zones taking into account DME's toxicity may therefore be considerably less stringent than, for example, ammonia toxicity zones. However, caution is still required in situations where personnel may be exposed to high concentrations of DME in confined spaces.

## 4.4 Functional requirements for FT-Diesel, HVO & FAME

FT-Diesel, HVO & FAME bear a close resemblance to conventional diesel fuels used in the maritime industry and these do qualify as fuels with flashpoints above 60$^{0}$C. While the other biofuels discussed in this guideline cover safety aspects, the relevant regulations concerning FT-Diesel, HVO & FAME also include pollution-related consequences viewed from a regulatory perspective for conventional fuels.

The regulatory requirements for these fuels are primarily addressed by SOLAS Chapter II-2, MARPOL Annex 1 and MSC.1/Circular 1321 - *Guidelines For Measures To Prevent Fires In Engine-Rooms And Cargo Pumprooms*. Since these are well regulated in the context of conventional fuels, the three fuels in question are not specifically discussed further in this guideline.

# 5. Ship design and arrangement considerations

This chapter intends to highlight key considerations to be made in terms of ship design and arrangement. It is to be noted that the key considerations cover parts of the existing regulations or guidelines, but they are not a detailed list but rather high-level considerations.

The early stages of development—concept selection, basic, and detailed engineering—present a critical opportunity to proactively identify and manage potential hazards. By implementing a systematic approach, such as the hierarchy of controls, designers can effectively mitigate risks. This proven methodology, widely endorsed by safety authorities like OSHA and CDC[10], prioritises hazard control strategies from most to least effective, as illustrated in Figure 5-1.

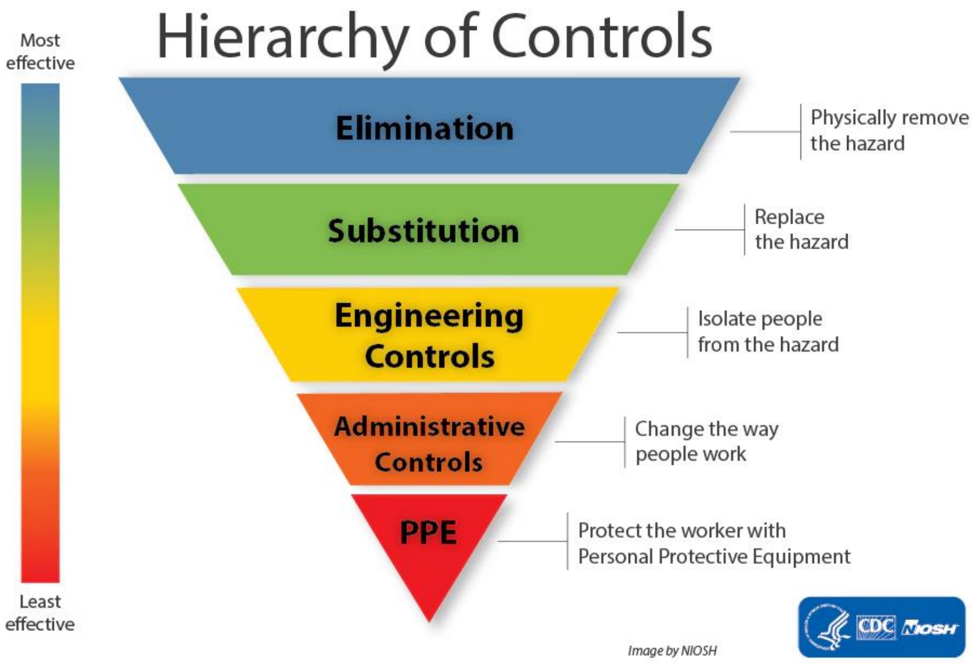


Figure 5-1 Hierarchy of controls (Source: NIOSH).

By systematically working through the hierarchy, which typically includes elimination, substitution, engineering controls, administrative controls, and personal protective equipment, teams can make informed decisions about the best ways to safeguard personnel and the environment. This proactive approach not only enhances safety but also contributes to regulatory compliance and overall project success. Essentially, the earlier hazards are identified and addressed in the design process, the more effectively they can be controlled or eliminated, leading to a safer and more efficient end product.

## 5.1 Application of Hierarchy of Controls

The successful implementation of biofuels as a marine fuel hinges on a robust approach to safety. The hierarchy of controls in Figure 5-1 offers a structured framework to achieve this.

### 5.1.1 The Inevitability of Engineering Controls

Given the compelling environmental advantages of biofuels as a marine fuel, its complete elimination or replacement is not a viable option at this time. Consequently, the primary focus must shift to implementing robust control measures.

[10] https://www.cdc.gov/niosh/hierarchy-of-controls/about/

### 5.1.2 Engineering Controls in Practice

To ensure the safety of personnel working with biofuels, it is crucial to systematically identify potential release points. A thorough examination of routine operations is necessary to pinpoint areas where biofuels could escape, whether in liquid or vapor form. This proactive approach helps to minimise the risk of exposure to biofuel, which can pose health, safety, and environmental hazards. Some key considerations include:

- Containment and Ventilation: Effective containment systems and ventilation strategies can prevent the accumulation of fuel vapours, reducing the risk of fire and explosion.
- Equipment Design and Material Selection: The careful selection of materials and equipment resistant to fuel corrosion and leakage is paramount.
- Leak Detection and Alarm Systems: Advanced leak detection systems with clear and audible alarms can provide early warnings of potential hazards.
- Emergency Shutdown Systems: Rapidly isolating fuel sources in case of emergencies is vital.
- Personal Protective Equipment (PPE): While PPE is the last line of defence, it should be considered as a supplementary measure, used in conjunction with other controls.

By prioritising engineering controls, ship operators can significantly reduce the likelihood of biofuel-related incidents. This proactive approach not only safeguards crew members but also protects the environment. It is important to note that a comprehensive safety management system, including regular inspections, maintenance, and employee training, is essential to ensure the effectiveness of engineering controls. These are further discussed in Chapter 6 and forwards.

## 5.2 Fuel containment system

The safe and environmentally responsible storage of alternative fuels requires meticulous attention to detail. Similar to traditional fuels, the design and construction of storage tanks for biofuels, synthetic fuels, or other emerging energy carriers must prioritise safety and environmental protection. Proper tank design, material selection, and operational procedures are essential to mitigate risks.

### 5.2.1 Bio-methanol

The goal set out in MSC.1/Circ.1621 Sec. 6 is to ensure that the fuel containment system minimizes risks to the ship, crew, and environment to a level equivalent to traditional oil-fuelled ships. The functional requirements set out in MSC.1/Circ.1621 Sec. 6 requires fuel tanks and their associated systems to be designed to prevent leaks and ensure safe operations. This includes protecting the ship, crew, and environment from fire, toxicity, and access restrictions. Further, the system should maintain functionality even in case of a leak, and portable tanks must meet the same safety standards as permanent tanks.

Many alternative fuels possess unique chemical properties necessitating specialized tank construction materials. Stainless steel often proves suitable due to its corrosion resistance, but specific grades must be chosen based on the fuel's characteristics. In certain cases, carbon steel tanks might be viable, provided they are equipped with robust protective coatings to withstand the fuel's corrosive or reactive properties.

Safeguarding alternative fuels necessitates a multi-faceted approach encompassing both primary and secondary safety measures. A summary of key requirements from the circular includes the following.

- Containment Systems: Physical barriers, such as cofferdams, are essential to contain potential leaks or spills, preventing the spread of flammable vapours and mitigating fire or explosion risks. Implementing secondary containment systems can prevent fuel spills from spreading.
- Fuel Tank Venting: Adequate ventilation helps to disperse flammable vapours and maintain safe oxygen levels.
    - Fuel tanks require controlled venting systems with pressure and vacuum relief valves.
    - Vent systems must prevent flame propagation and be designed for efficient gas freeing.
    - Vent outlets should be located safely (away from ignition sources and air intakes) and equipped with flame arrestors.
- Maintaining an inert atmosphere within storage tanks, often achieved by using nitrogen gas, helps prevent the formation of explosive mixtures and reduces fire hazards. Also, covering the fuel surface with an inert gas layer

protects the fuel from degradation and contamination, while also reducing the risk of fire and explosion. Additionally, it helps suppress the generation of static electricity, a potential ignition source.

- Inerting and Gas Freeing
    - Fuel tanks must be continuously inerted.
    - Cofferdams should be purged or filled with water.
    - Gas freeing systems must prevent flammable mixtures.
    - Inert gas systems require specific safety measures, including double block and bleed valves, and blanking arrangements.
    - Gas freeing methods must minimize vapour dispersion.
    - Inert gas supply should be sufficient for extended operations.
    - Inert gas production systems must maintain specific oxygen levels and safety measures.
    - Implement safety measures for inert gas systems, including ventilation and oxygen monitoring.

Beyond material selection and other primary measures, several additional safety practices are essential:

- Grounding: Effective grounding systems prevent the buildup of static electricity, reducing fire risks.
- Inspection and Maintenance: Regular inspections and maintenance programs ensure tank integrity and identify potential issues.

By carefully considering these factors, it is possible to store liquid fuels safely and responsibly, minimizing environmental impact.

### 5.2.2 DME

As mentioned earlier, currently, there are no specific regulations governing the safe bunkering of DME. While lacking dedicated guidelines, the shared characteristics of DME with liquefied gases like LNG and LPG suggest the potential application of existing regulations from these sectors as a starting point for developing safe bunkering procedures. The goal set out in MSC.1/Circ.1666 Sec. 6 (*Interim Guidelines for The Safety Of Ships Using LPG Fuels*) is to ensure that the fuel containment system minimises risks to the ship, crew, and environment to a level equivalent to traditional oil-fuelled ships. The functional requirement of the fuel containment system points to protecting the ship, crew, and environment from potential hazards associated with fuel leaks and explosions. It should also maintain the ship's structural integrity while ensuring operational capabilities in case of emergencies. Additionally, the system must be adaptable to different fuel types in terms of the compositions of DME and comply with equivalent safety standards for portable tanks if used.

The circular points to relevant requirements of IGF Code part A-1 chapter 6 and for the fuel tank located in enclosed space, a tank connection space should be provided separately from fuel storage hold space. A tank connection space should also be provided for the fuel tank located on an open deck where escaped gas may accumulate on the open deck or enter non-hazardous space such as accommodation space and machinery space based on the risk assessment. Based in IGF Code, Sec. 6, no secondary barrier should be required, and the hull structure may act as a secondary barrier.

Vent outlets must be strategically positioned to prevent the escape of gas into non-hazardous areas and to avoid trapping gas in structures. IGF requires vent outlets should be directed upwards to prevent gas accumulation and dispersion and the system should be designed to minimize the entry of water or snow, which could impede vent functionality. Vent outlets must be located at a minimum height of B/3 or 6 meters above the weather deck and working areas to disperse gas safely. However, this height may be adjusted based on specific administrative considerations. A gas dispersion analysis may be required to assess potential risks. Additionally, the vent piping system should be equipped with an inert gas purging interface to ensure safety during operations.

## 5.3 Bunkering systems

The safe and efficient transfer of biofuels necessitates specialised equipment and procedures. Similar to traditional marine fuels, double-walled piping systems can be implemented in critical areas to enhance leak protection and mitigate environmental risks. Adherence to relevant international standards and guidelines, such as the equivalent of MSC.1/Circ.1621 for methanol, is crucial.

### 5.3.1 Bio-methanol

The goal set out in MSC.1/Circ.1621 Sec. 6 is to ensure that the fuel containment system minimises risks to the ship, crew, and environment to a level equivalent to traditional oil-fuelled ships. The functional requirements set out in MSC.1/Circ.1621 Sec. 6 requires systems to prevent fuel leaks that could lead to fires, toxic exposure, or obstructions to emergency equipment. Additionally, the systems should be designed to maintain safe operations even in the event of a leak, without compromising the ship's power.

Section 6 of the Interim Guidelines provides comprehensive specifications for the design, installation, and operation of fuel tank venting, gas freeing, and inerting systems. This includes detailed requirements for equipment, procedures, and safety measures to ensure the safe handling and storage of fuel and covers aspects such as ventilation, pressure relief, gas freeing methods, inert gas generation and distribution, and emergency procedures. A summary of key requirements from the circular includes the following.

- Fuel Tank Venting and Gas Freeing
    - Dedicated venting system: Each fuel tank must have a controlled venting system.
    - Gas freeing system: A dedicated system is required for safe gas freeing and filling.
    - Gas pocket prevention: Tank design should minimise gas pocket formation.
    - Pressure/vacuum relief: Safety valves are essential to protect against overpressure and vacuum.
    - Valve configuration: Prevent accidental shut-off of venting systems.
    - System redundancy: Redundant safety measures are necessary.
    - Vent location and protection: Vent outlets must be safely located and protected from flame propagation.
    - Vent capacity: System must handle maximum bunkering rates.
    - Vent drainage: Prevent liquid accumulation in vent lines.
- Inerting and Atmospheric Control
    - Continuous inerting: Fuel tanks must be filled with inert gas during operation.
    - Cofferdam management: Proper ventilation or water filling of cofferdams required.
    - Flammable atmosphere prevention: Prevent flammable gas mixtures in fuel tanks.
    - Inert gas system integrity: Double block and bleed valves, along with non-return valves, are essential.
    - System isolation: Blanking arrangements for individual tanks are necessary.
    - Vent outlet location: Vent outlets must be safely positioned.
    - Flame arrestors: Vapour outlets require flame arrestors.
    - Gas freeing methods: Safe gas freeing methods are required to minimize vapour dispersion.
    - System design: Consider factors like materials, time, and airflow.
    - Inert gas availability: Sufficient inert gas supply is essential.
    - Inert gas production: Onboard inert gas production systems must meet specific standards.
    - Inert gas system components: System components must adhere to safety regulations.
    - External inert gas: External inert gas sources can be used for gas freeing.

### 5.3.2 DME

Section 8 & 9 of the Circular aim to establish requirements for fuel systems onboard ships to ensure safe and reliable bunkering operations, protecting personnel, the environment, and the ship from potential hazards associated with fuel handling and distribution. The fuel supply system must adhere to the relevant provisions of the IGF Code (part A-1 chapter 8), specifically those related to piping design, safety, and leak prevention. The system should be designed to prevent fuel leaks that could endanger personnel, the environment, or the ship while providing safe access for operation and inspection. Key requirements revolve around leak prevention (piping system must be designed to prevent fuel leaks and their associated hazards), safe access (inspection and maintenance), fuel delivery (deliver fuel at the required pressure, temperature, and flow rate) and vapour management (management of vapour generated during bunkering).

The circular (Sec. 9 covering LPG) outlines specific requirements for fuel supply systems using LPG as fuel, building upon the general provisions of the IGF Code. The requirements outline the following considerations around bleed line routing, need for vent lines to be routed to fuel tanks or gas-liquid separator, gas freeing requirements and calculation of inert gas generation.

## 5.4 Fire safety

This section outlines fire protection, detection, and suppression measures for systems involved in the storage, handling, transfer, and utilization of biofuels under discussion.

The regulatory requirements regarding fire safety for HVO, FAME and FT-diesel fuels are primarily addressed by SOLAS Chapter II-2, MARPOL Annex 1 and MSC.1/Circular 1321 - *Guidelines For Measures To Prevent Fires In Engine-Rooms And Cargo Pumprooms*. Since these are well regulated in the context of conventional fuels and their respective ignition temperatures, the three fuels in question are not specifically discussed further in this chapter.

### 5.4.1 Bio-methanol

The fire safety requirements from a regulatory standpoint are to a large extend covered by MSC.1/Circ.1621 section 11. The requirements set out in section 11 are complementary to those stipulated in SOLAS Chapter II-2. An overview of relevant requirements from section 11 is summarised below and related to fire protection, fire main, firefighting and fire extinguishing requirements towards engine room and fuel preparation phases.

- **Fire Protection**
  - Fuel preparation spaces should be classified as machinery spaces of category A for fire protection purposes. Boundaries separating these spaces from other category A machinery spaces, accommodation, control stations, or cargo areas must adhere to A-60 fire resistance standards.
  - Boundaries between accommodation up to navigation bridge windows, service spaces, control stations, machinery spaces, and escape routes facing open-deck fuel tanks should have A-60 fire integrity.
  - Fuel tanks must be separated from category A machinery spaces and other high-fire-risk areas by a 600 mm cofferdam with at least A-60 insulation.
  - Bunkering stations should be separated from category A machinery spaces, accommodation, control stations, and high-fire-risk areas by A-60 class divisions. Exceptions apply to spaces like tanks, voids, low-fire-risk auxiliary machinery spaces, sanitary areas, and similar spaces where A-0 insulation may suffice.
- **Fire Main**
  - Isolating valves should be installed in the fire main for sections where fuel storage tanks are located on the open deck to enable isolation of damaged sections without compromising water supply to the remaining fire line.
- **Firefighting**
  - Open-deck fuel tanks: Require a fixed PFAS-free alcohol-resistant foam fire-fighting system as per IBC Code Chapter 17 and FSS Code Chapter 14, covering the potential spill area.
  - Bunkering station: Must have a fixed alcohol-resistant foam system and a portable dry chemical powder extinguisher or equivalent.
  - Open-deck fuel tanks: Require a fixed water spray system for dilution, cooling, and fire prevention, covering exposed tank parts.
  - Fire detection: A fixed fire detection and alarm system conforming to the Fire Safety System Code is mandatory for all compartments containing the methyl/ethyl alcohol fuel system.
  - Detector selection: Smoke detectors should be combined with detectors specifically designed for methyl/ethyl alcohol fires.
  - Fire detection aids: Provide heat-detection devices for fire patrols and firefighting purposes.

- **Engine Room and Fuel Preparation Space Fire Extinguishing**
  - Fixed fire-extinguishing system: Required for machinery spaces and fuel preparation spaces housing methyl/ethyl alcohol-fuelled engines or pumps, complying with SOLAS regulation II-2/10 and the FSS Code. The system must be suitable for methyl/ethyl alcohol fires.
  - Alcohol-resistant foam system: Mandatory for machinery spaces of category A and fuel preparation spaces containing methyl/ethyl alcohol, covering the tank top and bilge area.

### 5.4.2 DME

Section 11 of the IMO Circular covers Fire Safety requirements. The requirements of IGF Code part A-1 chapter 11 apply, specifically 11.3.1 of the IGF Code stating the need for fuel preparation room to be separated from a machinery space of category A and rooms with high fire risks. The separation is to be done by a cofferdam of at least 900 mm with insulation of A-60 class. The room must be equipped with a fixed fire-extinguishing system designed specifically for the fuel type in question, complying with the provisions of the FSS Code. The fuel preparation room must adhere to the general fire safety requirements outlined in the IGF Code while incorporating additional measures to address the specific hazards associated with LPG fuels.

## 5.5 Explosion and toxic exposure protection

This section outlines explosion and toxic exposure protection for systems involved in the storage, handling, transfer, and utilization of biofuels under discussion.

### 5.5.1 Bio-methanol

The fire safety requirements from a regulatory standpoint are, to a large extent, covered by MSC.1/Circ.1621 section 12. The functional requirements are related to explosion risks that can be minimised by eliminating ignition sources, preventing the formation of flammable mixtures as well as using certified electrical equipment suitable for hazardous areas where necessary. A summary of the requirements is indicated below.

- **General Provisions -** Hazardous areas not specifically covered by the circular should be assessed and classified using recognized standards, such as IEC 60092-502:1999, Part 4.4. Electrical equipment in these areas must comply with the same standard.
- **Area Classification**: Area classification identifies places where explosive gas atmospheres may occur. This helps select suitable electrical equipment. Hazardous areas are categorised into zones 0, 1, and 2, with relevant definitions for the same in the circular. In complex cases, IEC 60079-10-1:2015 can be used with administrative approval. Ventilation ducts share the classification of the area they serve.
- **Hazardous Area Zones**: Defines the different zones as below:
    - Zone 0: Areas with continuous or frequent explosive gas mixtures, such as inside fuel tanks and associated piping.
    - Zone 1: Areas where explosive gas mixtures are likely to occur under normal operating conditions, including cofferdams, fuel preparation areas, and zones around fuel tank outlets, valves, and vents.
    - Zone 2: Areas where explosive gas mixtures are unlikely to occur, but may occur under abnormal conditions, such as areas outside Zone 1 boundaries and airlocks.

### 5.5.2 DME

To minimise the risk of explosions, it is essential to reduce both ignition sources and the formation of flammable mixtures. The classification of hazardous areas should be carefully determined based on the specific properties of DME, considering factors such as density and lower explosive limit (LEL). Relevant standards like IEC 60079-10-1 can be referenced for guidance. Adherence to the ignition prevention requirements outlined in the IGF Code is also crucial.

## 5.6 Electric installations

This section intends to cover high-level requirements for electrical installations for systems involved in the storage, handling, transfer, and utilisation of biofuels under discussion.

### 5.6.1 Bio-methanol

The fire safety requirements from a regulatory standpoint are, to a large extent, covered by MSC.1/Circ.1621 section 14. The functional requirements within this section of the circular aim at provision for electrical installations that minimise the risk of ignition in the presence of a flammable atmosphere.

The circular requires electrical installations to adhere to stringent safety standards and indicates that all electrical equipment should be designed, installed, and maintained in accordance with recognised industry standards, such as the IEC 60092 series. To minimise risks, electrical components should be restricted to hazardous areas only when absolutely necessary. Proper grounding, circuit separation for lighting systems, and careful equipment selection are crucial to prevent electrical hazards and ensure the safe operation of the vessel.

### 5.6.2 DME

The primary goal is to minimise ignition risks in areas with flammable atmospheres. Electrical systems must be designed to prevent single-point failures that could compromise essential ship functions like fuel tank pressure control and hull temperature maintenance.

Adherence to the general provisions of the IGF Code for electrical installations is seen as relevant. Use of certified explosion-proof equipment suitable for DME environments based on temperature class and equipment group in line with IEC 60079-20 may be required. Separation of the fuel preparation room from hazardous areas to prevent ignition sources must be considered.

## 5.7 Control, monitoring and safety systems

This section intends to cover the key requirements in terms of control, monitoring and safety systems for systems involved in the storage, handling, transfer, and utilization of biofuels under discussion.

### 5.7.1 Bio-methanol

The fire safety requirements from a regulatory standpoint are, to a large extent, covered by MSC.1/Circ.1621 section 15. This section aims to establish guidelines for control, monitoring, and safety systems that ensure the safe and efficient operation of the fuel installation. The functional requirements outline the requirements for control, monitoring, and safety systems in methyl/ethyl alcohol fuel installations to ensure safe and efficient operation requiring them to be robust and redundant. The systems must be designed to prevent power outages, automatically shut down the fuel supply in emergencies, and have independent safety features to avoid accidental shutdowns. Each fuel supply system requires its own dedicated control and safety systems. Key requirements pertaining to the circular are summarised below:

- **General Provisions**
    - Instrumentation: Essential system parameters should be monitored locally and remotely. (also refers to SOLAS chapter II-1, part C)
    - Leak detection: Implement leak detection in potential leak areas, including cofferdams, pipe ducts, and fuel preparation spaces.
    - Double-walled pipes: Monitor annular spaces for leaks and automatically shut down the system in case of a leak.
    - Bilge wells: Install bilge wells with alarms in areas with independent fuel tanks.
    - Portable tanks: Require the same level of monitoring as permanent tanks.
- **Fuel Tank Monitoring and Control**
    - Tank level: Use closed-level gauges for accurate tank level monitoring.
    - Overfill prevention: Install high and very high-level alarms with automatic shut-off valves.
    - Bunkering operations: Control bunkering from a safe location with monitoring capabilities, remote valve operation, and alarm systems.
    - Ventilation: Monitor ventilation in bunkering lines and activate alarms for failures.
- **Engine and Fuel Monitoring**
    - Engine performance: Monitor engine operation from multiple locations.
    - Gas detection: Install gas detectors in potential gas accumulation areas.
    - Gas alarms: Activate alarms and safety measures at predetermined gas levels.
    - Fire detection: Install fire detectors in relevant areas.
    - Ventilation monitoring: Monitor ventilation systems and activate alarms for failures.
    - Emergency procedures: Implement procedures for handling shutdowns and preventing damage.
    - Emergency stops: Provide multiple locations for emergency shutdown of fuel systems.

### 5.7.2 DME

The arrangement of control, monitoring and safety systems should support an efficient and safe operation of the DME-fuelled installation.

Functional Requirements for the control and safety systems should ensure continued power generation and propulsion in case of a single system failure, as per Sec.9.3.1 of IGF Code. According to Ch.15 of the IGF Code, a safety system is to be implemented whereby automatic shutdown of the fuel supply in case of system failures or abnormal conditions is possible. Integration of ESD protection for machinery configurations, where applicable, to shut down fuel supply and disconnect non-certified electrical equipment in case of leaks should be considered. Ensure independent safety systems to prevent common cause failures. Design of safety systems to consider spurious shutdowns due to faulty components or sensor failures. The need for redundancy in terms of provision for separate control and safety systems for multiple fuel supply systems is to be considered.

To ensure safety during bunkering operations, specific gas detection and monitoring measures must be implemented. Gas Detection systems in accommodations, machinery spaces, and other high-fire-risk areas, as required by IGF Code Part A-1 Chapter 15.8.1, may apply. Continuous monitoring of the bunkering station through direct visual observation or CCTV surveillance as an addition to IGF Code Part A-1 Chapter 8.3.1 may be required. Consider conducting risk assessments to determine the optimal placement of gas detectors, as per IGF Code Part A-1 Chapter 4.2.

# 6. Operations

## 6.1 General

Proper mitigation measures are crucial to ensure safe handling and use of biofuels. Chapters 4 and 5 covered the overall goals, functional descriptions and the receiving vessel/design arrangements to be considered towards bunkering operations.

The key phases of bunkering operations include:

- Pre-bunkering phase
- Connection of bunkering equipment
- Bunkering/transfer phase
- Disconnection of bunkering equipment.

This chapter covers each phase for the respective biofuels under discussion on a general basis with relevant considerations within a given phase for the respective fuel type. Further, the chapter also touches upon Simultaneous operations during the bunkering process and key considerations under this scenario.

Successful bunkering operations hinge on effective communication and strict adherence to safety protocols among all involved parties. A comprehensive checklist is crucial for ensuring safe bunkering operations. To minimise risks associated with handling flammable and potentially toxic fuels, detailed checklists have been developed. These checklists[11] included in the Appendices outlines specific procedures for each phase of the bunkering process to mitigate risks associated with handling flammable and potentially toxic fuels. While the provided checklists offer general guidance, they should be adapted to suit the specific characteristics of the bunker operation, vessel, fuel type, and bunkering mode. The checklist is divided into sections (Part A to E) with numbered sub-sections for easy reference intended to cover each phase of bunker operations.

- Part A PRE-BUNKERING PHASE
  - A1 Pre-operational considerations
  - A2 Alignment recording & sign off

- Part B CONNECTION PHASE (Connection Testing prior to transfer).
  - B1 Site & Equipment Readiness
  - B2 Safety Systems
  - B3 System Preparation
  - B4 Agreement Points - To be Recorded & signed off in a Safety Meeting

- Part C TRANSFER PHASE (Repetitive checks during transfer)
  - C1 Vessel approach & positioning
  - C2 Safety & operational procedures
  - C3 Watchkeeping & monitoring

- Part D DISCONNECTION PHASE
  - D1 Prior to disconnection
  - D2 Post disconnection

- Part E SIMOPS
  - E1 Operational restrictions
  - E2 SIMOPS Planning
  - E3 Safety considerations
  - E4 Continuous monitoring

[11] The checklists under the appendices are intended as more of a guide to develop and customise a checklist that needs to be adapted to ship type/ organisational procedures. It covers a collection of topics & items that should be considered for bunkering of biofuels being discussed. However, for sake of simplicity, it is being referred to as a checklist.

## 6.2 Safety Zones and Exclusion Areas

When handling biofuels, establishing clear safety zones is crucial to mitigate risks. Like practices in the LNG industry, specific areas should be designated to control access and manage potential hazards.

### 6.2.1 Hazardous Zones

Areas with a high likelihood of combustible, explosive, or toxic atmospheres should be classified as hazardous zones. Strict controls, including ignition source management and restricted access, are essential in these areas.

Consideration should be given to the relative toxicities of methanol and DME, which are much lower, than for example, ammonia. Hazardous zones can be applied accordingly, based on considerations of this toxicity, amongst other factors.

### 6.2.2 Safety Zones

A highly restricted safety zone should be implemented around biofuel transfer operations, especially near potential leak points such as manifolds and tank connections. This zone minimises personnel exposure and facilitates effective spill management. Only trained personnel equipped with appropriate protective equipment should be allowed within this area. To enhance safety, simultaneous operations and unauthorised personnel should be restricted in this zone.

### 6.2.3 Monitoring and Security Zones

An additional monitoring and security zone should be established beyond the safety zone. This area requires clear escape routes and emergency shelters. Personnel must undergo emergency training and may need protective equipment. Risk assessments and relevant guidelines determine the size of this zone. In essence, creating defined safety zones with strict controls is essential for handling biofuels safely. These zones help to protect personnel, equipment, and the environment from potential hazards.

Note: While the specific dimensions of safety zones may vary based on the type of biofuel and operational conditions, the general principle of establishing clear boundaries and implementing robust safety measures remains consistent.

## 6.3 Pre-bunkering phase (Part A)

This phase involves preparations prior to bunkering operations and mainly involves planning and coordination to facilitate a safe bunkering operation. Planning involves the exchange of information, ensuring compatibility between the vessels and their environment, as well as alignment between the bunker facility (can be bunker vessel, Port or Truck) and receiving vessels. This phase is further detailed in this section.

### 6.3.1 Checklist Codes and Guidelines

The checklist should consider employing specific codes to indicate the nature of each item so that there is a clear demarcation between items that are agreed upon, items that are subjected to repetitive checks, items that are part of agreement point, etc. A few examples of the same are listed below:

- Agreement Items: Items requiring mutual agreement are marked "A" and detailed in the pre-operational items
- Repetitive Checks: Items subject to repeated checks during the operation are marked "R" or “RC”
- Finalised agreement points (a.k.a. Joint Bunker Management Plan (JPBO) in some cases): Items referenced in the finalised agreement points are marked accordingly.
- Not Applicable: If an item is deemed irrelevant to the specific operation, all parties should mark it as "NA."
- Check Failures: If a "Yes" response cannot be achieved for a required item, the issue must be immediately addressed and resolved before proceeding. In cases where resolution is not possible, a joint decision on whether to proceed with the bunkering operation, along with any necessary additional safety measures, must be made.

The checklist system with codes and guidelines not only ensures operational efficiency but also provides a valuable tool for retrospective analysis. Documenting every step of the bunkering process facilitates traceability, enabling root cause analysis in case of incidents. This information is crucial for identifying areas of improvement and implementing corrective actions, ultimately contributing to enhanced safety and operational excellence.

### 6.3.2 Documentation and Planning

Safe and efficient bunkering operations require meticulous planning and coordination between the bunker facility and the receiving vessel. A comprehensive compatibility assessment is the cornerstone of this process, identifying potential risks and challenges associated with the operation. This assessment evaluates various factors, including vessel conditions, equipment compatibility, safety and operational procedures. The results of this assessment are then captured into items to be agreed and items to be signed off which may result in a Joint Plan of Bunkering Operation (JPBO) or an agreement plan or similar. This collaborative document outlines the specific steps and responsibilities of all parties involved in the bunkering process.

#### 6.3.2.1 Compatibility assessment (Part A1)

Before a bunkering operation, the bunker vessel and receiving vessel operators must conduct a compatibility assessment to identify potential risks and challenges. Such compatibility assessments (Checklist A1) involve local & site requirements (regulations, hazardous zones, safety zones, safety distances, etc.), mooring arrangements/plans, equipment involved in bunkering operations (manifold arrangements, connection details etc.), bunkering & safety measures considered, organisation of personnel on both sides and communication between the two parties. A thorough compatibility assessment is essential to ensure the safe transfer of fuel between vessels. This evaluation encompasses a wide range of factors to mitigate potential risks.

- **Safe Vessel Separation**: Safe mooring configurations, including adequate fendering or spacing, are crucial to prevent vessel collisions during the bunkering process.
- **Hose Management**: The reach of the bunker hoses must be sufficient to accommodate the relative positions of the vessels, allowing for safe connections and operations.
- **Equipment Compatibility**: Compatibility of manifold arrangements, spill containment systems, and hose connections on both vessels is paramount.
- **Emergency Procedures**: Emergency release mechanisms, such as hose breakaway systems, should be in place to minimise gas release in case of unexpected events.
- **Electrical Safety**: Additionally, measures to prevent electrical arcing, particularly for fuels with higher ignition risks, must be implemented.
- **Emergency Response**: Both the supply vessel and the receiving vessel must have compatible emergency shutdown systems, clearly defined emergency procedures, and robust safety measures in place.
- **Hazardous Area Control**: The hazardous area classifications on both vessels should be compatible to prevent ignition sources from entering hazardous zones.
- **Fuel Specifications**: Fuel compatibility involves verifying that the supply source's volume, pressure, and temperature align with the receiving vessel's tank specifications.
- **Purging & Inerting**: Both vessels should possess adequate inerting and purging capabilities to ensure safe fuel handling.
- **Communication**: Effective communication between the bunker supplier and receiver is essential for monitoring the operation and coordinating emergency responses. Compatible communication equipment and clear protocols are crucial.
- **Electrical Isolation**: Finally, electrical isolation arrangements must be in place to prevent electrical hazards during the bunkering process.

By conducting a comprehensive compatibility assessment and addressing these key factors, the risk of accidents and incidents can be significantly reduced, ensuring a safe and efficient bunkering operation.

#### 6.3.2.2 Agreement points for consideration (Part A2)

The results/inputs from the compatibility assessment should then be used to create a list of agreement points to be signed off on (Checklist A2), which outlines the specific procedures for the bunkering process. The agreement points should be a collaborative document developed by both vessel operators, incorporating their respective bunker management plans, local conditions, and the results of the compatibility assessment. It should include general/key information on the proposed operation, roles and responsibilities for the bunkering organization, plan for bunker operation, vessels details, bunker preparation in terms of vessel approach and mooring, safe positioning and securing of vessels, pre-bunkering checklist, hose handling and connection, equipment inspection & system preparation. The checklist details some of the key items to be considered, however, this is not a complete list and should be adapted & expanded, as seen fit, by the relevant parties as required.

## 6.4 Connection of bunkering equipment (Part B)

Prior to initiating the bunkering process, a comprehensive inspection of equipment and systems is essential to ensure safe operations.

- **Site & Equipment Readiness**: Bunker transfer equipment undergoes rigorous checks for its suitability. This encompasses assessing the equipment's overall condition, proper installation of seals and gaskets, and secure connections to manifolds. The equipment's alignment and support systems are also verified to prevent instability and potential hazards. Considerations around weather limits for operations and illumination to ensure visibility of operations should also be made.
- **Safety Systems Verification**: Safety devices, such as emergency stop buttons, alarms, and shutdown procedures, are thoroughly tested to ensure immediate response in case of emergencies. Gauges, high-level alarms, sensors and high-pressure alarms on the bunker system are calibrated and activated as relevant to monitor the bunkering process effectively. Ensure use of ex proof equipment in hazardous zones and means to prevent static electrical discharge should be in place. Considerations around vapor release prevention and monitoring of non-loading tanks to be ensured.
- **System preparation**: Before commencing bunkering operations, it is crucial to conduct thorough safety checks and ensure system readiness in terms of required testing, checks and adherence to procedures. These include testing safety systems verification checks and verifying the readiness of the transfer system. Additionally, careful planning of the bunkering schedule, monitoring tank levels, and managing vapor release are essential for a safe and efficient fuel transfer.
- **Agreement points**: Once all inspections and preparations are complete, all parties involved should document the agreement points. Such points may include vessel approach permission, MSDS review, plan for personnel transfer, tank soundings, safety measures and procedures around bunkering. This final confirmation ensures that everyone is aware of the operation's commencement and can initiate necessary actions.

All parties involved are notified of the vessel's readiness to commence bunkering and this is captured in the form of a checklist (Checklist B) filled out by both vessels.

## 6.5 Bunkering/Transfer phase (Part C)

Safe bunkering operations require careful attention to both environmental and operational factors. Essential considerations include:

- **Vessel approach & positioning**: Consideration around favourable weather conditions, vessel positioning & securing in terms of mooring and fendering, adequate & safe access to vessels, clear communication, sufficient lighting, possibility for safe vessel passage in case of an emergency etc should be made to ensure a safe bunkering operation.
- **Safety and Operational Procedures**: To ensure a safe bunkering operation, it is crucial to adhere to designated safety zones, use explosion-proof equipment in hazardous areas, and have appropriate safety measures in place, including personal protective equipment and emergency response plans. Regular monitoring of gas levels and timely activation of emergency procedures are essential. Control of ignition sources and management of toxic fumes are essential. Ignition sources must be strictly controlled to prevent fires, and toxic fumes must be managed to safeguard personnel health.
- **Watchkeeping & monitoring**: It is crucial to monitor connections, pressures, and tank levels for all connections and bunker lines for potential leakages and ensure adherence to strict safety protocols. Continued restriction on use of naked lights, smoking, ensuring plugged drains during bunkering are also to be followed. It is also important to maintain a bunker log while informing tank levels when designated and agreed levels are reached. Regular checks of fuel levels prevent overfilling and associated hazards. If simultaneous operations (SIMOPS) are being conducted, relevant restrictions must be observed.

To ensure consistency and accountability, checklists (Checklist C) are commonly used to verify compliance with these critical factors.

## 6.6 Disconnection of bunkering equipment (Part D)

Upon completion of the bunkering operation, several critical steps must be considered to ensure safety and environmental protection which are divided into prior disconnection and post disconnection.

- **Prior to disconnection:** Considerations around adjusting the filling rates during top off of tanks & notifying the bunker supplier of the same, system preparation in terms of purging, inerting, depressurisation, liquid draining, closure of valves for safe disconnect etc. should be made. Additionally, the Office On Watch (OOW) should be informed when the bunkering is complete so that both Bunker/Receiving vessel can be notified on “ready to disconnect”
- **Post disconnection**: Following the completion of bunkering operations, it is crucial to restore the bunker area to its original condition. In order to prevent contamination and related hazards, bunker hoses, vapour return lines, and associated equipment must be thoroughly cleaned, purged of any residual fuel, and depressurized. All valves should be closed to prevent accidental releases -including replacing of manifold blanks. Accurate and complete documentation, including transfer records and inspection reports, must be exchanged between parties including the Bunker Delivery Note (BDN) and verification of quantities delivered. Additionally, it is important to notify relevant authorities about the completion of the operation and report any incidents or near-misses.

By following these procedures, the risks associated with post-bunkering activities can be minimized, contributing to overall safety and environmental protection. Checklists (Checklist D) that cover the above activities are often utilised since the nature of operations is repetitive.

## 6.7 Simultaneous operations (Part E)

Vessel operators and terminals sometimes require conducting simultaneous cargo operations alongside bunkering to optimise vessel turnaround times. Other simultaneous operations could also involve stores or garbage handling, other operations such as oily bilge/sludge, transfer, loading and unloading of stores, etc. This practice, known as SIMOPS, involves cargo handling activities while bunkering is in progress. For passenger vessels, this includes bunkering with passengers on board or during embarkation/disembarkation. While ideal bunkering conditions involve a vessel solely dedicated to the operation, the reality often necessitates concurrent activities. However, it introduces additional complexities due to increased human activity and the potential presence of flammable gas mixtures. Part E of the checklists is indicated as a general guidance for considerations during SIMOPS. Please note that this has been developed to cover SIMOPS on a general basis and, unlike the other checklists, does not cover specific fuel types being discussed.

### 6.7.1 Ignition Sources and Risk

Bunkering operations inherently carry the risk of accidental gas/vapour release, which can create flammable mixtures. To mitigate this, ignition sources are strictly prohibited in hazardous areas. SIMOPS, especially those involving cargo handling near the bunkering area, increases the potential for uncontrolled ignition sources. The nature of cargo operations varies in terms of ignition risk; for example, loading containers near the bunker station is considered more critical than passenger embarkation on the opposite side of the vessel.

### 6.7.2 Human Factors and Risk

Beyond ignition risks, SIMOPS involving passengers poses a higher risk to human life in case of accidents. Compared to cargo operations with limited personnel, passenger vessels carry a larger number of individuals who may not be adequately trained in emergency procedures.

#### 6.7.3 Risk Assessment and Management:

Given the heightened risks, each SIMOPS operation requires a thorough risk assessment. This evaluation should consider the specific nature of the cargo operation, its proximity to the bunkering area, and the potential impact on personnel safety. Implementing robust safety measures, clear communication protocols, and emergency response plans is essential for managing these risks effectively.

#### 6.7.4 Risk Mitigation Strategies

It is important to account for SIMOPS and develop risk mitigating strategies, some of which could be around the considerations indicated below.

- **Dedicated Personnel:** Assign dedicated personnel to oversee SIMOPS activities. These individuals should have specific training in managing simultaneous operations and coordinating with the bunkering team.
- **Clear Communication:** Establish robust communication channels between all parties involved in both the bunkering and cargo operations. This includes clear protocols for information sharing, coordination, and emergency response.
- **Zone Management:** Implement strict zoning and segregation of operations. Clearly define areas for bunkering, cargo handling, and personnel movement.
- **Ignition Source Control:** Enforce stringent controls on ignition sources throughout the vessel, particularly in areas with potential gas accumulation. This includes the use of intrinsically safe equipment and regular inspections.
- **Emergency Response Plans:** Develop detailed emergency response plans specifically for SIMOPS, including evacuation procedures, firefighting, and spill response. Conduct regular drills to ensure personnel preparedness.
- **Risk Assessment:** Conduct regular risk assessments to identify potential hazards and implement appropriate control measures. This should be a continuous process to address changing conditions and operational requirements.
- **Permit-to-Work System:** Implement a permit-to-work system for critical activities during SIMOPS, such as hot work or entry into confined spaces. This ensures that necessary precautions are in place before commencing work.
- **Monitoring and Supervision:** Increase surveillance and monitoring of the bunkering and cargo operations during SIMOPS. This includes visual inspections, gas detection, and CCTV monitoring.
- **Weather Conditions:** Pay close attention to weather conditions, as adverse weather can increase risks during SIMOPS. Consider postponing operations if weather conditions deteriorate.
- **Vessel Stability:** Monitor vessel stability during SIMOPS, especially when dealing with heavy cargo loads.

By implementing these strategies, the risks associated with SIMOPS can be effectively managed, enhancing the overall safety of the operation. It is also important to develop suitable checklists for some of the items listed above and a general guidance on the structure of such a checklist is included under the appendices.

### 6.8 Other safety considerations

As discussed under 5.1 Application of Hierarchy of Controls, administrative controls and PPE are important elements of applying the hierarchy of controls ensuring the safe use of biofuels as a marine fuel.

#### 6.8.1 Administrative Controls

Effective administrative controls are paramount for ensuring the safe handling and operation of biofuel-fuelled vessels. These controls encompass a comprehensive framework of procedures designed to address various operational scenarios, including routine operations, maintenance, emergencies, and abnormal situations.

- **Procedural Development:** The creation of detailed procedures necessitates a thorough understanding of the vessel's design and equipment. Once finalized, these procedures should outline clear guidelines for tasks such as bunkering, fuel transfer, and daily operations.
- **Preventive Maintenance:** Regular inspections and maintenance are crucial to identify and rectify potential issues before they escalate into safety hazards. Implementing a structured maintenance program is essential.

- **Emergency Preparedness:** Developing comprehensive response plans for abnormal situations and emergencies is vital. These plans should cover equipment malfunctions, process deviations, fuel leaks, fires, and evacuation procedures.
- **Personnel Training:** A robust training program is essential to equip personnel with the knowledge and skills to execute procedures effectively. Regular training and competency assessments are necessary to maintain high safety standards.

### 6.8.2 Stakeholder Collaboration

Successful implementation of administrative controls requires close collaboration among industry stakeholders. This includes shipyards, equipment manufacturers, port authorities, and regulatory bodies. By working together, these parties can develop harmonized procedures and standards that enhance safety across the industry.

### 6.8.3 Personal Protective Equipment (PPE)

While PPE is the final line of defence in the hierarchy of controls, it is essential for protecting personnel from the hazards associated with exposure. The appropriate selection and use of PPE are crucial for mitigating risks.

- **PPE Requirements:** The specific PPE required depends on the task being performed. Generally, this includes eye protection, hand protection, respiratory protection, and protective clothing.
- **PPE Selection:** The choice of PPE should be based on the potential hazards and the level of protection required.
- **Training:** Personnel must be trained on the correct use and limitations of PPE.
- **Maintenance:** PPE should be regularly inspected, cleaned, and replaced as needed.
- **Emergency Preparedness:** Emergency escape breathing apparatus (EEBA) may be required in certain situations.

By combining effective administrative controls with the appropriate use of PPE, the risks associated with biofuel handling can be significantly reduced.

## 6.9 Bio-methanol

This section outlines high-level details of the typical bunkering operations that are intended to cover ship-to-ship transfer-based bunkering operations involving methanol and draws upon the boundaries of the HAZID study done as part of the previous phases of the study. It also covers the key considerations across different phases of bunkering operations that are related to the specific fuel(s) under discussion. The checklist for bunkering of bio-methanol is included in Appendix B, which contains detailed information and is therefore not addressed in this section.

Regulations for bunkering and handling bio-methanol are more stringent, requiring compliance with the IGF Code and interim guidelines (MSC/Circ. 1621) specific to bio-methanol. The IGF Code mandates that vessels fuelled by low flashpoint fuels conduct a separate risk assessment addressing potential onboard hazards, including bunkering scenarios. While methanol's primary hazard is its flammability, it is also a toxic substance that must be handled with care. Methanol toxicity is particularly dangerous through ingestion, skin contact, and inhalation, with long-term exposure limits set at 200 ppm (by ECHA, OSHA, NIOSH, ACGIH), and short-term exposure limits up to 250 ppm for 15 minutes (by ECHA, NIOSH, ACGIH). Preventing exposure through appropriate PPE is crucial. Recommendations for handling methanol include implementing technical measures to control process parameters, manage potential ignition sources, and enhance bunkering procedures, many of which are already addressed in the IGF Code and interim guidelines.

### 6.9.1 Pre-bunkering phase

Please refer to 6.3 Pre-bunkering phase for general details. The key aspects related to bio-methanol for this phase include fuel quality verification and compatibility assessment.

To mitigate risks associated with fuel quality and compatibility, it is strongly recommended that fuel samples be analysed upon delivery to verify adherence to agreed specifications and identify potential hazards. Sharing fuel quality analysis reports by the supplier prior to bunkering is considered best practice to allow for a thorough assessment of fuel compatibility by the vessel crew or a third party. Failure to conduct these checks could result in engine damage, equipment failure, or environmental incidents due to unexpected fuel properties.

To effectively assess and manage risks related to fuel compatibility and monitoring, the use of the following standards and guidelines as reference is recommended:

- International Regulations and Standards
  - MARPOL Annex VI: Regulates air pollution from ships, including emissions from fuel combustion. It provides essential guidelines for fuel quality and handling.
  - ISO 6583 (Part 8): Although under development, this standard is expected to offer specific requirements for marine fuels, contributing to fuel quality and compatibility assessments.
  - MSC.1/Circ. 1621 (Section 17): Provides additional guidance on fuel-related matters, offering supplementary information to the above standards.
- Fuel Quality Standards
  - ASTM D7901-20 and ISO 16861:2015: These standards establish specific criteria for fuel quality, aiding in the evaluation of fuel suitability and potential compatibility issues.
- Engine Manufacturer Recommendations
  - In addition to regulatory standards, the recommendations provided by engine manufacturers play a vital role in ensuring optimal fuel performance and equipment protection. Adherence to these guidelines is crucial for maintaining engine health and preventing unexpected issues.

### 6.9.2 Connection of bunkering equipment

Please refer to 6.4 Connection of bunkering equipment (Part B) for general details. The connection phase should consider risks related to spill containment, prevention of static electricity, the need for adequate inerting, and procedures for monitoring oxygen levels in the tanks and piping.

- Spill containment: Due to the water solubility of methanol, traditional oil spill containment methods may not be effective. Methanol spills in sea cannot be contained, but till biodegrade naturally at a high rate.
- Static electricity prevention: While methanol itself may not be a static accumulator, the potential for static build-up in other fluids or contaminants should not be disregarded Consider the use of electrical bonding (earthing) for bunkering hoses to reduce the risk of ignition from static discharge. Adherence to industry best practices for grounding and bonding remains essential. The use of insulating flanges, as recommended by SIGTTO and OCIMF, can help mitigate risks associated with electrical conductivity.
- Adequate inerting: Ensure sufficient nitrogen supply for proper purging of systems before bunkering to prevent the formation of flammable atmospheres. IGF code /Circ.1621 may be used as reference.
- Oxygen monitoring: Implement procedures for measuring oxygen levels in tanks and piping to verify the effectiveness of the inerting process. References to relevant standards and guidelines, such as OCIMF's guidelines for STS hoses and the IGF Code, should be incorporated into bunkering procedures.

### 6.9.3 Bunkering/Transfer phase

Please refer to 6.5 Bunkering/Transfer phase (Part C) for general details. Prior to initiating the bunkering process, a comprehensive inspection of equipment and systems is essential to ensure safe operations, and such considerations may include the following:

- **Communication**: Reliable communication channels between the bunker vessel and the receiving vessel are paramount. This includes both verbal and visual communication methods to coordinate activities and address potential issues promptly.
- **Equipment Readiness**: Bunker transfer equipment undergoes rigorous checks for its suitability. This encompasses assessing the equipment's overall condition, proper installation of seals and gaskets, and secure connections to manifolds. The equipment's alignment and support systems are also verified to prevent instability and potential hazards.
- **Safety Systems Verification**: Safety devices, such as emergency stop buttons, alarms, and shutdown procedures, are thoroughly tested to ensure immediate response in case of emergencies. Gauges, high-level alarms, and high-pressure alarms on the bunker system are calibrated and activated to monitor the bunkering process effectively.
- **Fuel Installation Checks**: Safety and control devices on the fuel installations are inspected to guarantee their proper functioning. The ship's emergency shutdown (ESD) system, including automatic and manual activation

mechanisms, is tested and confirmed to be operational. Interconnections between the ESD systems of both vessels are established and verified as per the agreement points discussed in Sec.6.3.2.2.

- **System Preparation**: The vapour return system, transfer system, and control valves are checked and prepared for the bunkering process. All systems are configured to ensure safe and efficient fuel transfer.
- **Final Confirmation**: Once all inspections and preparations are complete, all parties involved are notified of the vessel's readiness to commence bunkering. This final confirmation ensures that everyone is aware of the operation's commencement and can initiate necessary actions.

All parties involved are notified of the vessel's readiness to commence bunkering and this is captured in the form of a checklist (Checklist B) filled out by both vessels.

During the bunkering phase, several considerations must be made, such as planning and operational procedures, considerations around equipment and infrastructure, establishing operational restrictions, as well as the need for crew training and repetitive checks during the bunkering operations.

- Operational Planning and Procedures
    - Mooring Plans: Develop and implement specific mooring plans for STS bunkering to maintain vessel stability and prevent accidents. Mooring equipment guidelines for tankers in OCIMF & Port Authority Regulations on fuel supply could be a good reference in developing these plans. For example, the HELCOM Recommendation 28/3 Guidelines on bunkering operations and ship-to-ship cargo transfer of oils, subject to annex I of MARPOL 73/78, in the Baltic Sea area specifically requires a mooring plan.
    - Emergency Shutdown Systems: Install high-pressure ESD systems to protect against over-pressurization and consequent hose damage.
    - Valve Closure Optimization: Carefully determine optimal valve closing times to prevent water hammer effects while maintaining safety. While there is no maximum closing times specified for automatic valves (incl. bunker valves) in MSC.1/Circ.1621, the IGF code specifies 30 seconds for automatic valves other than bunker valves. For bunker valves the closing time shall be 5 seconds unless pressure surge calculations determine that an extended closing time is needed.
    - Tank Pressure Management: Maintain reduced target tank pressures on both bunker and receiving vessels to minimize vapour release risks.
- Equipment and Infrastructure
    - Hose Compatibility: Implement measures to prevent incorrect hose connections, such as physical incompatibility. Ensure that colour coding of methanol hose/piping is used to distinguish it from lines for other fuels and prevent incorrect connection.
    - Static Electricity Prevention: Assess the static electricity properties of bio-methanol and implement appropriate grounding and bonding procedures. Also refer to static electricity prevention in connection phase.
    - Spill Prevention: Consider the use of spill containment measures and emergency response plans.
- Operational Restrictions
    - Internal Fuel Transfer: Prohibit internal fuel transfer on bunker barges during bunkering to mitigate vapour release risks.

### 6.9.4 Disconnection of bunkering equipment

Please refer to 6.6 Disconnection of bunkering equipment (Part D) for general details. The key aspects in this phase related to hazards arising from residual fuel in hoses and pipes. Insufficient purging of hoses and pipes after bunkering operations can lead to personnel exposure, environmental contamination, and increased risk of fire or explosion. These are potentially caused by Inadequate purging procedures and/or equipment failures.

Therefore, it is important to have detailed purging procedures, including the use of inert gas when necessary. Proper training and supervision of personnel should be considered. Use of quick closing disconnect couplings to minimize residual fuel should be part of the procedures. Regular inspection and maintenance of hoses and pipes should be made mandatory.

### 6.9.5 Simultaneous operations

Please refer to 6.7 Simultaneous operations (Part E) for general details. Upon completion of the bunkering operation, several critical steps must be considered to ensure safety and environmental protection.

- **Equipment Clean-up**: To prevent contamination and hazards, bunker hoses, vapour return lines, and associated equipment must be thoroughly cleaned, purged of any residual fuel, and depressurized.
- **System Isolation**: All valves should be closed to prevent accidental releases.
- **Communication:** Both the bunker vessel and the receiving vessel must confirm readiness for disconnection and initiate the disconnection process.
- **Site Restoration**: The bunker area should be cleaned and restored to its original condition.
- **Documentation**: Accurate and complete documentation, including transfer records and inspection reports, must be exchanged between parties.
- **Incident Reporting**: Any near misses or incidents should be reported to the appropriate authorities for investigation and learning purposes.

By following these procedures, the risks associated with post-bunkering activities can be minimized, contributing to overall safety and environmental protection. Checklists (Checklist D) that cover the above activities are often utilised since the nature of operations is repetitive.

Simultaneous operations for general details. When carrying out SIMOPS, careful consideration in terms of establishing a safety zone, imposing operational restrictions and carrying out operational assessments should be mandatory.

- **Safety Zone Establishment:** Clearly define and enforce safety zones around bunkering operations to prevent unauthorised access and potential ignition sources. According to Methanol Bunker Operating Regulations, 23 /01/2023, developed by the Port of Gothenburg, safety zones and operational restrictions during methanol bunkering are to be established and respected. To mitigate the risks associated with methanol bunkering, strict safety zones are required to be established and enforced. A minimum 25-meter radius around the bunkering vessel should be maintained, free from obstructions and personnel unrelated to the operation. All potential ignition sources, including lighting, equipment, and personnel, must be excluded from this zone. Passenger access to areas adjacent to the bunkering operation should be restricted. Clear communication and coordination between the vessel and port authorities are essential for managing potential emergencies within the designated security zone.
- **Operational restrictions:**
  - Passenger Restrictions: Limit passenger access to areas where bunkering activities are taking place to minimise the risk of accidents.
  - Cargo Handling Restrictions: Prohibit cargo handling activities within the safety zone unless specifically authorised and detailed in SIMOPS procedures.
- **Operational assessments:** Thorough risk assessments must be conducted to evaluate the potential hazards and impacts of simultaneous operations during bunkering. By carefully considering the specific circumstances of each operation, appropriate mitigation measures can be implemented to safeguard personnel, equipment, and the environment. Failure to conduct such assessments could lead to increased risks of accidents, equipment damage, and environmental pollution.

## 6.10 DME

This section outlines high-level details of a typical bunkering operation that is intended to cover ship-to-ship transfer-based bunkering operations involving DME and draws upon the boundaries of the HAZID study done as part of the previous phases of the study. It also covers the key considerations across different phases of bunkering operations that is related to the specific fuel(s) under discussion. The checklist for bunkering of DME is included in Appendix C, which contains detailed information and is therefore not addressed in this section.

Regulations for bunkering and handling DME are more stringent, requiring compliance with the IGF Code. The IGF Code mandates that vessels fuelled by low flashpoint fuels conduct a separate risk assessment to address potential onboard hazards, including those associated with bunkering. For DME specifically, it's crucial to account for thermal expansion when determining filling limits. If DME is supplied at low temperatures, it could expand and cause overflow in the receiving ship's tanks. Additionally, the receiving ship's reliquefication system could exceed design limits if DME is supplied at ambient temperature. Storage compatibility is also a critical consideration, as DME is typically stored in a liquid state under refrigeration, pressurisation, or a combination of both. Hazards may arise if DME is bunkered in a state incompatible with the design of the fuel tank, with the worst-case scenario being tank rupture. Recommendations for handling DME include implementing technical and procedural measures to manage thermal challenges, control process parameters, refine bunkering procedures, and assess compatibility with LPG, which is considered the most closely related fossil fuel

### 6.10.1 Pre-bunkering phase

Please refer to 6.3 Pre-bunkering phase for general details. The pre-transfer operations should consider measures related to the prevention of static electricity, the need for cooling down of tanks and pipes, monitoring of oxygen levels, assessment of fuel quality, as well as relevant operational procedures.

- Static Electricity Prevention: Consider implementing ship-shore ESD links as required by the IGF Code and recommended by industry guidelines (e.g., MSC.1/Circ.1666) to mitigate the risk of static electricity.
- Thermal Stress Prevention: Adherence to recommended cooling procedures for fuel tanks and pipes to prevent thermal stress and equipment damage should be considered.
- Fuel Quality Assessment: Implement robust sampling and analysis procedures to verify fuel quality and compatibility, considering the specific challenges associated with gas fuels. Encourage fuel suppliers to share fuel quality analysis reports to facilitate compatibility assessments.
- Operational Procedures: Develop detailed pre-bunkering procedures, including checklists and guidelines for personnel. The procedures should consider measuring oxygen levels in tanks and piping to confirm effective inerting. It should also include conducting thorough checks to confirm effective inerting of tanks and piping prior to bunkering.

### 6.10.2 Connection of bunkering equipment

Please refer to 6.3 Connection of bunkering equipment for general details. The connection phase of DME bunkering operations, requires managing hazards related to static electricity, material compatibility, spill management, hose management, purging requirements and management of thermal stresses.

- Electrical Continuity: Ensure electrical continuity of the bunkering system in accordance with industry standards (API RP 2003, ISGOTT) to mitigate the risk of static discharge. IGF (18.4.5) specifies that hoses, transfer arms, piping and fittings provided by the delivering facility used for bunkering shall be electrically continuous, suitably insulated and shall provide a level of safety compliant with recognised standards e.g. API RP 2003, ISGOTT: International Safety Guide for Oil Tankers and Terminals. Consider implementing the use of insulating flanges as recommended by SIGTTO and OCIMF to further reduce the risk of electrical conductivity.
- Bonding wires is not recommended by SIGTTO and OCIMF. Instead, installation of insulating flanges is recommended at one end of the connection hoses for all transfer or vapour return connections. Insulation flange specifications and arrangements are to be in accordance with recognised industry standards such as ISGOTT “International Safety Guide for Oil Tankers and Terminals” and SIGTTO “LNG Ship to Ship Transfer Guide for Petroleum, Chemicals and Liquefied Gases”.
- Material Compatibility: Ensure all components in contact with DME, including hoses, gaskets, and seals, are compatible to prevent equipment failure and environmental contamination. ISO 2928:2021(en) requires rubber hoses and hose assemblies for liquefied petroleum gas (LPG) in the liquid or gaseous phase and natural gas up to 2,5 MPa (25 bar). Specification or Standard EN1762, BS4089, ISO 2928:2003, British Standard (BS) EN 13766:2010, BS EN 1762:2003 are also good references.
- Spill Containment: Implement measures such as water curtains and drip trays to mitigate the impact of potential methanol spills and protect the ship's hull. IGF Code (6.5) and MSC Circ. 1666 are also good references.
- Hose Security: Select and maintain hoses in accordance with relevant standards (ISO 2928, BS 4089, EN 13766) to ensure their suitability for methanol service. Utilise dry break-away couplings to prevent excessive leakage in case of accidental disconnection during the connection phase. IGF Code (8.4.1) and MSC Circ. 1666 are also good references.
- System Purging: Ensure adequate nitrogen supply and verification procedures for effective purging of tanks, pipes, and hoses prior to connection. Adhere to established procedures for purging and inerting systems before connection to ensure a safe operating environment.

- Thermal Management: Monitor tank and pipe temperatures to prevent excessive cooling and potential equipment damage, particularly during the connection phase when hoses are being attached. Utilise temperature sensors on tanks and piping to monitor and control cooling processes, preventing thermal stress on equipment. IGF Code (15.4.11) requires shell temperature measurements in top, middle and top of tanks. While LNG piping is subject to mandatory pipe stress analysis to demonstrate management of thermal stresses, similar considerations should be made for DME if seen relevant.

### 6.10.3 Bunkering/Transfer phase

Please refer to 6.5 for general details. Prior to initiating the bunkering process, a comprehensive inspection of equipment and systems is essential to ensure safe operations, and such considerations may include the following:

- **Communication**: Reliable communication channels between the bunker vessel and the receiving vessel are paramount. This includes both verbal and visual communication methods to coordinate activities and address potential issues promptly.
- **Equipment Readiness**: Bunker transfer equipment undergoes rigorous checks for its suitability. This encompasses assessing the equipment's overall condition, proper installation of seals and gaskets, and secure connections to manifolds. The equipment's alignment and support systems are also verified to prevent instability and potential hazards.
- **Safety Systems Verification**: Safety devices, such as emergency stop buttons, alarms, and shutdown procedures, are thoroughly tested to ensure immediate response in case of emergencies. Gauges, high-level alarms, and high-pressure alarms on the bunker system are calibrated and activated to monitor the bunkering process effectively.
- **Fuel Installation Checks**: Safety and control devices on the fuel installations are inspected to guarantee their proper functioning. The ship's emergency shutdown (ESD) system, including automatic and manual activation mechanisms, is tested and confirmed to be operational. Interconnections between the ESD systems of both vessels are established and verified as per the agreement points discussed in Sec.6.3.2.2.
- **System Preparation**: The vapour return system, transfer system, and control valves are checked and prepared for the bunkering process. All systems are configured to ensure safe and efficient fuel transfer.
- **Final Confirmation**: Once all inspections and preparations are complete, all parties involved are notified of the vessel's readiness to commence bunkering. This final confirmation ensures that everyone is aware of the operation's commencement and can initiate necessary actions.

All parties involved are notified of the vessel's readiness to commence bunkering and this is captured in the form of a checklist (Checklist B) filled out by both vessels.

During the bunkering phase, there are several considerations to be made, such as operational procedures, considerations around equipment and system designs, establishing the zones, as well as the need for crew training and repetitive checks during the bunkering operations. Operational Procedures and Equipment designs to consider developing specific mooring plans for STS operations, implementing high-pressure ESD systems to protect against over-pressurization and hose damage, establishing inspection and maintenance routines for the bunkering equipment to prevent failures.

- Operational Procedures and Planning
  - Mooring Plans: Develop specific mooring plans for STS bunkering operations to ensure vessel stability and prevent accidents.
  - Bunkering Procedures: Incorporate tightness testing into bunkering procedures to minimize leakages.
  - Simultaneous Operations: Strictly control simultaneous operations to avoid interference with bunkering activities.
  - Location-Specific Risk Assessments (Quantitative RA): Conduct QRAs for bunkering operations, considering DME properties and establishing appropriate safety zones.
- Equipment and System Enhancements
  - ESD Systems: Implement high-pressure ESD systems to protect against over-pressurization and hose damage.
  - Liquid Relief Valves: Install liquid relief valves on both supply and receiving sides to prevent excessive hose pressure in case of emergencies.
  - Valve Closure Times: Optimize valve closing times to avoid water hammer effects.

    - Target Tank Pressure: Maintain low target tank pressures on both vessels to minimize vapour release.
    - Gas Detection: Install gas detection systems on both vessels to monitor for potential gas leaks.
    - Hose Compatibility: Ensure methanol hoses are physically incompatible with other fuel types and meet required certifications (e.g., IGC Code 5.11.7).
- Safety Zones and Emergency Response
    - Safety Zones: Establish clear safety zones around bunkering operations to restrict access and prevent ignition sources.
    - Internal Fuel Transfer: Prohibit internal fuel transfer on bunker barges during bunkering to minimize vapour release risks.
    - Emergency Response: Develop comprehensive emergency response plans for various incident scenarios, including spills, fires, and equipment failures.
- Additional Considerations
    - Crew Training: Provide thorough training to personnel involved in bunkering operations on safety procedures, emergency response, and equipment operation.
    - Regular Inspections: Conduct regular inspections of equipment and systems to identify and address potential issues.

While addressing the above, it is important to ensure adherence to relevant industry standard and regulation to ensure safety and efficiency during bunkering operations. Port Authority Regulations could be a good reference when establishing guidelines for bunkering activities, including safety zones, vessel requirements, and emergency response procedures. Hose Standards that comply with hose standards (ISO 2928, BS 4089, EN 13766) to ensure equipment integrity and safety is a key consideration given the critical operations involving hoses. IGF Code requiring implementation of valve closing time requirements considering potential water hammer effects.

### 6.10.4 Disconnection of bunkering equipment

Please refer to 6.6 Disconnection of bunkering equipment (Part D) for general details. The disconnection phase of bunkering operations presents several potential hazards, including trapped liquid, hose damage, and equipment failure. Residual fuel left in hose and/or pipes due to Insufficient purging, Insufficient draining etc. poses significant risks, including personnel exposure, environmental contamination, and fire or explosion hazards. Some key considerations in addressing such hazards are included below.

- Pressure Management: Implement liquid relief valves and pressure sensors to prevent over-pressurization and detect residual fuel. For example, a pressure sensor outboard of the bunkering valve to detect pressure increase due to residual fuel in the hose, and no pressure increase when the hose is empty could be considered.
- Emergency Shutdown: Consider implementing high-pressure ESD triggers to prevent uncontrolled liquid relief in case of unexpected pressure surges or against uncontrolled liquid release.
- Hose and Equipment Integrity: Prioritize hose and equipment maintenance, adhering to industry standards to prevent damage and leaks. Strict adherence to relevant industry standards (e.g., MSC Circular 1666, ISO 28460) for hose selection, installation, and maintenance should be mandated.
- Operational Procedures: Develop detailed disconnection procedures (use of quick closing disconnect couplings to reduce purging time), including purging, draining, and personnel safety measures including emergency response plans.
- Spill Prevention: Consider additional safeguards like water curtains and drip trays to minimize the impact of potential spills.

### 6.10.5 Simultaneous operations

Please refer to 6.7 Simultaneous operations (Part E)for general details. Upon completion of the bunkering operation, several critical steps must be considered to ensure safety and environmental protection.

- **Equipment Clean-up**: To prevent contamination and hazards, bunker hoses, vapour return lines, and associated equipment must be thoroughly cleaned, purged of any residual fuel, and depressurized.
- **System Isolation**: All valves should be closed to prevent accidental releases.
- **Communication:** Both the bunker vessel and the receiving vessel must confirm readiness for disconnection and initiate the disconnection process.
- **Site Restoration**: The bunker area should be cleaned and restored to its original condition.

- **Documentation**: Accurate and complete documentation, including transfer records and inspection reports, must be exchanged between parties.
- **Incident Reporting**: Any near misses or incidents should be reported to the appropriate authorities for investigation and learning purposes.

By following these procedures, the risks associated with post-bunkering activities can be minimized, contributing to overall safety and environmental protection. Checklists (Checklist D) that cover the above activities are often utilised since the nature of operations is repetitive.

When carrying out SIMOPS, careful consideration in terms of establishing a safety zone, imposing operational restrictions and carrying out operational assessments should be mandatory.

- Simultaneous Operations: Carefully assess the potential risks and impacts of conducting simultaneous operations during bunkering to prevent accidents and equipment damage. Implement clear guidelines and restrictions to maintain a safe working environment.
- Safety Zones: Establish and maintain clear safety zones around bunkering operations to protect personnel and equipment.
- Passenger Access Control: Limit passenger access to areas near bunkering operations to minimise the risk of accidents and equipment damage.

## 6.11 FT-Diesel, HVO & FAME

This section outlines high-level details of the typical bunkering operations that are intended to cover ship to ship transfer based bunkering operations involving FT-diesel, HVO or FAME, and draws upon the boundaries of the HAZID study done as part of the previous phases of the study. It also covers the key considerations across different phases of bunkering operations that are related to the specific fuel(s) under discussion. The checklist is included in Appendix D, which contains detailed information and is therefore not addressed in this section.

HVO, FT-diesel, and FAME, as alternative fuels, require specific attention due to limited operational experience. Unlike traditional marine fuels, these biofuels may have different properties that could impact equipment and system compatibility. To mitigate potential issues, it is essential to closely monitor their performance and conduct thorough compatibility assessments. This includes regular inspections and analysis to detect any signs of equipment degradation or fuel-related problems.

### 6.11.1 Pre-bunkering phase

Please refer to 6.3 Pre-bunkering phase for general details. To enhance safety and operational efficiency when handling biofuels, several additional measures should be considered.

Procedures should be added to regularly check the bunker area and implement protections for hot surfaces above 200°C to prevent autoignition, noting that the current requirement applies to surfaces above 220°C, which is particularly relevant for FT and HVO fuels. This should be a key consideration when developing the bunkering procedures.

Fuel suppliers are advised to provide a detailed fuel analysis report for both 100% biofuel and blends prior to bunkering, ensuring that the fuel quality meets specifications. This report should also be available at the time of fuel delivery.

Consider increasing the inspection interval until more operational experience is gained regarding the potential for increased corrosivity. Additionally, research should be conducted into the corrosivity of different fuel blends on unprotected steel tanks, especially for heated fuels and long-term storage.

Suppliers must verify the compatibility of seals, gaskets, and bunker hoses with biofuels to reduce the risk of leaks. Similarly, when receiving biofuels, ensure that gaskets, seals, and coatings are compatible with the specific fuel type.

### 6.11.2 Connection of bunkering equipment

Please refer to 6.4 Connection of bunkering equipment for general details. The key hazard in this phase is related to potential fuel leakage upon commencement of bunkering. This could be due to assembly error, damaged hoses, defective gaskets/seals or leaking drain valves. Given the similarities to conventional diesel fuels, some of the mitigating actions include the use of drip trays, SOPEP/SMPEP equipment, and fixed fire extinguishing systems. Bunker vessels are often equipped with spill coamings at the aft and sides to prevent spills from reaching the sea, and scupper plugs are employed during bunkering. Additionally, standardised bunkering procedures are in place to further reduce risks.

Additional action points to consider in the context of biofuels discussed here include taking special care and precautions when heating fuel to within 10°C of its flashpoint, even if the flashpoint is above 60°C. The high viscosity of biofuels, as previously discussed, should also be factored into safety measures. According to IEC standard 60092-502, bunker vessels that heat their cargo within 10°C of the flashpoint are classified as carrying low flashpoint cargo, necessitating heightened safety protocols.

### 6.11.3 Bunkering/Transfer phase

Please refer to 6.5 Bunkering/Transfer phase (Part C) for general details. Prior to initiating the bunkering process, a comprehensive inspection of equipment and systems is essential to ensure safe operations and such considerations may include the following.

- **Communication**: Reliable communication channels between the bunker vessel and the receiving vessel are paramount. This includes both verbal and visual communication methods to coordinate activities and address potential issues promptly.
- **Equipment Readiness**: Bunker transfer equipment undergoes rigorous checks for its suitability. This encompasses assessing the equipment's overall condition, proper installation of seals and gaskets, and secure connections to manifolds. The equipment's alignment and support systems are also verified to prevent instability and potential hazards.
- **Safety Systems Verification**: Safety devices, such as emergency stop buttons, alarms, and shutdown procedures, are thoroughly tested to ensure immediate response in case of emergencies. Gauges, high-level alarms, and high-pressure alarms on the bunker system are calibrated and activated to monitor the bunkering process effectively.
- **Fuel Installation Checks**: Safety and control devices on the fuel installations are inspected to guarantee their proper functioning. The ship's emergency shutdown (ESD) system, including automatic and manual activation mechanisms, is tested and confirmed to be operational. Interconnections between the ESD systems of both vessels are established and verified as per the agreement points discussed in Sect. 6.3.2.2).
- **System Preparation**: The vapour return system, transfer system, and control valves are checked and prepared for the bunkering process. All systems are configured to ensure safe and efficient fuel transfer.
- **Final Confirmation**: Once all inspections and preparations are complete, all parties involved are notified of the vessel's readiness to commence bunkering. This final confirmation ensures that everyone is aware of the operation's commencement and can initiate necessary actions.

All parties involved are notified of the vessel's readiness to commence bunkering and this is captured in the form of a checklist (Checklist B) filled out by both vessels.

To address the risks associated with bunker transfer, several recommendations, as given below, may be considered for implementation.

- Vessels should install independent overflow alarms in fuel tanks to prevent overfilling incidents.
- The certification and inspection regime for bunker hoses, particularly those used for biofuels, should be revised to account for potential material incompatibility, referencing standards such as EN1765 (2016).
- It is also advisable to establish a manual emergency shutdown (ESD) link with a remote stop button between the receiving vessel and the fuel supplier, allowing the receiving vessel to halt operations in case of any deviations. Additionally, consideration should be given to the failure modes of remotely operated valves in the bunker system to mitigate the potential for water hammer effects.
- Finally, it is important to investigate the potential for electrostatic charging during bunker operations and assess its implications for fuels with flashpoints above 60°C.

### 6.11.4 Disconnection of bunkering equipment

Please refer to 6.6 Disconnection of bunkering equipment for general details. The disconnection phase of bunkering operations presents hazards related to external leakages due to residual fuel and potential trapped liquid in the hoses post-bunkering operations. Given the similarities with conventional diesel fuels, safeguards such as drip trays, bunker procedures, slow ramp-up of pumps, air blowing of bunker lines post bunkering, and SOPEP/SMPEP equipment should be sufficient mitigations. It is expected that the bunker vessels would have spill coamings aft and sides to prevent spills from going to sea, and scupper plugs are in use while bunkering.

A potential hazard related to FAME would be the solidification of the previous bunker in the bunker system, which may be alleviated by heat tracing and insulation of the bunkering line to counter cold flow issues.

### 6.11.5 Simultaneous operations

Please refer to 6.7 Simultaneous operations (Part E)for general details. Upon completion of the bunkering operation, several critical steps must be considered to ensure safety and environmental protection.

- **Equipment Clean-up**: To prevent contamination and hazards, bunker hoses, vapour return lines, and associated equipment must be thoroughly cleaned, purged of any residual fuel, and depressurized.
- **System Isolation**: All valves should be closed to prevent accidental releases.

- **Communication:** Both the bunker vessel and the receiving vessel must confirm readiness for disconnection and initiate the disconnection process.
- **Site Restoration**: The bunker area should be cleaned and restored to its original condition.
- **Documentation**: Accurate and complete documentation, including transfer records and inspection reports, must be exchanged between parties.
- **Incident Reporting**: Any near misses or incidents should be reported to the appropriate authorities for investigation and learning purposes.

By following these procedures, the risks associated with post-bunkering activities can be minimized, contributing to overall safety and environmental protection. Checklists (Checklist D) that cover the above activities are often utilised since the nature of operations is repetitive.

When carrying out SIMOPS, careful consideration in terms of imposing operational restrictions and carrying out operational assessments should be mandatory.

- Simultaneous Operations: Carefully assess the potential risks and impacts of conducting simultaneous operations during bunkering to prevent accidents and equipment damage. Implement clear guidelines and restrictions to maintain a safe working environment.
- Passenger Access Control: Limit passenger access to areas near bunkering operations to minimize the risk of accidents and equipment damage.

# 7. Scope and Criteria for Verification

This chapter discusses the responsibilities of the various stakeholders and the process of verifying biofuel bunkering. This includes verifying bunkering compatibility, but also the bunker fuel itself. Given that biofuels can be mixed with traditional fuels, there is a growing need for documenting, verifying, and ensuring the quality of biofuel blends to avoid misrepresentation of the actual biofuel blend ratio.

Additionally, stakeholders should have a degree of confidence in facilitating and providing approval to a biofuel bunkering operation in terms of safety and operability. Prior to facilitating or approving a biofuel bunkering operation, all stakeholders should be aligned where necessary. A risk assessment and compatibility assessment should be carried out. To ensure risk levels are acceptable and that the bunkering operation is technically and operationally possible. The compatibility assessment should cover the following topics (IAPH, 2020):

1. Local and site requirements
2. Mooring
3. Equipment
4. Manifold
5. Connection
6. Bunkering procedures
7. Safety measures
8. Personnel
9. Emergency contingencies
10. Communication

IMO's interim guidelines covering ships using methyl/ethyl alcohol as fuel provide some specific guidance when it comes to methanol (IMO, 2020). These specifically outline requirements for pre-bunkering verification. Encompassing the following:

The verification of:

- *all the communications methods, including SSL, if fitted*
- *the operation of fixed fire detection equipment*
- *the operation of portable gas detection equipment*
- *the readiness of fixed and portable fire-fighting systems and appliances*
- *the operation of remote-controlled valves; and*
- *inspection of hoses and couplings*

Verification, in the same vein as DME and biodiesels, is not explicitly covered by IMO requirements.

Successful verification at the pre-bunkering stage, which is documented and agreed upon by parties, provides a confident backdrop from which to commence bunkering operations. The following sections will specify additional verification criteria for the various stakeholders involved with bunkering biofuels.

## 7.1 Stakeholders

### 7.1.1 Vessels

Onboard safety management systems are in place to verify the bunkering of biofuels, generally falling under the Safety Management System (SMS). This provides a degree of confidence to stakeholders when facilitating a bunkering operation.

The Tanker Management and Self-Assessment 3, provides a good starting point for the onboard management of vessels during bunkering (OCIMF, 2017). Highlighting some best practices for bunkering:

- Documented procedures and checklists (covering, for example, bunker safety, tank gauging, bunker sampling)
- Documentation covering tests and checks of equipment
- Guidance covering co-mingling of bunkers (especially important for biofuel blends)

- Standardised templates for bunker planning and record keeping
- Method for auditing

This selection of best practices can be co-opted for the bunkering of biofuels specifically.

### 7.1.2 Supplier

Bunkering facilities/providers generally require a licence to operate, and this allows receivers and ports to verify suppliers before bunkering. These licenses can require a specific Quality Management System. The Port of Singapore requires that bunker suppliers have a certified Quality Management System for Bunker Supply Chain (MPA Singapore , 2024). Which entails:

- Organisation & leadership
- Planning, support & operation
- Delivery
- Performance evaluation

Additionally bunker suppliers are verified further by taking part in an accreditation scheme. Where a supplier can receive accreditation through good practice, measured by KPIs.

### 7.1.3 Ports

Ports have an essential role when it comes to bunkering. While bunkering generally follows international guidance and best practices, they also have primary jurisdiction over the bunkering facilities and thereby can introduce their own requirements. It should be noted that Ports vary in how they operate and sometimes their jurisdiction over shipping safety shifts accordingly.

#### 7.1.3.1 Permitting

It is common for ports to issue a permitting regime for bunkering operations. These set minimum requirements for bunkering approval in the permitting port and can be dependent on the fuel type being bunkered. The Central Nautical Management North Sea Canal Area provides some examples of bunkering permit requirements (De raad van de gemeente Amsterdam, 2023):

- Qualified personnel that will carry out bunkering operations
- Financial integrity of the permit holder
- Appropriate and maintained equipment to conduct bunkering operations
- Availability of the permit holder to bunker at all bunkering locations in varying conditions
- Compliance with relevant environmental regulations
- The reliability of the permit holder

Permit requirements could be broadened to cover additional topics, depending on the fuel type, such as:

- Bunkering location and relevant safety/security/hazardous zones
- Operational procedures and safety, permitting of SIMOPS
- Nautical safety
- External safety
- Notifications towards port authorities regarding bunkering operations

Permitting bunkering operations allows ports to verify that the necessary requirements are in place to execute bunkering operations and can be tailored specifically to the fuel type.

#### 7.1.3.2 Quality

Ports generally have regulations in place to ensure the quality of bunkered biofuels. The Port of Singapore, for example, gives additional requirements specifically for the quality of biofuel for bunkering, through Singapore Standards (SS) 524 - *Singapore Specification for quality management for bunker supply chain* and SS 600 – *Singapore Standard Code of Practice for Bunkering:*

Additionally, to supply biofuel within the Port of Singapore, one must fulfil the following requirements:

Mass Flow Meter (MFM):

- The bunker supplier must ensure that the MFM installed on the bunker craft is specifically intended for measuring biofuel, with an uncertainty of measurement not exceeding 0.5%
- The biofuel supplied must meet density and kinematic viscosity specifications outlined in the MFM approval letter issued by the Maritime & Port Authority of Singapore (MPA) for the specific bunker craft

Carriage Requirements for Biofuel Blends:

Parties must meet the carriage requirements for the different biofuel blend ratios. Biofuel blends are categorised based on their volumetric composition:

- ≥75% of a MARPOL Annex I cargo: Subject to MARPOL Annex I[12].
- 1% but <75% of a MARPOL Annex I cargo: Subject to MARPOL Annex II (IBC Code, chapter 17).
- ≤1% of a MARPOL Annex I cargo: Not considered blends; shipped under MARPOL Annex II[13].

The ISO standard on *Products from petroleum, synthetic and renewable sources — Fuels (class F) — Specifications of marine fuels* (ISO, 2024) introduces requirements for certain biofuels and their blends, especially FAME, specifically:

- Marine fuel with 100% FAME: Must meet EN 14214 (except for sulphur, cloud point (CP) and cold filter plugging point requirements or ASTM D6751 (except for the sulphur requirement). It must also meet the applicable grade[14].
- Marine fuel with, up to, 100% FAME: Must meet the specifications outlined in Table 1 (providing characteristics of distillates and bio-distillate marine fuels (DM/DF grades)) of the standard.

Approval and Documentation:

- The Flag Administration and Class Society of the bunker craft must approve or have no objection to biofuel loading, carriage, and delivery. Deviations should be prone to an approved SOLAS alternative design process.
- The Standards and Investigation – Marine Fuel (SIMF) Department is informed of biofuel bunker deliveries
- Commercial agreements between bunker supplier and buyer should cover biofuel supply

Operational Considerations:

- No blending allowed on board the bunker craft within the Port of Singapore
- A Certificate of Quality (COQ) must be issued by the supplier and comply with ISO 8217:2024 specifications (except clause 5.1 on FAME levels).
- Loading operations must adhere to Singapore's statutory and port/coastal State requirements
- Biofuel blends should be tested for FAME and results incorporated in the COQ
- The COQ must be sent to the SIMF Department at least one day before biofuel delivery
- The product name of the biofuel supplied should be accurately filled in the Bunker Delivery Note (BDN).
- The bunker supplier must maintain records of all relevant documentation

### 7.1.4 Class Societies & Flag Administrations

While flag Administrations ensure that ships under its flag comply with regulations this task can be delegated to recognised organisations such as class societies. Class society's approval of vessels ensures that they comply with minimum standards of safety, when it comes to system design and construction. Shore-side operational

[12] Only TAEE, Ethanol, FAME and Vegetable fatty acid distillates may be carried as part of a Bio-fuel blend under annex I of MARPOL, see MSC-MEPC.2/Circ.17 and annex 11 of the latest MEPC.2 Circular (MEPC.2/Circ.29).
[13] Some bio-fuels, known as recognized energy-rich fuels, are transported under MARPOL Annex I in their pure form, these are often referred to as renewable diesel etc. See MEPC.1/Circ.879 and annex 12 of the latest MEPC.2 Circular (MEPC.2/Circ.29) for the complete list.
[14] Specified in Table 1 of the ISO 8217:2024 standard

procedures are not included under class coverage; however, it is important for all stakeholders to recognize and be confident in the safety of the bunkering operation. The International Association for Classification Societies (IACS) provides a recommendation (No. 146) for conducting risk assessments on board IGF Code vessels[15] (i.e. Methanol & DME) which can provide guidance to stakeholders for assessing risk on these vessels (IACS, 2016). Class approval by classification societies, for example, in bunkering system arrangements or recommended practices in bunkering facilities, builds confidence in the safe execution of biofuel bunkering. Deviations or alternative arrangements of the bunkering system should be approved via SOLAS alternative design process. Vessels should ensure they have the relevant Class documentation on board, the scope of which is dependent on the Class Society.

### 7.1.5 IMO

The IMO, under MEPC.1/Circ.905[16], highlights the documentation required for sustainable biofuels and their relevance towards calculating carbon intensity indicators (CII). Allowing for the fuel oil supplier to provide the $CO_2$ Emission Conversion Factor if their fuel is not covered under the CII guidelines, which biofuels aren't. This means that a "Proof of Sustainability" or similar needs to be provided with the BDN when bunkering biofuel. In order to facilitate the verification of the reported biofuel consumption and be able to use the greener carbon factor instead of its equivalent fossil fuel type.

[15] Risk assessment as required by the IGF code

[16] INTERIM GUIDANCE ON THE USE OF BIOFUELS UNDER REGULATIONS 26, 27 AND 28 OF MARPOL ANNEX VI (DCS AND CII)

# 8. Roles, Training, and Responsibilities

A clear designation of roles and responsibilities is essential to conduct any safe bunkering. Bunkering biofuels included. However, roles and responsibilities will differ depending on the supply mode, circumstances, local rules/regulations and supplier procedures. This section will provide a general overview.

## 8.1 Bunkering roles overview

This overview will limit itself to Ship-to-Ship transfers, as these are the most likely to play a prominent role in bunkering biofuels and their blends.

### 8.1.1 POAC

For Ship-to-Ship (STS) transfers, generally, the STS Superintendent is the person in overall advisory control (POAC) of the operation. If no designated STS Superintendent is available, then a Master from one of the vessels can take the role of POAC.

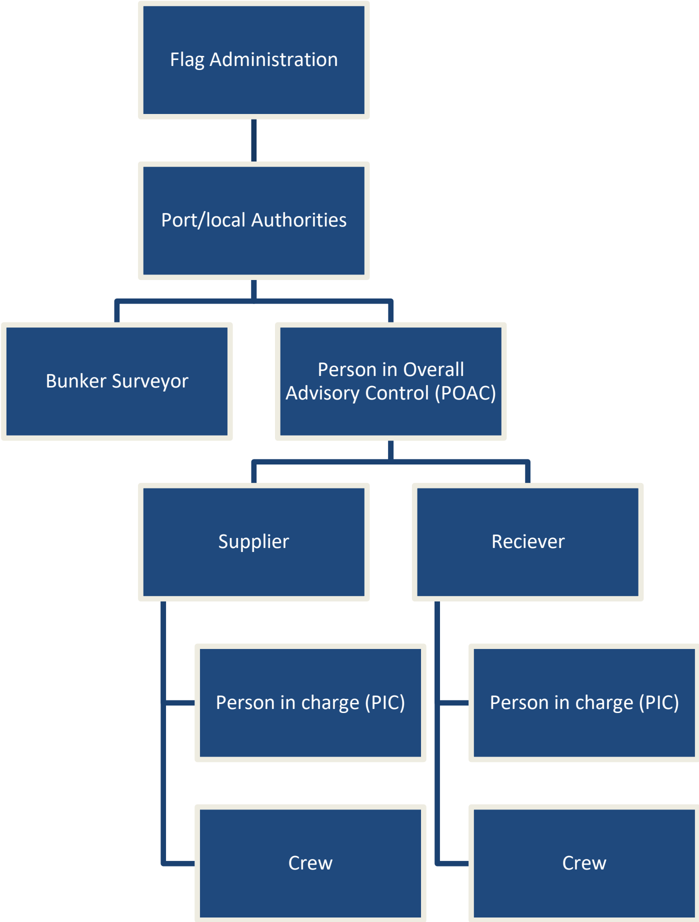

Figure 8-1 Overview of STS biofuel bunkering roles and stakeholders

The POAC provides advice and guidance to the master on the co-ordination and safe completion of the STS operation and has the following responsibilities (CDI, ICS, OCIMF, SIGTTO, 2013):

- Reviewing location-specific risk assessments and operating procedures
- Ensuring compliance with regulatory requirements and that all reports are made to the appropriate authorities
- Confirming that all parties involved are competent, adequately briefed, and aware of their roles
- Overseeing the correct placement of fenders, sighting mooring equipment, and supervising vessel approaches and manoeuvring
- Confirming the safe connection of transfer hoses/arms and emergency systems, monitoring cargo transfer rates, and ensuring the integrity of the mooring arrangement
- Activating contingency plans in emergencies and supervising the unmooring and separation of vessels
- Advise on when to suspend or terminate STS operations

### 8.1.2 Supplier

For the supplier of the bunkering fuel the following roles and responsibilities are typical, as stated in ISO 13739:2020[17]:

- Complete a pre-delivery safety checklist
- Prepare relevant documentation, such as:
    - Bunker requisition form

[17] Petroleum products — Procedures for the transfer of bunkers to vessels

- Non-cargo tank inspection form
    - Cargo tank measurement/calculation form
    - Bunker delivery note
- Take bunker samples
- Provide said documentation to receiver

### 8.1.3 Receiver

For the chief engineer on the receiving vessel the following roles and responsibilities are typical, as stated in ISO 13739:2020[18]:

- Prepare vessel for bunkering
- Complete relevant checklists detailing precautions and actions to be taken by receiver
- Inspect and verify received documentation
- Witness the opening and closing of tank gauges or flow meter readings and confirm the cargo tanks measurement/calculation form

### 8.1.4 Person in Charge (PIC)

A dedicated PIC for the supplier and receiver side should be clear to both parties before commencing bunkering. They have ultimate responsibility for the successful completion of the bunkering operation. The PICs should have the competences required to be able to organise and coordinate a bunkering operation between themselves and handle potential emergencies, such as leaks, fires and spills. Generally, the master/representative/chief engineer of the supplier/receiver will act as the person in charge during the operation. They have overall responsibility.

### 8.1.5 Crew

Crew roles are dependent on the type of vessel and fuel bunkered. Some general roles are outlined below:

Chief engineer - should coordinate bunkering parameters (filling rate, pressure, sampling procedure etc.) and direct potential emergency contingencies

Chief officer - can fill the role of PIC and may be assisted by deck officers

Bunkering crew - Consisting primarily of engineering officers and ratings. They man the bunkering station and engineering control room (ECR)

An overview of some general role expectations can be found in Table 8-1 below:

Table 8-1 Crew roles during bunkering

| Role | Crewmember |
|---|---|
| Person in Charge | Overall vessel responsibility |
| OOW | Monitor ballast operations |
| 1st Engineer | Assist as necessary |
| ETO | Attends to lights at all points being worked |
| Bosun | Plug scuppers and save-alls |
| Motorman | Attends to valves/sampling points as ordered by PIC<br>Attends to tank soundings and reports to PIC<br>Attends to moorings, hoist signals and standby moorings<br>Keeps watch at bunker tank vents |
| Fitter | Connect/disconnect flanges and general assistance |

[18] Petroleum products — Procedures for the transfer of bunkers to vessels

| Role | Crewmember |
|---|---|
| | Connect/disconnect oil discharge containment<br>Prepare oil pollution equipment<br>Attends to moorings, hoist signals and standby moorings |

These roles are for standard operations. Emergencies would entail additional or different roles for crew during bunkering.

### 8.1.6 Emergency roles

Roles may differ during an emergency as this will require additional personnel to attend the emergency. The following emergency duties are examples pulled from the STS guide (CDI, ICS, OCIMF, SIGTTO, 2013).

Table 8-2 Example emergency roles during as STS transfer as per the STS guide

| Post | Location | Duties |
|---|---|---|
| Master | Bridge | Overall vessel responsibility |
| POAC | Bridge | Provide advice to Masters of both vessels |
| Chief Officer | Cargo Control Room | Stops cargo operations as appropriate and responsible for hose disconnection |
| 2nd Officer | Manifold Area | Prepares bridge for disconnection |
| 3rd Officer | Bridge | In charge of hose connection |
| Chief Engineer | Engine Control Room | Prepares main engine for manoeuvres and auxiliary equipment |
| 2nd Engineer | Engine Control Room | Secures cargo plant |
| 3rd Engineer | Engine Control Room | Under Chief Engineer or 2nd Engineer's orders |
| Electrical Officer | As required | Under Chief Engineer or 2nd Engineer's orders |
| Pumpman | As directed by Chief Officer | Under direction of Chief Officer, provides assistance |
| Bosun and Deck Ratings | Bridge/Main Deck as required | Under Officer of the Watch (Deck) and Chief Officer orders |
| Engine Room Ratings | Engine Room | Under Officer of the Watch (Engine) orders |

## 8.2 Competence & training requirements

In general, personnel should conform to the applicable training requirements as outlined in the Seafarers Training Certification and Watchkeeping (STCW) code. Additionally, they should be familiarised with the appropriate equipment, PPEs, procedures, contingencies and documentation.

At present, the qualifications and training standards required for seafarers to operate safely aboard vessels are based on the STCW Code's competence tables. These tables are integral to the STCW Code and establish essential minimum criteria and specific training mandates for various types of ships. For instance, section A-V/3 of the STCW Code details the *"Mandatory minimum requirements for the training and qualification of masters, officers, ratings, and other personnel on ships governed by the IGF Code."* The competence tables in this section are fundamental to the competency requirements for ships operating under the IGF Code. Nevertheless, the current training and competency standards outlined in the STCW Convention and Code do not fully address the specifics associated with biofuel usage.

Training requirements will depend heavily on crew experience and competence levels. If bunkering experience with a particular biofuel is lacking, then additional training may be required to raise the crew to the required level. Pre-bunkering risk assessments will highlight any high-risk areas that may require additional training.

The STS transfer guide (CDI, ICS, OCIMF, SIGTTO, 2013) provides some relevant areas for potential training:

- Transfer procedures
- Roles and responsibilities
- Watchkeeping
- Machinery/equipment operation
- Mooring
- Connection of hoses/arms
- Connection supports
- Contingencies

Crew should also be familiar with the vessel itself and its equipment/machinery. The following sections will attempt to outline these for each biofuel drawing from existing research and the HAZID conducted in Task 2.

### 8.2.1 General

The STCW provides a competence foundation when dealing with the bunkering of fuels. Section A-V/3 of the STCW pertains the *mandatory minimum requirements for the training and qualification of masters, officers, ratings and other personnel on ships subject to the IGF Code*. While the biofuels within the scope of this study lack their own fuel specific competence tables the IGF code provides a feasible basis, especially for bio-methanol and potentially DME. The IGF code is split between basic and advanced levels depending on the crewmember's role. The relevant competence requirements specific to bunkering are outlined below:

*Basic*

- *Contribute to the safe operation of a ship subject to the IGF Code*
    - *Basic knowledge of fuels and fuel storage systems' operations on board ships subject to the IGF Code: basic bunkering operations and bunkering systems*

*Advanced*

- *Familiarity with physical and chemical properties of fuels aboard ships subject to the IGF Code*
    - *Basic knowledge and understanding of simple chemistry and physics and the relevant definitions related to safe bunkering and use of fuels used on board ships subject to the IGF Code*
- *Plan and monitor safe bunkering, stowage and securing of the fuel on board ships subject to the IGF Code*
    - *Ability to use all data available on board related to bunkering, storage and securing of fuels addressed by the IGF Code*
    - *Ability to establish clear and concise communications and between the ship and the terminal, truck or the bunker- supply ship*
    - *Knowledge of safety and emergency procedures for operation of machinery, fuel- and control systems for ships subject to the IGF Code*
    - *Proficiency in the operation of bunkering systems on board ships subject to the IGF Code including:*
        - *bunkering procedures*
        - *emergency procedures*
        - *ship-shore/ship-ship interface*
        - *prevention of rollover*
    - *Proficiency to perform fuel-system measurements and calculations, including:*
        - *maximum fill quantity*
        - *On Board Quantity (OBQ)*
        - *Minimum Remain On Board (ROB)*
        - *fuel consumption calculations*
    - *Ability to ensure the safe management of bunkering and other IGF Code fuel related operations concurrent with other onboard operations, both in port and at sea"*

The following sections will go more into detail on the specific biofuels.

### 8.2.2 Biofuels

This section aims to give an overview of recommended general competence/training requirements for each biofuel.

#### 8.2.2.1 Bio-methanol

Seafarers on vessels running on bio-methanol will have to fulfil standard competence requirements of the STCW code, along with the IGF code competence table as per the interim guidelines for methyl/ethyl alcohol fuels (IMO, 2020). This indicates that these seafarers must follow the competence requirements for the IGF code but take into account the differences in fuels and their specific properties.

For methanol this entails that crew are properly trained and are competent in methanol bunkering and methanol related contingencies. Including competence/training requirements covering operational procedures, roles/responsibilities, leakage, spillage and firefighting (ABS, 2024).

The European Committee for Standardization Workshop Agreement (CWA) 17540 - *Specification for bunkering of methanol fuelled vessels* outlines the specialised training requirements for personnel involved in bunkering operations. It mandates additional training regarding methanol specific competences, equipment familiarisation, and emergency procedures, with a focus on handling dangerous situations (CEN, 2020). Port terminal or mobile facility personnel must comply with local regulations and industry standards. Parties are required to keep updated records of all training, including personnel names and training dates, and ensure refresher training is conducted every five years to maintain safety and adherence to regulations.

#### 8.2.2.2 DME

Currently, no specific guidance on competence or training requirements is available for DME. The competence and training requirements for LPG can serve as a starting point for discerning those for DME.

Along with the standard STCW code requirements, the SIGTTO - *LPG Shipping Suggested Competency Standards* provides a good starting point for DME when taking into consideration the differences between LPG and DME. This guidance highlights the competences for the different functions on board. The following is a non-exhaustive list (SIGTTO, 2022).

- Competence in the procedures and features specific to the loading and unloading of cargo, along with the typical cargo handling cycles. Clarify the duties of each team member involved in these processes
  - Knowledge and understanding of loading procedures
  - Knowledge regarding procedures and requirements for multiple grade loading
  - Knowledge of de-ballasting procedures
  - Knowledge and understanding of line draining
- Competence in the interfaces and apparatus for transfers between ship and shore or between ships. Investigate any operational challenges that may be encountered due to these systems
  - Knowledge and understanding of safety procedures and checklists
  - Knowledge and understanding of manifold connections
  - Knowledge and understanding STS hose connections and equipment
  - Knowledge and understanding of STS specific ESD systems
  - Knowledge and understanding procedures for maintenance of STS equipment
- Competence in the procedures and criteria for conducting risk assessments pertaining to ship and cargo operations, ensuring clarity of responsibilities for all parties involved
- Competence in the activities, accountabilities and responsibilities for relevant for cargo cycle operations
- Competence in handling non-standard, emergency conditions, for example:
  - Leakage/ accidental release
  - Inerting failure
  - Overfilling of tank
  - Automation failure
  - Under/over pressure

DME differs from LPG and the differences between them should be taken into account.

#### 8.2.2.3 FT-diesel, HVO and FAME

From Task 2 - Risk Assessment, the need for crew to have received the relevant STCW training for FT-diesel, HVO and FAME was reiterated. Mainly due to the similarity between these biofuels and their conventional fossil counterparts.

It's essential for crew to understand the potential long-term impact of these biodiesels on machinery and their unique storage needs. For instance, the crew must pay careful attention to how different biofuels are stored, as they may degrade over time, potentially impacting operation. Additionally, it`s crucial for the crew to have an understanding in the compatibility of materials between onboard equipment and the various biodiesels.

In essence, regarding the bunkering operation itself, crew competence in the material compatibility and storage of the various biodiesels is needed, but out of scope for this study.

## 8.3 Stakeholders

Various stakeholders have important roles during bunkering operations.

### 8.3.1 Bunker surveyor

The bunker surveyor is an independent third-party that verifies the bunkers received under valid bunker surveyor license. This is especially important with biofuels to avoid misrepresentation when it comes to biofuel blends. Their role and responsibilities are generally as follows:

- Verify and ensure that the bunkered fuel matches the ordered specification
- Document and report measured fuel specifications and particulars
- Help facilitate the safe and efficient bunkering operation and procedures between the various parties

The bunker surveyor thereby plays an important role in verifying the bunker fuel.

### 8.3.2 Fuel supplier

Fuel suppliers provide the bunker fuel, they must ensure their fuel meets the specifications required and is supported by the correct documentation.

This generally entails that the fuel must meet fuel standards. For example, HVO and FAME fuels would fall under ISO 8217:2024. Where Table 3 covers bio-residual marine fuel and Table 1 distillate & bio-distillate fuels. This standard also sets out testing and sampling methods. Fuel suppliers must adhere to these and provide proper documentation, such as providing a proper BDN and CoQ. This is especially important when dealing with blends, as the actual blend ratio bunkered as fuel should be transparent to all parties.

### 8.3.3 Ports

Ports also have an important role to play during bunkering. With general roles/responsibilities that include the following (EMSA, 2017):

*Regulatory framework* – ports provide the rules and regulations required for bunkering parties to comply to and contributes to the safe bunkering of biofuel. These regulations should be aligned with all levels of governance.

*Facilitate reporting procedures* – ports should have clearly outlined communication lines for verifying, approving and supporting bunkering operations. Reporting procedures should be clear to all parties and a dedicated safety channel implemented.

*Bunkering restrictions* – ports should put in place transparent restrictions on bunkering operations, these should be incorporated into risk assessments and be based on real-time events such as weather, traffic and technical availability. Restrictions should not unduly inhibit bunkering operations.

*Zones* – ports may need to ensure the establishment of appropriate zones depending on the bunkered biofuel, these will need approval and enforcement:

- *Safety zone:* bunkering facilities should have appropriate safety zones depending on the fuel being bunkered. Ports should ensure that these are properly implemented. Consideration should be given to keeping potential safety zones flexible with the risk inherent to the bunker fuels.
- *Security zone:* bunkering may require a security zone, to be approved and enforced by the port administration. The security zone would control and monitor external activities in the are surrounding the bunkering operation.
- *Hazardous zone:* the direct area surrounding the bunkering operation may be subject to a hazardous zone depending on the biofuel. Port administrations should ensure that work within the hazardous zone follows safety standards.
- *Control zone:* additional zones may have to be implemented and defined by the port administration relating to bunkering operations and depending on local circumstances.

*Passing distances* – Bunkering facilities should have appropriate, navigational, passing distances depending on the fuel being bunkered and the supply mode used. Ports should define and enforce these.

*Mooring requirements* – Port administrations may implement mooring requirements for vessels bunkering biofuels and under which circumstances mooring may need to be expanded.

*Environmental protection requirements* – Ports administrations should consider the environmental requirements necessary for bunkering the various biofuels and can consider disallowing venting of vapours/gasses.

*Bunkering checklists* – Ports should consider introducing biofuel specific bunkering checklists tailored to the local conditions of the port. These should be verified and validated by the port.

*Spatial planning* – Ports should consider the spatial planning of the port and bunkering locations. These should consider accessibility, emergency response, zones and proximity to civilian areas.

*SIMOPS* – Simultaneous operation (SIMOPS) introduce additional safety considerations for a port. Ports should introduce fuel specific measures to facilitate safe SIMOPS. Ports should work with other stakeholders to ensure the smooth commencement of SIMOPS.

*Traffic restrictions* – Ports should maintain control over the flow of traffic within ports and especially around bunkering locations. Active traffic control can be considered.

*Emergency response* – Ports, in collaboration with other stakeholders should determine appropriate emergency response measures. Ports should align with bunkering facilities to ensure that emergency procedures are compatible.

*Enforcement* – Ports should have sufficient capacity to enforce requirements and verify bunkering parties.

*Qualification/ accreditation of relevant parties (i.e. bunker facility operator, bunker surveyor etc.)* – The qualification and accreditation of relevant parties involved in the biofuel bunkering process should fall under a framework set by the port administration. The following aspects may be considered:

- Certification of bunkering equipment
- Qualification of bunker personnel
- Verification of safety management systems

Ports play a crucial role in ensuring safe and efficient biofuel bunkering and contribute to the overall safety of bunkering operations.

## 8.4 Responsibilities

Accountability is crucial throughout the entire bunkering operation. It is important to establish a clear line of responsibility and ensure comprehensive reporting. Each party involved must maintain a specific level of accountability to ensure smooth and compliant operations.

*The Flag Administration* holds a high level of responsibility for the accountability of (biofuel) bunkering. However, this responsibility is often delegated to local parties to ensure effective oversight and enforcement at the operational level.

*Port and local authorities* are tasked with the enforcement of bunkering regulations. They ensure that all bunkering activities within their jurisdiction comply with established laws and standards, thereby maintaining safety and environmental protection.

*The bunker surveyor* acts as an independent third-party responsible for ensuring compliance with bunker standards and delivery procedures. Their primary accountability lies in conducting the Bunker Quantity Survey (BQS), which verifies the quantity and quality of the fuel delivered. The bunker surveyor ultimately submits a detailed BQS report, which serves as an official record of the bunkering operation. Any fuel sampling & analysis documentation may run through the bunker surveyor.

*The POAC* does not directly manage the bunkering operation but provides crucial advisory support. Their role is to offer guidance and ensure that the operation adheres to best practices and regulatory requirements.

*The PIC on the receiver's side* is ultimately accountable for the bunkering operation from their perspective. They oversee the entire process to ensure it is conducted safely and efficiently. Both the PIC from the receiver's side and the supplier's side sign the Bunker Delivery Note (BDN), which is a critical document outlining the details of the fuel delivery as specified in MARPOL Annex VI, Appendix V.

*The PIC on the supplier's side* is responsible for the bunkering operation from their end. They ensure that the fuel supplied meets the required standards and specifications. For instance, the Port of Singapore mandates that suppliers provide a Certificate of Quality (COQ) detailing the biofuel's characteristics to ensure transparency and compliance.

Table 8-3 Bunkering documentation overview

| Documentation | Description | Parties |
|---|---|---|
| Bunker Delivery Note (BDN) | Records details of the fuel delivery, including quantity, quality, date, and signatures. Must comply with MARPOL Annex VI, Appendix V. | ▪ PIC - Supplier<br>▪ PIC - Receiver |
| Bunker Quantity Survey (BQS) | Verifies the quantity of fuel delivered through measurements and calculations. Ensures transparency and accuracy. SS 600:2022 outlines a methodology for this survey. | Bunker Surveyor |
| Certificate of Quality (COQ) | Details the quality specifications of the fuel, including density, viscosity, and sulphur content. For biofuels, this should follow ISO 8217:2024. | Fuel Supplier |
| Bunkering Safety Checklist | Safety checks and procedures to ensure a safe and compliant operation. Reviewed and signed before bunkering begins. | ▪ PIC - Supplier<br>▪ PIC - Receiver |
| Fuel Sampling and Analysis Records | Records of fuel samples taken during bunkering for quality verification and dispute resolution. | ▪ PIC - Supplier<br>▪ PIC - Receiver |
| Bunkering Log | Detailed log of the bunkering operation, including start and end times, interruptions, and actions taken. | ▪ PIC - Supplier<br>▪ PIC - Receiver |
| Incident Reports | Documents any incidents or accidents during bunkering, including mitigation actions and lessons learned. | ▪ PIC - Supplier<br>▪ PIC - Receiver<br>▪ POAC |

# 9. Emergency Preparedness & Response

## 9.1 Introduction

Bunkering of biofuels presents, in some cases, unique risks and challenges compared to conventional fuels, but biofuel bunkering emergency preparedness and response does not. At its core, it is managed the same as all ship operation risk management and is exercised in the same manner as other ISM responsibilities and included in a ship's SMS through its SOPEP, SMPEP or VRP as appropriate. Safety barriers for FT-diesel, HVO and FAME are similar to conventional fuels, safety barriers for DME are similar to LNG/LPG, and safety barriers for bio-methanol are similar to methanol. The following chapter aims to provide an overview of barriers identified for preventing or controlling the causes potentially leading to an emergency or limiting the consequences following the occurrence of an emergency.

## 9.2 Emergency Systems & Barrier Management

To describe the various safety barriers involved with bunkering of biofuels we apply a bowtie model adopted from DNV-RP-G105 as seen in Figure 9-1. Note that in Figure 9-1 the top event is set to "Release of biofuel" as an example, however other top events such as "collision during bunkering" or "mooring failure during bunkering" are also relevant top events.

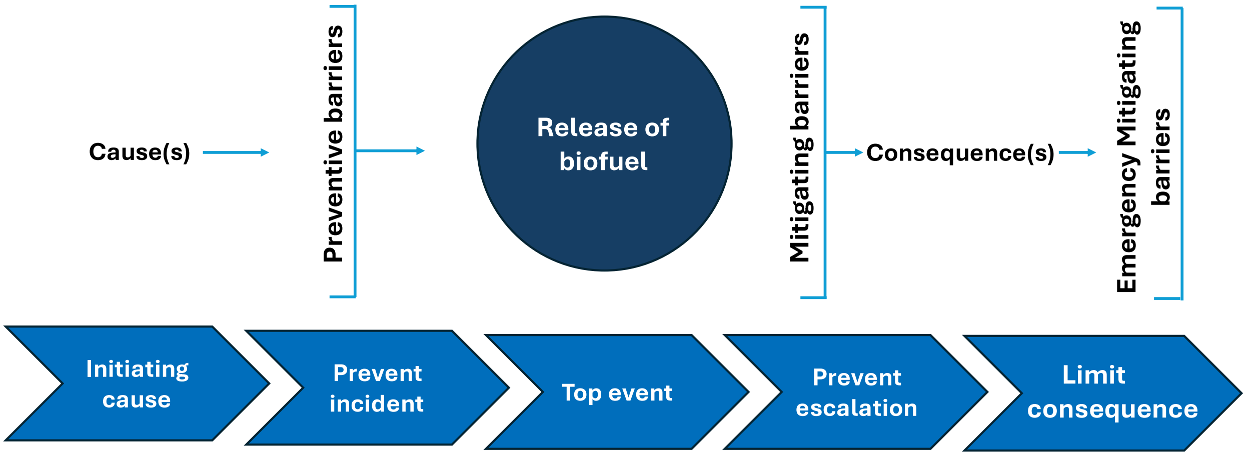


Figure 9-1 Bowtie model adapted from DNV-RP-G105.

The philosophy of the bow-tie model is to establish a connection between the risks associated with a hazard and the effectiveness of the barriers in place to prevent, contain, and/or mitigate the resulting events. Barriers can be classified into three categories:

- **Passive** barriers are barriers which are always in place and do not require any actions to respond to a hazardous event. Examples include drip trays and double-walled piping.
- **Active** barriers are barriers which require either a manual or automatic activation to respond to a hazardous event. Examples include emergency shutdowns, control and monitoring systems, and automatic fire suppression systems.
- **Procedural / operational** barriers are active barriers which are dependent on personnel correctly following procedures or correctly responding to a predefined situation.

Passive barriers are generally preferred compared to active barriers which again are generally preferred to procedural/operational barriers.

The barriers identified in the bow-tie model can be divided into types of barriers of defence, each corresponding to a different stage in the sequence of events. The three barrier types are adopted from DNV-RP-G105 and defined below.

- Preventive barriers aimed at preventing the top event from occurring (such as accidental release of biofuels).
- Mitigative barriers aimed at controlling the hazardous situations in the event that a release occurs and thereby preventing/minimising the harmful effects.
- Emergency mitigating barriers aimed at minimising the consequences and harmful effects in situations that are not contained by the second layer of defence. This layer encompasses fire protection and suppression systems.

A non-exhaustive list of barriers compiled from Task 2, as well as other sources, such as *Guidance of LNG Bunkering, ISO 20519:2022* can be seen below in Table 9-1 Preventive barriers, Table 9-2 Mitigating barriers and Table 9-3 Emergency mitigating barriers.

Table 9-1 Preventive barriers

| Barrier | Type of barrier | | | Biofuel applicability | | |
|---|---|---|---|---|---|---|
| | Passive | Active | Procedural / Operational | Bio-methanol | DME | FT-diesel, HVO & FAME |
| Bunker hose testing and certification | x | | | x | x | x |
| Loading arm (Hose support / saddles) | x | | | x | x | |
| Quick Connect-Disconnect Couplings | x | | | x | x | x |
| Bunkering connections | x | | | x | x | |
| Vapour return | x | | | | | |
| Compatibility assessment | | | x | x | x | x |
| Communications between supplier and receiver during bunkering | | | x | x | x | x |
| Bunkering procedures incl. tightness testing and weather limitations | | | x | x | x | x |
| Dedicated bunkering crew with relevant training | | | x | x | x | x |
| Maintenance and inspection | | | x | x | x | x |
| Automatic closing of ship bunker valve at H-H level | | | x | | x | x |
| Ship side instrumentation (sensors and alarms) | | x | | x | x | x |
| Ship mooring arrangement and fenders | x | | x | x | x | x |
| Fuel tank inerted and gassed up prior to bunkering | | | x | | x | |
| Mooring | x | | | x | x | x |

Table 9-2 Mitigating barriers

| Barrier | Type of barrier | | | Biofuel applicability | | |
|---|---|---|---|---|---|---|
| | Passive | Active | Procedural / Operational | Bio-methanol | DME | FT-diesel, HVO & FAME |
| Emergency release system (automatic or manually) | | x | x | x | x | x |
| Ship-shore/ship ESD link | | x | | x | x | x |
| CCTV for thermal or visual leak detection | | | x | x | x | x |
| Gas detection sensors and alarms | | x | | x | x | x |
| Structural thermal protection | x | | | | x | |
| Water spray (for thermal protection) | | x | | | x | |
| Containment (Drip trays and double-walled pipework) | x | | | x | x | x |
| Physical layout / separation | x | | | x | x | x |
| Safety / security zones | | | x | x | x | x |
| Hazardous zones and EX equipment at outlets | x | | | x | x | x |
| Pressure relief valves, liquid relief valves and burst discs | x | | | x | x | x |

| Barrier | Type of barrier | | | Biofuel applicability | | |
|---|---|---|---|---|---|---|
| | Passive | Active | Procedural / Operational | Bio-methanol | DME | FT-diesel, HVO & FAME |
| Opening of vent valves (either manual or automated) | | x | x | x | x | x |
| Personal Protective Equipment | | | x | x | x | x |
| Ship fenders | x | | | x | x | x |

Table 9-3 Emergency mitigating barriers

| Barrier | Type of barrier | | | Biofuel applicability | | |
|---|---|---|---|---|---|---|
| | Passive | Active | Procedural /Operational | Bio-methanol | DME | FT-diesel, HVO & FAME |
| Fire barriers | x | | | x | x | x |
| Fire hose, monitors and extinguishers | | | x | x | x | x |
| Water curtains / spray | | x | | x | x | x |
| Evacuation and emergency response plan | | | x | x | x | x |
| Personal Protective Equipment | | | x | x | x | x |

## 9.3 Emergency response plans

The potentially severe consequences in the event of an accident occurring during bunkering necessitates that vessel operators develop emergency response plans. These ship-specific contingency plans should address a wide range of potential scenarios and be incorporated into the vessel's safety management system (SMS). Emergency procedures should address incidents such as spills, vapour releases, fires and evacuation. All crew members must be informed of these procedures, provided with the necessary materials, and trained in their specific roles and responsibilities prior to bunkering operations.

During the risk assessment (Task 2), no additional risks were attributed to the bio-component of the biofuels used as blend-in and drop-in fuels (i.e., HVO, FT-diesel and FAME when compared with conventional fuels. As such, it is considered acceptable that for these biofuels bunkering operations can be carried out using established best practices and procedures for conventional fuels such as HFO and MGO. Likewise, bio-methanol and DME are considered to be comparable to methanol and LPG and must adhere to the IGF Code and interim guidelines (MSC/Circ. 1621), just as for ships using LPG, and methanol. Adherence to MSC/Circ. 1621 requires a separate ship-specific risk assessment for the fuel supply system, thus covering potential hazards and resulting emergencies that may occur onboard during the bunkering operation

While a challenge shared with conventional fuels, it should be noted that water (fresh and salt), is not considered to be an effective fire extinguisher for any of the biofuels. HVO, FT-diesel and FAME are lighter than water and will float and continue burning. DME, in addition to being lighter than water, water would also increase the evaporation rate of the DME, creating gases potentially exacerbating the fire. Bio-methanol, like methanol, will continue to burn until the water content is up to 90%, which puts large requirements on management of water run-off. Alternative extinguishing mediums to be considered include oxygen deprivation expunging agents such as, dry chemical powder, CO2 or firefighting foams such as alcohol-resistant AFFF.

Firefighters should use full-face, self-contained breathing apparatus, and wear impervious and chemical-resistant clothing, gloves and boots. Adequate training in the use of this equipment is crucial for the safety of responders.

Crews must undergo training, drills, and exercises to ensure readiness for emergencies. Insights from previous operations should be used to refine the emergency procedures. These procedures should comprehensively address all scenarios specific to the ship, the nature of the incident, the equipment, and the related areas.

## 9.4 Pollution prevention & control

The risk of pollution from biofuel bunkering operations is assessed to be no greater than during comparable conventional fuel bunkering when similar preventive and mitigating measures have been taken. Efforts should focus on containing the spill and mitigating its impact. The measures used to contain conventional oil spills, such as containment booms and skimmers are considered appropriate for HVO, FT-diesel and FAME. DME and bio-methanol released to sea would mix with water and containment by oil boom and skimmers would not be possible. For these biofuel types, absorbent materials should be utilised or other specialised methods to restrict the movement of the leak from entering the sea.

Once the leak is under control, thorough cleanup and remediation efforts are essential. This includes the safe removal and disposal of contaminated materials and conducting post-incident assessments to identify lessons learned for future prevention.

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# Appendix A Description of Bunkering Checklists

The bunkering checklists, with IAPH[19] & SGMF used as main source of references, cover the different phases of bunkering operations as below. The provided checklists, covering essential aspects of bunkering, serve as a general guideline and should be adapted & customized to suit specific ship types and organizational procedures to ensure safe and efficient bunkering operations. For the sake of for simplicity, it is referred to as a checklist.

- Phase 1 - PRE-BUNKERING PHASE (Part A checklists)
  - This phase covers different activities towards the pre-bunkering phase and consists of two (2) x parts within this phase - Part A1 & Part A2.
  - Part A1 focuses on pre-operational considerations including compatibility topics that are considered key inputs towards Part A2.
  - Part A2 focuses on alignment & agreement of Part A1 items that may be recorded and signed off.
- Phase 2 - CONNECTION PHASE (Part B checklists)
  - This phase covers different activities towards the connection & testing prior transfer of fuels and consists of four (4) parts – Part B1 to Part B4.
  - Part B1 focuses on aspects related to site and equipment readiness that needs to be evaluated/considered.
  - Part B2 focuses on safety systems that needs to be specially considered.
  - Part B3 focuses on system preparation to facilitate efficient and safe bunkering operation.
  - Part B4 focuses on Agreement Points that are recommended to be recorded & signed off in a safety meeting. This could also be combined with Part A2.
- Phase 3 - TRANSFER PHASE (Part C checklists)
  - This phase covers different activities that cover repetitive checks during transfer towards the connection & testing prior transfer of fuels and consists of three (3) parts – Part C1 to Part C3.
  - Part C1 focuses on vessel approach & positioning considerations to ensure that there are no changes to be arrangement/configuration of the vessels/terminal.
  - Part C2 focuses on safety & operational procedures that needs to be monitored to ensure no deviations during bunkering.
  - Part C3 covers watchkeeping & monitoring during the bunkering process.
  - Part C covers environmental and operational considerations.
- Phase 4 - DISCONNECTION PHASE (Part D checklists)
  - This phase covers different activities that cover post transfer operations both in terms of prior to disconnection as well as post disconnection. It also focuses on considerations to ensure safety and environmental protection.
  - Part D mainly has two (2) parts; D1 covering prior to disconnection & D2 covering post disconnection.

Further to the above, there is also included a checklist that covers key considerations towards simultaneous operations (SIMOPS) which is covered as SIMOPS (Part E).

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[19] Bunker checklists – World Port Sustainability Program (sustainableworldports.org)

The checklists cover different supply modes of bunkering (presented in section 3 Bunkering supply modes, facilities and equipment) for each of the biofuels/biofuel groups considered. There is a total of three (3) x checklists (Part A to Part E) corresponding to each biofuel group, covering different supply modes, included in the appendixes (Appendix A, Appendix B, Appendix C and Appendix D). It is to be noted that the checklists are intended as key information to be considered towards bunkering of biofuels and for bunkering operations, these will need to be adapted to each bunkering operation being performed to account for variables within different parameters discussed.

# Explanation

Table 10-1 Overview of checklists structure for Safe bunkering of biofuel discussed in this guideline

| | | |
|---|---|---|
| **Ph.1** | **PRE-BUNKERING PHASE (Part A)** | There are 2 x parts within this phase - Part A1 & Part A2. |
| **A1** | **Pre-operational considerations** | **Part A1** focuses on pre-operational considerations, including compatibility assessments |
| **A2** | **Alignment - To be Recorded & signed off** | **Part A2** involves aligning and finalizing these considerations |
| **Ph.2** | **CONNECTION PHASE (Part B)** | Subdivided into four (4) parts B1 to B4 that covers comprehensive inspection/ checkpoints of equipment and systems. |
| **B1** | **Site and Equipment Readiness** | **Part B1** focuses on Site and Equipment Readiness aimed at ensuring all equipment and infrastructure are ready for bunkering operations. |
| **B2** | **Safety Systems** | **Part B2** focuses on Safety Systems that calls for verifying the functionality of safety systems, including fire detection and suppression systems. |
| **B3** | **System Preparation** | **Part B3** focuses on System Preparation in terms of preparing the bunkering system, including purging and depressurizing pipelines |
| **B4** | **Agreement Points** | **Part B4** focuses on Agreement Points that aims to finalise the key aspects of the bunkering operation, such as safety procedures and emergency response plans which is also linked to Part A2. |
| **Ph.3** | **TRANSFER PHASE (Part C)** | Subdivided into three (3) parts C1 to C3 covers a series of checks and monitoring activities focussing on environmental and operational considerations. |
| **C1** | **Vessel approach & positioning** | **Part C1** focuses on vessel approach and positioning considerations. |
| **C2** | **Safety Procedures** | **Part C2** covers adherence to safety procedures to prevent accidents and environmental incidents. |
| **C3** | **Watchkeeping** | **Part C3** is focussed on vigilant watchkeeping to respond to any emergencies or deviations. |
| **Ph.4** | **DISCONNECTION PHASE (Part D)** | Subdivided into two (2) parts D1 & D2 that covers considerations to ensure safety and environmental protection in disconnection and post disconnection phases |
| **D1** | **Prior to disconnect** | **Part D 1** covers items to consider before disconnection. |
| **D2** | **Post disconnection** | **Part D 2** covers items to consider post disconnection. |
| **Ph.5** | **SIMOPS (Part E)** | Subdivided into four (4) parts E1 to E4 that covers considerations to be made when carrying out SIMOPS |
| **E1** | **Operational restrictions** | **Part E1** covers the various operational restrictions to be adhered to. |
| **E2** | **SIMOPS Planning** | **Part E2** covers planning/compliance aspects related to SIMOPS. |
| **E3** | **Safety considerations** | **Part E3** includes safety considerations to be made when carrying out SIMOPS. |
| **E4** | **Continuous monitoring** | **Part E4** includes items that require continuous monitoring. |

# Appendix B Checklists for bunkering of bio-methanol

## Pre-bunkering Phase (Part A)

Table 10-2 Checklist for Pre-bunkering phase for bunkering of bio-methanol.

| 1 | PRE-BUNKERING PHASE (Part A) BIO-METHANOL | Appl. | Status | Remarks | TTS | PTS | STS |
|---|---|---|---|---|---|---|---|
| A1 | **Pre-operational considerations** | | | | | | |
| **1.1** | **Compliance considerations** | BV/RV | | | | | |
| 1.1.1 | International (IMO/ISO) | | | | X | X | X |
| 1.1.2 | Regional (EU) | | | | X | X | X |
| 1.1.3 | Port State/Flag State Requirements | | | | X | X | X |
| 1.1.4 | State (US) | | | | X | X | X |
| 1.1.5 | Port specific requirements | | | | | X | |
| 1.1.6 | Terminal | | | | X | X | |
| **1.2** | **Bunkers** | | | | | | |
| 1.2.1 | Bunker Purchase Contract | RV | | | X | X | X |
| 1.2.2 | Bunker Delivery Note (BDN) | | | | X | X | X |
| 1.2.3 | Proof of Sustainability | | | | X | X | X |
| 1.2.4 | Certificate of Quality (Bunker Spec) | | | | X | X | X |
| 1.2.5 | Verify mass/volume and density | | | | X | X | X |
| **1.3** | **Plan to include discussion on method of bunker delivery:** | RV | | | | | |
| 1.3.1 | Terminal | | | | | X | |
| 1.3.2 | Bunker Vessel | | | | | | X |
| 1.3.3 | STS bunkering | | | | | | X |
| 1.3.4 | Trucks | | | | X | | |
| 1.3.5 | Notification of bunker operation is given to relevant authorities | BV/RV | | | X | X | X |
| **1.4** | **Discuss & document, where relevant, with Responsible Officer on RV:** | BV/RV | | | | | |
| 1.4.1 | Compatibility documents enabling checks on zones (Refer 6.2 of the guidance document) – hazardous, safety & security, mooring, fendering & other compatibility aspects | | | | X | X | X |
| 1.4.2 | Draft, trim and list conditions | | | | X | X | X |
| 1.4.3 | Vessel info/Details/Arrival -BV/RV | | | | X | X | X |
| 1.4.4 | Calculated tank quantities (Converting contracted mass to volume) | | | | X | X | X |
| 1.4.5 | Ensure sufficient ullage space in the tanks for line blowing | RV | | | X | X | X |
| 1.4.6 | Operating limits (environmental) | | | More relevant for STS | X | X | X |
| 1.4.7 | Emergency preparedness/plans | | | | X | X | X |
| **1.5** | **Agreement points - Discuss & agree on:** | | | | | | |
| 1.5.1 | Means of communication | | | | X | X | X |
| 1.5.2 | Emergency procedures | | | | X | X | X |

| 1 | PRE-BUNKERING PHASE (Part A) BIO-METHANOL | Appl. | Status | Remarks | TTS | PTS | STS |
|---|---|---|---|---|---|---|---|
| 1.5.3 | Hose connection and disconnection procedures incl. Nitrogen purging | | | | X | X | X |
| 1.5.4 | Crew transfer procedures (BV) | | | | | | X |
| 1.5.5 | Use of ESD link | | | | X | X | X |
| 1.5.6 | Use of vapour return | | | | X | X | X |
| 1.5.7 | Access between vessels | | | | | | X |
| 1.5.8 | Mandatory permission points | | | | X | X | X |
| 1.5.9 | Agreement on bunkering schedule in terms of bunkering rates and max pressure (initial rate, max. transfer rate, topping-off rate). | | | | X | X | X |
| 1.5.10 | Fuel quality analysis/sampling requirements | | | | X | X | X |
| **1.6** | **Operational considerations for bunkering** | BV/RV | | | | | |
| 1.6.1 | Ensure valves & actuators are well maintained and in good working order | BV/RV | | | X | X | X |
| 1.6.2 | Ensure availability & sufficiency of suitable PPE | | | | X | X | X |
| 1.6.3 | Ensure all relevant equipment are approved for use | | | | X | X | X |
| 1.6.4 | Hoses, Saddles, drip trays, manifold connections | | | | X | X | X |
| 1.6.5 | Connection, tightness tests and purging | | | | X | X | X |
| **1.7** | **Approach of BV to RV** | | | | | | |
| 1.7.1 | Anchoring considerations to allow favourable approach & mooring for BV | | | | X | X | X |
| **1.8** | **Mooring/Fendering** | BV/RV | | | | | |
| 1.8.1 | Mooring analysis is carried out | | | | X | X | X |
| 1.8.2 | Mooring equipment is in good condition and ready for use | | | | X | X | X |
| 1.8.3 | Mooring and fendering arrangement is agreed | | | | X | X | X |
| 1.8.4 | Fendering and safety distances | | | | X | X | X |
| **1.9** | **Determine organizational plan during bunker (example below):** | BV/RV | | | | | |
| 1.9.1 | Duty officer (deck) | | | | X | X | X |
| 1.9.2 | Person in charge of bunkering | | | | X | X | X |
| 1.9.3 | Persons assisting with bunkering | | | | X | X | X |
| 1.9.4 | Fuel tank and bunker / lube oil manifold manning | | | | | | X |
| 1.9.5 | Ensure continuous supervision at the bunkering manifold | | | | X | X | X |
| **1.10** | **Adequacy of illumination** | BV/RV | | | | | |
| 1.10.1 | Evaluate the need for nighttime operations | BV/RV | | | | | X |
| 1.10.2 | Evaluate feasibility of start & completion of operation during daylight | | | | | | X |
| 1.10.2 | Ensure adequate lighting for nighttime operations | | | | X | X | X |
| **1.11** | **Other considerations** | | | | | | |
| 1.11.1 | Restricted area classifications are compatible Classification in terms of Hazardous, Safety & Security zones & ex-considerations (Refer 6.2 of the guidance document) | BV/RV | | | | | X |
| 1.11.2 | Ensure that means for prevention of static electric discharge is available and functional | BV/RV | | | X | X | X |
| 1.11.3 | Ensure fuel control, P/V valves/ESD system, Fire | BV/RV | | | X | X | X |

| 1 | PRE-BUNKERING PHASE (Part A) BIO-METHANOL | Appl. | Status | Remarks | TTS | PTS | STS |
|---|---|---|---|---|---|---|---|
| | fighting systems are functional and appropriate with regards to configuration of bunker stations – closed/semi closed. | | | | | | |
| 1.11.4 | Ensure unused bunker connections are blanked and fully secured | BV/RV | | | X | X | X |
| 1.11.5 | Considerations towards environmental protection in case of spills | BV/RV | | | X | X | X |
| 1.11.6 | Ensure that an International Shore connection is available (on RV) | BV/RV | | | X | X | X |
| 1.11.7 | Consider the need for closure of external doors, portholes & other devices to prevent gas ingress into non-hazardous spaces during bunkering | BV/RV | | | X | X | X |
| 1.11.8 | Ensure steering and propulsion can be readily deployed - i.e. Vessels can sail under its own power in a safe and non-obstructed direction | BV/RV | | | X | X | |
| **A2** | **Alignment – To be Recorded & signed off** | | | | | | |
| **2.1** | **Record agreed operational limits** | BV/RV | | | | | |
| 2.1.1 | Wind speed | | | | X | X | X |
| 2.1.2 | Wave heights | | | | X | X | X |
| 2.1.3 | Draft and tidal conditions | | | | X | X | X |
| 2.1.4 | Forecast for Thunderstorms | | | | X | X | X |
| 2.1.5 | Visibility & other criteria | | | | X | X | X |
| 2.1.6 | Record agreed bunker specifications: product/grade, density, volume (in m3) at loading temperature, loading temperature, transfer rates, and line pressures as agreed. | | | | X | X | X |
| **2.2** | **Safe access confirmation** | BV/RV | | | | | |
| 2.2.1 | Ensure safe access between the ships | | | | | | X |
| 2.2.2 | Ensure access between the ship and shore is safe and controlled | | | | X | X | |
| **2.3** | **Ensure adequateness of operation supervision and watchkeeping** | BV/RV | | | | | |
| 2.3.1 | Agreed upon Means of communications | | | | X | X | X |
| 2.3.2 | Ensure awareness of Emergency shutdown event, location of emergency stop buttons, ESD link functionality | | | | X | X | X |
| **2.4** | **Ensure operational/safety measures are agreed upon** | BV/RV | | | | | |
| 2.4.1 | Ensure that the different zones/boundaries are well understood (Refer 6.2 of the guidance document) | | | | X | X | X |
| 2.4.2 | Ensure use of ex proof Inside Haz Zone | | | | X | X | X |
| 2.4.3 | Material Safety data sheets (MSDS) are available | | | | X | X | X |
| 2.4.4 | Agreed safety measures within the safety area are in place including the use of proper PPE - EEBD, Portable gas detectors etc. | | | | X | X | X |
| 2.4.5 | Incident management planning is in place to treat | | | | X | X | X |

| 1 | PRE-BUNKERING PHASE (Part A) BIO-METHANOL | Appl. | Status | Remarks | TTS | PTS | STS |
|---|---|---|---|---|---|---|---|
| | injuries - for e.g. use of antidotes/Medical assistance | | | | | | |
| 2.4.6 | Sampling procedure and equipment is provided | | | | X | X | X |
| 2.4.7 | Vapour management procedures - both vapor return and /or vapor balancing are agreed upon & prepared | | | | X | X | X |
| 2.4.8 | Ensure that arrangements for preventing static electrical discharges are operational (hose and coupling) | | | | X | X | X |
| **2.5** | **Emergency preparedness** | BV/RV | | | | | |
| 2.5.1 | Emergency procedures and plans, including the emergency contact list, are known to the persons in charge | | | | X | X | X |
| 2.5.2 | Emergency shut down and release procedures agreed upon | | | | X | X | X |
| **2.6** | **SIMOPS** | | | | | | |
| 2.6.1 | Safety procedures and risk mitigation for SIMOPS are made aware of | BV/RV | | Part E | X | X | X |
| **NOTE** | *Although some of the items are not marked as relevant for truck to ship and port to ship, due considerations may be made to evaluate the need to include these items.* | | | | | | |

# Connection Phase (Part B)

Table 10-3 Checklist for the Connection Phase for bunkering of bio-methanol

| 2 | CONNECTION PHASE (Part B) FOR BIO-METHANOL | Appl. | Status | Remarks | TTS | PTS | STS |
|---|---|---|---|---|---|---|---|
| **B1** | **Site Equipment Readiness** | | | | | | |
| 1.1 | Master to monitor that weather limits specified in Part A2 are met | RV | | | X | X | X |
| 1.2 | Confirm adequate lighting at manifold | BV/RV | | | X | X | X |
| 1.3 | Confirm transfer equipment (piping, hose, hose supports, flanges, gaskets, etc.) in order including good condition, appropriateness, lining up, rigging etc. | RV | | | X | X | X |
| 1.4 | Confirm tightness testing of relevant bunker equipment:<br>- confirm all bolts are fixed and tightened at bunker manifold (for bolted hose connections)<br>- tightness test for QCDC | BV/RV | | | X | X | X |
| 1.5 | Confirm that the bunker tank's vents/PV valves are operational | RV | | | X | X | X |
| 1.6 | Confirm that tanks and piping have been inerted | RV | | | X | X | X |
| 1.7 | Confirm that bunker manifold drip tray valves are closed, and deck scuppers plugs are fitted | RV | | | X | X | X |
| 1.8 | Blank unused bunker manifolds and close unused bunker manifold valves | RV | | | X | X | X |
| 1.9 | Confirm that all drain valves, purge valves etc. are closed | RV | | | X | X | X |
| 1.10 | Confirm that any overflow tank, if installed, is empty | RV | | | X | X | X |
| 1.11 | Confirm that spill containment systems and equipment are available and ready | RV | | | X | X | X |
| 1.12 | If vapor return/balancing is applicable, confirm that Bunker and vapor hoses are correctly connected, and pressure monitoring systems are operational | | | | | | X |
| **B2** | **Safety Systems** | | | | | | |
| 2.1 | All safety systems associated with bunkering shall be tested. This includes the fire and gas detection system and emergency shut-down system, emergency stop buttons, ESD arrangements including automatic valves and ESD link system, and automatic closing of ship bunker valve at high-high level in fuel tank. | BV/RV | | | X | X | X |
| 2.2 | Confirm that all portable electrical equipment incl. Communication equipment used within Hazardous zones are confirmed ex-certified | | | | X | X | X |
| 2.3 | Confirm that arrangements for preventing static electrical discharge are operational | BV/RV | | | X | X | X |
| 2.4 | Test all tank alarms (high [95%] and overfill alarms [98%]) | RV | | | X | X | X |
| 2.5 | Consider additional high level alarm setting to 90% of nominated loading level | RV | | | X | X | X |
| 2.6 | Monitor filling in non-loading tanks or set alarms to warn of change in non-loading tanks | RV | | | X | X | X |

| 2 | CONNECTION PHASE (Part B) FOR BIO-METHANOL | Appl. | Status | Remarks | TTS | PTS | STS |
|---|---|---|---|---|---|---|---|
| 2.7 | Set a target tank pressure on the bunker vessel to minimize the risk of unintentional methanol vapor venting and gas release on the receiving vessel. | BV | | | | | X |
| **B3** | **System Preparation** | | | | | | |
| 3.1 | Transfer system tested and ready for use in accordance with an approved bunkering procedure | RV | | | X | X | X |
| 3.2 | Confirm sufficient nitrogen supply before bunkering for system purging | RV | | | X | X | X |
| 3.3 | Confirm that piping systems and bunkering hoses are purged with Nitrogen prior to bunkering | | | | X | X | X |
| 3.4 | Agreement on bunkering schedule & rates | | | | X | X | X |
| 3.5 | Confirm that hoses and manifolds are compatible and confirm use of appropriate color coding to prevent accidental cross-connection with other fuels. | RV | | | X | X | X |
| 3.6 | Control valves are in the correct initial positions | RV | | | X | X | X |
| 3.7 | Vapour return system tested and ready for use | BV/RV | | | | | X |
| 3.8 | Keep all doors to non-hazardous spaces closed. | RV | | | X | X | X |
| 3.9 | Consider measures to operate ventilation systems to reduce gas ingress into non-hazardous spaces | RV | | | X | X | X |
| 3.10 | Avoid internal transfers between bio methanol tanks | RV | | | | | X |
| **B4** | **Agreement Points - To be Recorded & signed off in a Safety Meeting** | | | | | | |
| 4.1 | Master to confirm permission for barge to come alongside | RV | | | | | X |
| 4.2 | Safety data sheets are available and reviewed | BV/RV | | | X | X | X |
| 4.3 | Hazardous properties of the product to be transferred identified in the safety data sheet are discussed | BV/RV | | | X | X | X |
| 4.4 | Personnel transfer and lifting to follow ship's procedures for the same including risk assessments as required | RV | | | X | X | X |
| 4.5 | Responsible Engineer to confirm barge soundings | RV | | | X | X | X |
| 4.6 | Bunker watch is established | BV/RV | | | X | X | X |
| 4.7 | Bunker tanks to be loaded (in m3) with tank number, capacities (before, free volume and final volumes) are to be agreed. | BV/RV | | | X | X | X |
| 4.8 | Smoking restrictions and designated smoking areas are established | BV/RV | | | X | X | X |
| 4.9 | Naked light restrictions are established | BV/RV | | | X | X | X |

# Transfer Phase (Part C)

Table 10-4 Checklist for the Transfer Phase for bunkering of bio-methanol

| 3 | TRANSFER PHASE (Part C) FOR BIO-METHANOL | Appl. | Status | Remarks | TTS | PTS | STS |
|---|---|---|---|---|---|---|---|
| | **Requires repetitive checks with frequency of checks to be agreed (for example every 30 mins)** | | | | | | |
| **C1** | **Vessel Approach & positioning** | | | | | | |
| 1.1 | Weather conditions are within limits agreed upon in Pt. A | | | | X | X | X |
| 1.2 | Mooring arrangement is secure | BV/RV | | | | | X |
| 1.3 | Fenders are in place and functional | BV/RV | | | | | X |
| 1.4 | Access between vessels is adequate | BV/RV | | | | | X |
| 1.5 | Communication is functioning | BV/RV | | | X | X | X |
| 1.6 | In the case of night time operations the lighting is sufficient for the bunker area to be well illuminated | | | | X | X | X |
| 1.7 | Doors to non-hazardous spaces are closed and measures are taken to operate ventilation systems to reduce potential gas ingress into these spaces. | | | | X | X | X |
| 1.8 | Steering and propulsion of Bunker/Receiving vessel can be readily deployed so the vessel can sail under its own power in a safe and non-obstructed direction | BV/RV | | | | | X |
| **C2** | **Safety and Operational Procedures** | | | | | | |
| 2.1 | Ensure that the designated zones maintained | | | | X | X | X |
| 2.2 | Ensure that all electrical equipment used within hazardous zones is explosion-proof (Ex-proof) to prevent ignition. | | | | X | X | X |
| 2.3 | Safety measures are in place within safety area (PPE-EEBD, Portable gas detectors, etc.) | | | | X | X | X |
| 2.4 | If gas is detected follow Safety Procedures | | | | X | X | X |
| 2.5 | Emergency procedures and plans are in place, including emergency contact list, incident management planning, and emergency shut down and release procedures | | | | X | X | X |
| 2.6 | Firefighting systems are in place and functional | | | | X | X | X |
| **C3** | **Watchkeeping** | | | | | | |
| 3.1 | Ensure monitoring of all connections and bunker lines for potential leakages, line pressure, and levels of non-nominated bio methanol tanks | | | | X | X | X |
| 3.2 | Naked light restrictions are complied with | | | | X | X | X |
| 3.3 | Smoking restrictions and designated smoking areas are maintained | | | | X | X | X |
| 3.4 | Save-all, drains and scuppers are plugged | | | | X | X | X |
| 3.5 | Bunker Sounding Log at half hour intervals | | | | X | X | X |
| 3.6 | Compare with supplier's figures | | | | X | X | X |
| 3.7 | Responsible Officer to Inform bunkering facility when bunkered tanks reaches agreed levels (for e.g. 70% or 75%) | | | | X | X | X |
| 3.8 | Relevant restrictions are in place during SIMOPS (see Pt.E) | RV | | Ref. Part E | X | X | X |

# Disconnection of bunkering equipment (Part D)

Table 10-5 Checklist for the Post Transfer Operations for bunkering of bio-methanol

| 4 | DISCONNECTION PHASE (Part D) BIO-METHANOL | Appl. | Status | Remarks | TTS | PTS | STS |
|---|---|---|---|---|---|---|---|
| **D1** | **Prior to disconnection** | | | | | | |
| 1.1 | Ensure adjusted loading rate during top off of tanks and open additional tanks if relevant | RV | | | X | X | X |
| 1.2 | Provide adequate notice to the bunker supplier to allow them to adjust their loading operations accordingly. | RV | | To be logged | X | X | X |
| 1.3 | System Preparation: Relevant bunker hoses, vapour return lines, fixed pipelines and manifolds are: | BV/RV | | | X | X | X |
| 1.3.1 | Purged | | | | X | X | X |
| 1.3.2 | Inerted | | | | X | X | X |
| 1.3.3 | Depressurized | | | | X | X | X |
| 1.3.4 | Liquid free/ drained (if local rules permit, blow through transfer hoses) | | | | X | X | X |
| 1.3.5 | Ready for disconnection | | | | X | X | X |
| 1.4 | All remotely and manually operated valves are closed as required for safe disconnection | BV/RV | | To be logged | X | X | X |
| 1.5 | Advise Officer on Watch (OOW) when bunkering complete | BV/RV | | To be logged | X | X | X |
| 1.6 | Bunker/Receiving vessel is notified on “ready to disconnect” | BV/RV | | | | | X |
| 1.6.1 | Disconnect transfer hose | | | | | | X |
| **D2** | **Post disconnection** | | | | | | |
| 2.1 | Bunker area on the vessel is cleared and restored to standard condition | BV/RV | | | X | X | X |
| 2.2 | Manifold blanks are replaced | | | | X | X | X |
| 2.3 | Relevant documents are signed and exchanged | BV/RV | | To be logged | X | X | X |
| 2.3.1 | Sign bunker delivery notes (BDN) after verifying Quantities shown/BDN details (Chemical contents etc.) | | | | X | X | X |
| 2.3.2 | Apply temperature and density corrections to convert: Gross to net volume/ Net volume to weight | | | | X | X | X |
| 2.3.3 | Update logbooks in accordance with vessel procedures | | | | X | X | X |
| 2.4 | Competent authorities are notified on the completion of the bunker operation | BV/RV | | To be logged | X | X | X |
| 2.5 | Near misses and incidents are reported to competent authorities | BV/RV | | To be logged | X | X | X |

# Simultaneous Operations – SIMOPS (Part E)

Table 10-6 Checklist for Simultaneous Operations when bunkering of bio-methanol.

| 5 | SIMOPS (Part E) FOR BIO-METHANOL | Appl. | Status | Remarks | TTS | PTS | STS |
|---|---|---|---|---|---|---|---|
| | **SIMOPS should be avoided as far as practicable and to be done only if absolutely necessary.** | | | | | | |
| **E1** | **Operational restrictions** | | | | | | |
| 1.1 | Ensure no stores or garbage handling during bunker operations & other operations such as oily bilge/sludge, transfer, loading and unloading of stores, etc. | RV | | Most applicable for STS | X | X | X |
| 1.2 | Any labour intensive tasks to be done in parallel with bunkering to be risk assessed | RV | | Most applicable for STS | X | X | X |
| 1.3 | No cargo operations to be planned when bunkering but if unavoidable a separate risk assessment to be done | RV | | | X | X | X |
| 1.4 | Avoid scheduling vetting, charterers, Flag State or other inspection or audit | RV | | | X | X | X |
| 1.5 | Ensure compliance with procedures for internal transfer of bunker/cargo | RV | | | X | X | X |
| 1.6 | Clear protocols for: information sharing, coordination, and emergency response | BV/RV | | | X | X | X |
| 1.7 | Clear communication channels are established between all parties involved | BV/RV | | | X | X | X |
| 1.8 | Permit-to-work system is implemented for critical activities during SIMOPS | BV/RV | | | X | X | X |
| **E2** | **SIMOPS Planning** | | | | | | |
| 2.1 | Planned SIMOPS are in accordance with the safety procedures and risk mitigation in ship's operational documentation for Receiving Vessel. | RV | | To be logged | X | X | X |
| 2.2 | Ensure that SIMOPS are compliant with local regulations and restrictions | RV | | To be logged | X | X | X |
| **E3** | **Safety considerations** | | | | | | |
| 3.1 | Safety procedures and risk mitigation for SIMOPS are made aware of to all parties concerned | RV | | To be logged | X | X | X |
| 3.1.1 | Establish a safe working area for bunkering operations, free from obstructions and potential hazards. | RV | | | X | X | X |
| 3.1.2 | Strict zoning is implemented: operations are segregated, areas for bunkering, cargo handling, and personnel movement is clearly defined | RV | | | X | X | X |
| 3.1.3 | Ignition source control: equipment ex-certified for zone 1 is used, and inspections are carried out regularly | RV | | | X | X | X |
| 3.1.4 | Surveillance and monitoring of bunkering and cargo operations are increased during SIMOPS | BV/RV | | | X | X | X |
| **E4** | **Continuous monitoring** | | | | | | |
| 4.1 | Ignition source & toxicity restrictions are observed Ex-proof in Haz zones, EEBD, PPE, Gas detection, use of antidotes/Medical assistance on board | RV | | | X | X | X |
| 4.2 | Areas with potential gas accumulation are particularly checked | RV | | | X | X | X |

| 5 | SIMOPS (Part E) FOR BIO-METHANOL | Appl. | Status | Remarks | TTS | PTS | STS |
|---|---|---|---|---|---|---|---|
| 4.3 | SIMOPS restrictions are observed | RV | | | X | X | X |
| 4.4 | Maintain adequate separation between bunkering operations and cargo handling activities to prevent interference and potential hazards. | BV/RV | | | X | X | X |
| 4.5 | Be aware of how ship movement due to cargo operations may affect bunkering stability and prevent overflows. | RV | | | | | X |
| 4.6 | Address potential dust issues from cargo operations and the impact of weather conditions on dust movement. | RV | | | X | X | X |
| 4.7 | Dedicated personnel are assigned to oversee SIMOPS activities | RV | | | | | X |
| 4.8 | Dedicated personnel have specific training in managing SIMOPS and coordinating with the bunker team | RV | | | | | X |

# Appendix C Checklists for bunkering of DME

## Pre-bunkering Phase (Part A)

Table 10-7: Checklist for Pre-bunkering phase for bunkering of DME.

| 1 | PRE-BUNKERING PHASE (Part A) FOR DME | Appl. | Status | Remarks | TTS | PTS | STS |
|---|---|---|---|---|---|---|---|
| A1 | **Pre-operational considerations** | | | | | | |
| **1.1** | **Compliance considerations** | BV/RV | | | | | |
| 1.1.1 | International (IMO/ISO) | | | | X | X | X |
| 1.1.2 | Regional (EU) | | | | X | X | X |
| 1.1.3 | Port State/Flag State Requirements | | | | X | X | X |
| 1.1.4 | State (US) | | | | X | X | X |
| 1.1.5 | Port specific requirements | | | | | X | |
| 1.1.6 | Terminal | | | | X | X | |
| **1.2** | **Bunkers** | | | | | | |
| 1.2.1 | Bunker Purchase Contract | RV | | | X | X | X |
| 1.2.2 | Bunker Delivery Note (BDN) | | | | X | X | X |
| 1.2.3 | Proof of Sustainability | | | | X | X | X |
| 1.2.4 | Certificate of Quality (Bunker Spec) | | | | X | X | X |
| 1.2.5 | Verify mass/volume and density | | | | X | X | X |
| **1.3** | **Plan to include discussion on method of bunker delivery:** | RV | | | | | |
| 1.3.1 | Terminal | | | | | X | |
| 1.3.2 | Bunker Vessel | | | | | | X |
| 1.3.3 | STS bunkering | | | | | | X |
| 1.3.4 | Trucks | | | | X | | |
| 1.3.5 | Notification of bunker operation is given to relevant authorities | BV/RV | | | X | X | X |
| **1.4** | **Discuss & document, where relevant, with Responsible Officer on RV:** | BV/RV | | | | | |
| 1.4.1 | Compatibility documents enabling checks on zones(Refer 6.2 of the guidance document) – hazardous, safety & security, mooring, fendering & other compatibility aspects | | | | X | X | X |
| 1.4.2 | Draft, trim and list conditions | | | | X | X | X |
| 1.4.3 | Vessel info/Details/Arrival -BV/RV | | | | X | X | X |
| 1.4.4 | Calculated tank quantities (Converting contracted mass to volume) | | | | X | X | X |
| 1.4.5 | Ensure sufficient ullage space in the tanks for line blowing | RV | | | X | X | X |
| 1.4.6 | Operating limits (environmental) | | | More relevant for STS | X | X | X |
| 1.4.7 | Emergency preparedness/plans | | | | X | X | X |
| **1.5** | **Agreement points - Discuss & agree on:** | | | | | | |
| 1.5.1 | Means of communication | | | | X | X | X |
| 1.5.2 | Emergency procedures | | | | X | X | X |
| 1.5.3 | Hose connection and disconnection procedures incl. Nitrogen purging | | | | X | X | X |

| 1 | PRE-BUNKERING PHASE (Part A) FOR DME | Appl. | Status | Remarks | TTS | PTS | STS |
|---|---|---|---|---|---|---|---|
| 1.5.4 | Crew transfer procedures (BV) | | | | | | X |
| 1.5.5 | Use of ESD link | | | | X | X | X |
| 1.5.6 | Use of vapour return | | | | X | X | X |
| 1.5.7 | Access between vessels | | | | | | X |
| 1.5.8 | Mandatory permission points | | | | X | X | X |
| 1.5.9 | Agreement on bunkering schedule in terms of bunkering rates and max pressure (initial rate, max. transfer rate, topping-off rate). | | | | X | X | X |
| 1.5.10 | Fuel quality analysis/sampling requirements | | | | X | X | X |
| **1.6** | **Operational considerations for bunkering** | BV/RV | | | | | |
| 1.6.1 | Ensure valves & actuators are well maintained and in good working order | BV/RV | | | X | X | X |
| 1.6.2 | Ensure availability & sufficiency of suitable PPE | | | | X | X | X |
| 1.6.3 | Ensure all relevant equipment are approved for use | | | | X | X | X |
| 1.6.4 | Hoses, Saddles, drip trays, manifold connections | | | | X | X | X |
| 1.6.5 | Connection, tightness tests and purging | | | | X | X | X |
| **1.7** | **Approach of BV to RV** | | | | | | |
| 1.7.1 | Anchoring considerations to allow favourable approach & mooring for BV | | | | X | X | X |
| **1.8** | **Mooring/Fendering** | BV/RV | | | | | |
| 1.8.1 | Mooring analysis is carried out | | | | X | X | X |
| 1.8.2 | Mooring equipment is in good condition & ready for use | | | | X | X | X |
| 1.8.3 | Mooring and fendering arrangement is agreed | | | | X | X | X |
| 1.8.4 | Fendering and safety distances | | | | X | X | X |
| **1.9** | **Determine organizational plan during bunker (example below):** | BV/RV | | | | | |
| 1.9.1 | Duty officer (deck) | | | | X | X | X |
| 1.9.2 | Person in charge of bunkering | | | | X | X | X |
| 1.9.3 | Persons assisting with bunkering | | | | X | X | X |
| 1.9.4 | Fuel tank and bunker / lube oil manifold manning | | | | | | X |
| 1.9.5 | Ensure continuous supervision at the bunkering manifold | | | | X | X | X |
| **1.10** | **Adequacy of illumination** | BV/RV | | | | | |
| 1.10.1 | Evaluate the need for nighttime operations | BV/RV | | | | | X |
| 1.10.2 | Evaluate feasibility of start & completion of operation during daylight | | | | | | X |
| 1.10.3 | Ensure adequate lighting for night time operations | | | | X | X | X |
| **1.11** | **Other considerations** | | | | | | |
| 1.11.1 | Restricted area classifications are compatible Classification in terms of Hazardous, Safety & Security zones & ex-considerations (Refer 6.2 of the guidance document) | BV/RV | | | | | X |
| 1.11.2 | Ensure that means for prevention of static electric discharge are available and functional | BV/RV | | | X | X | X |
| 1.11.3 | Ensure fuel control, P/V valves/ESD system, Fire fighting systems are functional and appropriate with regards to configuration of bunker stations – closed/semi closed. | BV/RV | | | X | X | X |
| 1.11.4 | Ensure unused bunker connections are blanked and | BV/RV | | | X | X | X |

| 1 | PRE-BUNKERING PHASE (Part A) FOR DME | Appl. | Status | Remarks | TTS | PTS | STS |
|---|---|---|---|---|---|---|---|
| | fully secured | | | | | | |
| 1.11.5 | Considerations towards environmental protection in case of spills | BV/RV | | | X | X | X |
| 1.11.6 | Ensure that an International Shore connection is available (on RV) | | | | X | X | X |
| 1.11.7 | Consider the need for closure of external doors, portholes & other devices to prevent gas ingress into non-hazardous spaces during bunkering | BV/RV | | | X | X | X |
| 1.11.8 | Ensure steering and propulsion can be readily deployed - i.e. Vessels can sail under its own power in a safe and non-obstructed direction | BV/RV | | | X | X | |
| 1.11.9 | Ensure pre-bunkering cooling: Before commencing bunkering, verify that fuel tanks and pipes are adequately cooled to prevent thermal stress and potential damage. | | | | X | X | X |
| **A2** | **Alignment – To be Recorded & signed off** | | | | | | |
| **2.1** | **Record agreed operational limits** | BV/RV | | | | | |
| 2.1.1 | Wind speed | | | | X | X | X |
| 2.1.2 | Wave heights | | | | X | X | X |
| 2.1.3 | Draft and tidal conditions | | | | X | X | X |
| 2.1.4 | Forecast for Thunderstorms | | | | X | X | X |
| 2.1.5 | Visibility & other criteria | | | | X | X | X |
| 2.1.6 | Record agreed bunker specifications: product/grade, density, volume (in m3) at loading temperature, loading temperature, transfer rates, and line pressures as agreed. | | | | X | X | X |
| **2.2** | **Safe access confirmation** | BV/RV | | | | | |
| 2.2.1 | Ensure safe access between the ships | | | | | | X |
| 2.2.2 | Ensure access between the ship and shore is safe and controlled | | | | X | X | |
| **2.3** | **Ensure adequateness of operation supervision and watchkeeping** | BV/RV | | | | | |
| 2.3.1 | Agreed upon Means of communications | | | | X | X | X |
| 2.3.2 | Ensure awareness of Emergency shutdown event, location of emergency stop buttons, ESD link functionality | | | | X | X | X |
| **2.4** | **Ensure operational/safety measures are agreed upon** | BV/RV | | | | | |
| 2.4.1 | Ensure that the different zones/boundaries are well understood (Refer 6.2 of the guidance document) | | | | X | X | X |
| 2.4.2 | Ensure use of ex proof Inside Haz Zone | | | | X | X | X |
| 2.4.3 | Material Safety data sheets (MSDS) are available | | | | X | X | X |
| 2.4.4 | Agreed safety measures within the safety area are in place including the use of proper PPE - EEBD, Portable gas detectors etc. | | | | X | X | X |
| 2.4.5 | Incident management planning is in place to treat injuries - for e.g. use of antidotes/Medical assistance | | | | X | X | X |
| 2.4.6 | Sampling procedure and equipment is provided | | | | X | X | X |

| 1 | PRE-BUNKERING PHASE (Part A) FOR DME | Appl. | Status | Remarks | TTS | PTS | STS |
|---|---|---|---|---|---|---|---|
| 2.4.7 | Vapour management procedures - both vapor return and /or vapor balancing are agreed upon & prepared | | | | X | X | X |
| 2.4.8 | Ensure that arrangements for preventing static electrical discharges are operational (hose &coupling) | | | | X | X | X |
| **2.5** | **Emergency preparedness** | BV/RV | | | | | |
| 2.5.1 | Emergency procedures and plans, including the emergency contact list, are known to the persons in charge | | | | X | X | X |
| 2.5.2 | Emergency shut down and release procedures agreed upon | | | | X | X | X |
| **2.6** | **SIMOPS** | | | | | | |
| 2.6.1 | Safety procedures and risk mitigation for SIMOPS are made aware of | BV/RV | | Part E | X | X | X |
| **NOTE** | *Although some of the items are not marked as relevant for truck to ship and port to ship, due considerations may be made to evaluate the need to include these items.* | | | | | | |

# Connection Phase (Part B)

Table 10-8 Checklist for the Connection Phase for bunkering of DME.

| 2 | CONNECTION PHASE (Part B) FOR DME | Appl. | Status | Remarks | TTS | PTS | STS |
|---|---|---|---|---|---|---|---|
| **B1** | **Site Equipment Readiness** | | | | | | |
| 1.1 | Master to monitor that weather limits specified in Part A2 are met | RV | | | X | X | X |
| 1.2 | Confirm adequate lighting at manifold | BV/RV | | | X | X | X |
| 1.3 | Confirm transfer equipment (piping, hose, hose supports, flanges, gaskets, etc.) in order including good condition, appropriateness, lining up, rigging etc. | RV | | | X | X | X |
| 1.4 | Confirm tightness testing of relevant bunker equipment:<br>- confirm all bolts are fixed and tightened at bunker manifold (for bolted hose connections)<br>- tightness test for QCDC | BV/RV | | | X | X | X |
| 1.5 | Confirm that the bunker tank's vents/PV valves are operational | RV | | | X | X | X |
| 1.6 | Confirm that tanks and piping have been inerted | RV | | | X | X | X |
| 1.7 | Confirm that bunker manifold drip tray valves are closed and deck scuppers plugs are fitted | RV | | | X | X | X |
| 1.8 | Blank unused bunker manifolds and close unused bunker manifold valves | RV | | | X | X | X |
| 1.9 | Confirm that all drain valves, purge valves etc. are closed | RV | | | X | X | X |
| 1.10 | Confirm that any overflow tank, if installed, is empty | RV | | | X | X | X |
| 1.11 | Confirm that spill containment systems and equipment are available and ready | RV | | | X | X | X |
| 1.12 | If vapor return/balancing is applicable, confirm that Bunker and vapor hoses are correctly connected, and pressure monitoring systems are operational | | | | | | X |
| 1.13 | Confirm that all components in contact with DME are compatible, such as: hoses, gaskets, seals, etc. | BV/RV | | | X | X | X |
| 1.14 | Tank and pipe temperatures are within the acceptable range | BV/RV | | | X | X | X |
| 1.15 | Cooling processes are monitored and controlled with temperature sensors | BV/RV | | | X | X | X |
| 1.16 | Means of shell temperature measurements in the top, middle, and bottom of tanks is available | BV/RV | | | X | X | X |
| **B2** | **Safety Systems** | | | | | | |
| 2.1 | All safety systems associated with bunkering shall be tested. This includes the fire and gas detection system and emergency shut-down system, emergency stop buttons, ESD arrangements including automatic valves and ESD link system, and automatic closing of ship bunker valve at high-high level in fuel tank. | BV/RV | | | X | X | X |
| 2.2 | Confirm that all portable electrical equipment incl. Communication equipment used within Hazardous zones are confirmed ex-certified | | | | X | X | X |
| 2.3 | Test all tank alarms (high [90%] and overfill alarms [95%]) | RV | | | X | X | X |

| 2 | CONNECTION PHASE (Part B) FOR DME | Appl. | Status | Remarks | TTS | PTS | STS |
|---|---|---|---|---|---|---|---|
| 2.4 | Consider additional high level alarm setting to 90% of nominated loading level | RV | | | X | X | X |
| 2.5 | Monitor filling in non-loading tanks or set alarms to warn of change in non-loading tanks | RV | | | X | X | X |
| 2.6 | Confirm provision of portable oxygen measurement devices to verify the effectiveness of the inerting process in piping and tanks prior to gassing-up. | RV | | | X | X | X |
| 2.7 | Confirm that safety measures such as spill containment (utilizing water curtains to protect the ship's hull from thermal damage in case of liquid DME leaks), drip trays (for spill containment) & dry break-away couplings in bunker hoses are in place. | RV | | | X | X | X |
| 2.8 | Confirm that electrical insulation is effective | BV/RV | | | X | X | X |
| 2.9 | Confirm that gas detection systems on the bunker vessel are functional to identify any potential gas leaks from tanks. | RV | | | | | X |
| 2.10 | Set a target tank pressure on the bunker vessel to minimize the risk of unintentional DME vapor venting and gas release on the receiving vessel. | BV | | | | | X |
| **B3** | **System Preparation** | | | | | | |
| 3.1 | Transfer system tested and ready for use in accordance with an approved bunkering procedure | RV | | | X | X | X |
| 3.2 | Confirm sufficient nitrogen supply before bunkering for system purging | RV | | | X | X | X |
| 3.3 | Confirm that piping systems and bunkering hoses are purged with Nitrogen prior to bunkering | | | | X | X | X |
| 3.4 | Agreement on bunkering schedule & rates | | | | X | X | X |
| 3.5 | Confirm that hoses and manifolds are compatible and confirm use of appropriate colour coding to prevent accidental cross-connection with other fuels. | RV | | | X | X | X |
| 3.6 | Control valves are in the correct initial positions | RV | | | X | X | X |
| 3.7 | Vapour return system tested and ready for use | BV/RV | | | | | X |
| 3.8 | Keep all doors to non-hazardous spaces closed. | RV | | | X | X | X |
| 3.9 | Consider measures to operate ventilation systems to reduce gas ingress into non-hazardous spaces | RV | | | X | X | X |
| 3.10 | Avoid internal transfers between DME tanks | RV | | | | | X |
| **B4** | **Agreement Points - To be Recorded & signed off in a Safety Meeting** | | | | | | |
| 4.1 | Master to confirm permission for barge to come alongside | RV | | | | | X |
| 4.2 | Safety data sheets are available and reviewed | BV/RV | | | X | X | X |
| 4.3 | Hazardous properties of the product to be transferred identified in the safety data sheet are discussed | BV/RV | | | X | X | X |
| 4.4 | Personnel transfer and lifting to follow ship's procedures for the same including risk assessments as required | RV | | | X | X | X |
| 4.5 | Bunker watch is established | BV/RV | | | X | X | X |
| 4.6 | Bunker tanks to be loaded (in m3) with tank number, capacities (before, free volume and final volumes) are to be agreed. | BV/RV | | | X | X | X |

| 2 | **CONNECTION PHASE (Part B) FOR DME** | **Appl.** | **Status** | **Remarks** | **TTS** | **PTS** | **STS** |
|---|---|---|---|---|---|---|---|
| 4.7 | Smoking restrictions and designated smoking areas are established | BV/RV | | | X | X | X |
| 4.8 | Naked light restrictions are established | BV/RV | | | X | X | X |

# Transfer Phase (Part C)

Table 10-9 Checklist for the Transfer Phase for bunkering of DME.

| 3 | TRANSFER PHASE (Part C) FOR DME | Appl. | Status | Remarks | TTS | PTS | STS |
|---|---|---|---|---|---|---|---|
| | **Requires repetitive checks with frequency of checks to be agreed (for example every 30 mins)** | | | | | | |
| **C1** | **Vessel Approach & positioning** | | | | | | |
| 1.1 | Weather conditions are within limits agreed upon in Pt. A | | | | X | X | X |
| 1.2 | Mooring arrangement is secure | BV/RV | | | | | X |
| 1.3 | Fenders are in place and functional | BV/RV | | | | | X |
| 1.4 | Access between vessels is adequate | BV/RV | | | | | X |
| 1.5 | Communication is functioning | BV/RV | | | X | X | X |
| 1.6 | In the case of nighttime operations the lighting is sufficient for the bunker area to be well illuminated | | | | X | X | X |
| 1.7 | Doors to non-hazardous spaces are closed and measures are taken to operate ventilation systems to reduce potential gas ingress into these spaces. | | | | X | X | X |
| 1.8 | Steering and propulsion of Bunker/Receiving vessel can be readily deployed so the vessel can sail under its own power in a safe and non-obstructed direction | BV/RV | | | | | X |
| **C2** | **Safety and Operational Procedures** | | | | | | |
| 2.1 | Ensure that the designated zones maintained | | | | X | X | X |
| 2.2 | Ensure that all electrical equipment used within hazardous zones is explosion-proof (Ex-proof) to prevent ignition. | | | | X | X | X |
| 2.3 | Safety measures are in place within safety area (PPE-EEBD, Portable gas detectors, etc. ) | | | | X | X | X |
| 2.4 | If gas is detected follow Safety Procedures | | | | X | X | X |
| 2.5 | Emergency procedures and plans are in place, including emergency contact list, incident management planning, and emergency shut down and release procedures | | | | X | X | X |
| 2.6 | Firefighting systems are in place and functional | | | | X | X | X |
| 2.7 | Ignition sources are under control | BV/RV | | | X | X | X |
| 2.8 | Toxic fumes are managed | BV/RV | | | X | X | X |
| 2.9 | Ensure filling levels also account for thermal expansion | RV | | | X | X | X |
| **C3** | **Watchkeeping** | | | | | | |
| 3.1 | Ensure monitoring of all connections and bunker lines for potential leakages, line pressure, and levels of non-nominated DME tanks | | | | X | X | X |
| 3.2 | Naked light restrictions are complied with | | | | X | X | X |
| 3.3 | Smoking restrictions and designated smoking areas are maintained | | | | X | X | X |
| 3.4 | Bunker Sounding Log at half hour intervals | | | | X | X | X |
| 3.5 | Compare with supplier's figures | | | | X | X | X |
| 3.6 | Responsible Officer to Inform bunkering facility when bunkered tanks reach agreed levels (for e.g. 70% or 75%) | | | | X | X | X |
| 3.7 | Relevant restrictions are in place during SIMOPS (see Pt.E) | RV | | Ref. Part E | X | X | X |

| 3 | TRANSFER PHASE (Part C) FOR DME | Appl. | Status | Remarks | TTS | PTS | STS |
|---|---|---|---|---|---|---|---|
| 3.8 | Monitor line pressure and leakage when bunker barge changes tanks | BV/RV | | | | | X |
| 3.9 | Ensure/check that state of DME is compatible at the time of bunkering | BV/RV | | | X | X | X |

# Disconnection of bunkering equipment (Part D)

Table 10-10 Checklist for the Post Transfer Operations for bunkering of DME.

| 4 | DISCONNECTION PHASE (Part D) FOR DME | Appl. | Status | Remarks | TTS | PTS | STS |
|---|---|---|---|---|---|---|---|
| **D1** | **Prior to disconnection** | | | | | | |
| 1.1 | Ensure adjusted loading rate during top off of tanks and open additional tanks if relevant | RV | | | X | X | X |
| 1.2 | Provide adequate notice to the bunker supplier to allow them to adjust their loading operations accordingly. | RV | | To be logged | X | X | X |
| 1.3 | System Preparation: Relevant bunker hoses, vapour return lines, fixed pipelines and manifolds are: | BV/RV | | | X | X | X |
| 1.3.1 | Purged | | | | X | X | X |
| 1.3.2 | Inerted | | | | X | X | X |
| 1.3.3 | Depressurized | | | | X | X | X |
| 1.3.4 | Liquid free/ drained (if local rules permit, blow through transfer hoses) | | | | X | X | X |
| 1.3.5 | Ready for disconnection | | | | X | X | X |
| 1.4 | All remotely and manually operated valves are closed as required for safe disconnection | BV/RV | | To be logged | X | X | X |
| 1.5 | Advise Officer on Watch (OOW) when bunkering complete | BV/RV | | To be logged | X | X | X |
| 1.6 | Bunker/Receiving vessel is notified on “ready to disconnect” | BV/RV | | | | | X |
| 1.6.1 | Disconnect transfer hose | | | | | | X |
| **D2** | **Post disconnection** | | | | | | |
| 2.1 | Bunker area on the vessel is cleared and restored to standard condition | BV/RV | | | X | X | X |
| 2.2 | Manifold blanks are replaced | | | | X | X | X |
| 2.3 | Relevant documents are signed and exchanged | BV/RV | | To be logged | X | X | X |
| 2.3.1 | Sign bunker delivery notes (BDN) after verifying Quantities shown/BDN details (Chemical contents etc.) | | | | X | X | X |
| 2.3.2 | Apply temperature and density corrections to convert: Gross to net volume/ Net volume to weight | | | | X | X | X |
| 2.3.3 | Update logbooks in accordance with vessel procedures | | | | X | X | X |
| 2.4 | Competent authorities are notified on the completion of the bunker operation | BV/RV | | To be logged | X | X | X |
| 2.5 | Near misses and incidents are reported to competent authorities | BV/RV | | To be logged | X | X | X |

# Simultaneous Operations – SIMOPS (Part E)

Table 10-11 Checklist for Simultaneous Operations when bunkering of DME.

| 5 | SIMOPS (Part E) FOR DME | Appl. | Status | Remarks | TTS | PTS | STS |
|---|---|---|---|---|---|---|---|
| | **SIMOPS should be avoided as far as practicable and to be done only if absolutely necessary.** | | | | | | |
| **E1** | **Operational restrictions** | | | | | | |
| 1.1 | Ensure no stores or garbage handling during bunker operations & other operations such as oily bilge/sludge, transfer, loading and unloading of stores, etc. | RV | | Most applicable for STS | X | X | X |
| 1.2 | Any labour-intensive tasks to be done in parallel with bunkering to be risk assessed | RV | | Applicable for STS | X | X | X |
| 1.3 | No cargo operations to be planned when bunkering but if unavoidable a separate risk assessment to be done | RV | | | X | X | X |
| 1.4 | Avoid scheduling vetting, charterers, Flag State or other inspection or audit | RV | | | X | X | X |
| 1.5 | Ensure compliance with procedures for internal transfer of bunker/cargo | RV | | | X | X | X |
| 1.6 | Clear protocols for: information sharing, coordination, and emergency response | BV/RV | | | X | X | X |
| 1.7 | Clear communication channels are established between all parties involved | BV/RV | | | X | X | X |
| 1.8 | Permit-to-work system is implemented for critical activities during SIMOPS | BV/RV | | | X | X | X |
| **E2** | **SIMOPS Planning** | | | | | | |
| 2.1 | Planned SIMOPS are in accordance with the safety procedures and risk mitigation in ship's operational documentation for Receiving Vessel. | RV | | To be logged | X | X | X |
| 2.2 | Ensure that SIMOPS are compliant with local regulations and restrictions | RV | | To be logged | X | X | X |
| **E3** | **Safety considerations** | | | | | | |
| 3.1 | Safety procedures and risk mitigation for SIMOPS are made aware of to all parties concerned | RV | | To be logged | X | X | X |
| 3.1.1 | Establish a safe working area for bunkering operations, free from obstructions and potential hazards. | RV | | | X | X | X |
| 3.1.2 | Strict zoning is implemented: operations are segregated, areas for bunkering, cargo handling, and personnel movement is clearly defined | RV | | | X | X | X |
| 3.1.3 | Ignition source control: equipment ex-certified for zone 1 is used, and inspections are carried out regularly | RV | | | X | X | X |
| 3.1.4 | Surveillance and monitoring of bunkering and cargo operations are increased during SIMOPS | BV/RV | | | X | X | X |
| **E4** | **Continuous monitoring** | | | | | | |
| 4.1 | Ignition source & toxicity restrictions are observed Ex-proof in Haz zones, EEBD, PPE, Gas detection, use of antidotes/Medical assistance on board | RV | | | X | X | X |
| 4.2 | Areas with potential gas accumulation are particularly checked | RV | | | X | X | X |

| 5 | SIMOPS (Part E) FOR DME | Appl. | Status | Remarks | TTS | PTS | STS |
|---|---|---|---|---|---|---|---|
| 4.3 | SIMOPS restrictions are observed | RV | | To be logged | X | X | X |
| 4.4 | Maintain adequate separation between bunkering operations and cargo handling activities to prevent interference and potential hazards. | BV/RV | | | X | X | X |
| 4.5 | Be aware of how ship movement due to cargo operations may affect bunkering stability and prevent overflows. | RV | | | | | X |
| 4.6 | Address potential dust issues from cargo operations and the impact of weather conditions on dust movement. | RV | | | X | X | X |
| 4.7 | Dedicated personnel are assigned to oversee SIMOPS activities | RV | | | | | X |
| 4.8 | Dedicated personnel have specific training in managing SIMOPS and coordinating with the bunker team | RV | | | | | X |

# Appendix D Checklists for bunkering of FT-diesel, HVO and FAME

## Pre-bunkering Phase (Part A)

Table 10-12: Checklist for Pre-bunkering phase for bunkering of FT-diesel, HVO & FAME.

| 1 | PRE-BUNKERING PHASE (Part A) FT-DIESEL,HVO,FAME | Appl. | Status | Remarks | TTS | PTS | STS |
|---|---|---|---|---|---|---|---|
| A1 | **Pre-operational considerations** | | | | | | |
| **1.1** | **Compliance considerations** | BV/RV | | | | | |
| 1.1.1 | International (IMO/ISO) | | | | X | X | X |
| 1.1.2 | Regional (EU) | | | | X | X | X |
| 1.1.3 | Port State/Flag State Requirements | | | | X | X | X |
| 1.1.4 | State (US) | | | | X | X | X |
| 1.1.5 | Port specific requirements | | | | | X | |
| 1.1.6 | Terminal | | | | X | X | |
| **1.2** | **Bunkers** | | | | | | |
| 1.2.1 | Bunker Purchase Contract | RV | | | X | X | X |
| 1.2.2 | Bunker Delivery Note (BDN) | | | | X | X | X |
| 1.2.3 | Proof of Sustainability | | | | X | X | X |
| 1.2.4 | Certificate of Quality (Bunker Spec) | | | | X | X | X |
| 1.2.5 | Verify mass/volume and density | | | | X | X | X |
| **1.3** | **Plan to include discussion on method of bunker delivery:** | RV | | | | | |
| 1.3.1 | Terminal | | | | | X | |
| 1.3.2 | Bunker Vessel | | | | | | X |
| 1.3.3 | STS bunkering | | | | | | X |
| 1.3.4 | Trucks | | | | X | | |
| 1.3.5 | Notification of bunker operation is given to relevant authorities | BV/RV | | | X | X | X |
| **1.4** | **Discuss & document, where relevant, with Responsible Officer on RV:** | BV/RV | | | | | |
| 1.4.1 | Compatibility documents enabling checks on zones (Refer 6.2 of the guidance document) – hazardous, safety & security, mooring, fendering & other compatibility aspects | | | | X | X | X |
| 1.4.2 | Draft, trim and list conditions | | | | X | X | X |
| 1.4.3 | Vessel info/Details/Arrival -BV/RV | | | | X | X | X |
| 1.4.4 | Calculated tank quantities (Converting contracted mass to volume) | | | | X | X | X |
| 1.4.5 | Ensure sufficient ullage space in the tanks for line blowing | RV | | | X | X | X |
| 1.4.6 | Operating limits (environmental) | | | More relevant for STS | X | X | X |
| 1.4.7 | Emergency preparedness/plans | | | | X | X | X |
| **1.5** | **Agreement points - Discuss & agree on:** | | | | | | |
| 1.5.1 | Means of communication | | | | X | X | X |
| 1.5.2 | Emergency procedures | | | | X | X | X |

| 1 | PRE-BUNKERING PHASE (Part A) FT-DIESEL,HVO,FAME | Appl. | Status | Remarks | TTS | PTS | STS |
|---|---|---|---|---|---|---|---|
| 1.5.3 | Hose connection and disconnection procedures incl. purging | | | | X | X | X |
| 1.5.4 | Crew transfer procedures (BV) | | | | | | X |
| 1.5.5 | Use of ESD link | | | | X | X | X |
| 1.5.6 | Use of vapour return | | | | X | X | X |
| 1.5.7 | Access between vessels | | | | | | X |
| 1.5.8 | Mandatory permission points | | | | X | X | X |
| 1.5.9 | Agreement on bunkering schedule in terms of bunkering rates and max pressure (initial rate, max. transfer rate, topping-off rate). | | | | X | X | X |
| 1.5.10 | Fuel quality analysis/sampling requirements | | | | X | X | X |
| **1.6** | **Operational considerations for bunkering** | BV/RV | | | | | |
| 1.6.1 | Ensure valves & actuators are well maintained and in good working order | BV/RV | | | X | X | X |
| 1.6.2 | Ensure availability & sufficiency of suitable PPE | | | | X | X | X |
| 1.6.3 | Ensure all relevant equipment are approved for use | | | | X | X | X |
| 1.6.4 | Hoses, Saddles, drip trays, manifold connections | | | | X | X | X |
| 1.6.5 | Connection, tightness tests and purging | | | | X | X | X |
| **1.7** | **Approach of BV to RV** | | | | | | |
| 1.7.1 | Anchoring considerations to allow favourable approach & mooring for BV | | | | X | X | X |
| **1.8** | **Mooring/Fendering** | BV/RV | | | | | |
| 1.8.1 | Mooring analysis is carried out | | | | X | X | X |
| 1.8.2 | Mooring equipment is in good condition and ready for use | | | | X | X | X |
| 1.8.3 | Mooring and fendering arrangement is agreed | | | | X | X | X |
| 1.8.4 | Fendering and safety distances | | | | X | X | X |
| **1.9** | **Determine organizational plan during bunker (example below):** | BV/RV | | | | | |
| 1.9.1 | Duty officer (deck) | | | | X | X | X |
| 1.9.2 | Person in charge of bunkering | | | | X | X | X |
| 1.9.3 | Persons assisting with bunkering | | | | X | X | X |
| 1.9.4 | Fuel tank and bunker / lube oil manifold manning | | | | | | X |
| 1.9.5 | Ensure continuous supervision at the bunkering manifold | | | | X | X | X |
| **1.10** | **Adequacy of illumination** | BV/RV | | | | | |
| 1.10.1 | Evaluate the need for nighttime operations | BV/RV | | | | | X |
| 1.10.2 | Evaluate feasibility of start & completion of operation during daylight | | | | | | X |
| 1.10.3 | Ensure adequate lighting for nighttime operations | | | | X | X | X |
| **1.11** | **Other considerations** | | | | | | |
| 1.11.1 | Restricted area classifications are compatible Classification in terms of Hazardous, Safety & Security zones & ex-considerations (Refer 6.2 of the guidance document) | BV/RV | | | | | X |
| 1.11.2 | Ensure that means for prevention of static electric discharge is available and functional | BV/RV | | | X | X | X |
| 1.11.3 | Ensure fuel control, P/V valves/ESD system, Fire | BV/RV | | | X | X | X |

| 1 | PRE-BUNKERING PHASE (Part A) FT-DIESEL,HVO,FAME | Appl. | Status | Remarks | TTS | PTS | STS |
|---|---|---|---|---|---|---|---|
| | fighting systems are functional and appropriate with regards to configuration of bunker stations – closed/semi closed. | | | | | | |
| 1.11.4 | Ensure unused bunker connections are blanked and fully secured | BV/RV | | | X | X | X |
| 1.11.5 | Considerations towards environmental protection in case of spills | BV/RV | | | X | X | X |
| 1.11.6 | Ensure that an International Shore connection is available (on RV) | BV/RV | | | X | X | X |
| 1.11.7 | Consider the need for closure of external doors, portholes & other devices to prevent gas ingress into non-hazardous spaces during bunkering | BV/RV | | | X | X | X |
| 1.11.8 | Ensure steering and propulsion can be readily deployed - i.e. Vessels can sail under its own power in a safe and non-obstructed direction | BV/RV | | | X | X | |
| **A2** | **Alignment – To be Recorded & signed off** | | | | | | |
| **2.1** | **Record agreed operational limits** | BV/RV | | | | | |
| 2.1.1 | Wind speed | | | | X | X | X |
| 2.1.2 | Wave heights | | | | X | X | X |
| 2.1.3 | Draft and tidal conditions | | | | X | X | X |
| 2.1.4 | Forecast for Thunderstorms | | | | X | X | X |
| 2.1.5 | Visibility & other criteria | | | | X | X | X |
| 2.1.6 | Record agreed bunker specifications: product/grade, density, volume (in m3) at loading temperature, loading temperature, transfer rates, and line pressures as agreed. | | | | X | X | X |
| **2.2** | **Safe access confirmation** | BV/RV | | | | | |
| 2.2.1 | Ensure safe access between the ships | | | | | | X |
| 2.2.2 | Ensure access between the ship and shore is safe and controlled | | | | X | X | |
| **2.3** | **Ensure adequateness of operation supervision and watchkeeping** | BV/RV | | | | | |
| 2.3.1 | Agreed upon Means of communications | | | | X | X | X |
| 2.3.2 | Ensure awareness of Emergency shutdown event, location of emergency stop buttons, ESD link functionality | | | | X | X | X |
| **2.4** | **Ensure operational/safety measures are agreed upon** | BV/RV | | | | | |
| 2.4.1 | Ensure that the different zones/boundaries are well understood (Refer 6.2 of the guidance document) | | | | X | X | X |
| 2.4.2 | Ensure use of ex proof Inside Haz Zone | | | | X | X | X |
| 2.4.3 | Material Safety data sheets (MSDS) are available | | | | X | X | X |
| 2.4.4 | Agreed safety measures within the safety area are in place including the use of proper PPE - EEBD, Portable gas detectors etc. | | | | X | X | X |
| 2.4.5 | Incident management planning is in place to treat injuries - for e.g. use of antidotes/Medical assistance | | | | X | X | X |

| 1 | PRE-BUNKERING PHASE (Part A) FT-DIESEL,HVO,FAME | Appl. | Status | Remarks | TTS | PTS | STS |
|---|---|---|---|---|---|---|---|
| 2.4.6 | Sampling procedure and equipment is provided | | | | X | X | X |
| 2.4.7 | Vapour management procedures - both vapor return and /or vapor balancing are agreed upon & prepared | | | | X | X | X |
| 2.4.8 | Ensure that arrangements for preventing static electrical discharge are operational (hose and coupling) | | | | X | X | X |
| **2.5** | **Emergency preparedness** | BV/RV | | | | | |
| 2.5.1 | Emergency procedures and plans, including the emergency contact list, are known to the persons in charge | | | | X | X | X |
| 2.5.2 | Emergency shut down and release procedures agreed upon | | | | X | X | X |
| **2.6** | **SIMOPS** | | | | | | |
| 2.6.1 | Safety procedures and risk mitigation for SIMOPS are made aware of | BV/RV | | Part E | X | X | X |
| **NOTE** | *Although some of the items are not marked as relevant for truck to ship and port to ship, due considerations may be made to evaluate the need to include these items.* | | | | | | |

# Connection Phase (Part B)

Table 10-13 Checklist for the Connection Phase for bunkering of FT-diesel, HVO & FAME.

| 2 | CONNECTION PHASE (Part B) FT-DIESEL, HVO & FAME | Appl. | Status | Remarks | TTS | PTS | STS |
|---|---|---|---|---|---|---|---|
| **B1** | **Site Equipment Readiness** | | | | | | |
| 1.1 | Master to monitor that weather limits specified in Part A2 are met | RV | | | X | X | X |
| 1.2 | Confirm adequate lighting at manifold | BV/RV | | | X | X | X |
| 1.3 | Confirm transfer equipment (piping, hose, hose supports, flanges, gaskets, etc.) in order including good condition, appropriateness, lining up, rigging etc. | RV | | | X | X | X |
| 1.4 | Confirm tightness testing of relevant bunker equipment:<br>- confirm all bolts are fixed and tightened at bunker manifold (for bolted hose connections)<br>- tightness test for QCDC | BV/RV | | | X | X | X |
| 1.5 | Confirm that the bunker tank's vents/PV valves are operational | RV | | | X | X | X |
| 1.6 | Confirm that tanks and piping have been inerted | RV | | | X | X | X |
| 1.7 | Confirm that bunker manifold drip tray valves are closed, and deck scuppers plugs are fitted | RV | | | X | X | X |
| 1.8 | Blank unused bunker manifolds and close unused bunker manifold valves | RV | | | X | X | X |
| 1.9 | Confirm that all drain valves, purge valves etc. are closed | RV | | | X | X | X |
| 1.10 | Confirm that any overflow tank, if installed, is empty | RV | | | X | X | X |
| 1.11 | Confirm that spill containment systems and equipment are available and ready | RV | | | X | X | X |
| 1.12 | If vapor return/balancing is applicable, confirm that Bunker and vapor hoses are correctly connected, and pressure monitoring systems are operational | | | | | | X |
| **B2** | **Safety Systems** | | | | | | |
| 2.1 | All safety systems associated with bunkering shall be tested. This includes the fire and gas detection system and emergency shut-down system, emergency stop buttons, ESD arrangements including automatic valves and ESD link system, and automatic closing of ship bunker valve at high-high level in fuel tank. | BV/RV | | | X | X | X |
| 2.2 | Confirm that all portable electrical equipment incl. Communication equipment used within Hazardous zones are confirmed ex-certified | | | | X | X | X |
| 2.3 | Confirm that arrangements for preventing static electrical discharge are operational | BV/RV | | | X | X | X |
| 2.4 | Test all tank alarms (high [95%] and overfill alarms [98%]) | RV | | | X | X | X |
| 2.5 | Consider additional high level alarm setting to 90% of nominated loading level | RV | | | X | X | X |
| 2.6 | Monitor filling in non-loading tanks or set alarms to warn of change in non-loading tanks | RV | | | X | X | X |
| 2.7 | Confirm that flash point is above 60C (quality certificate) | RV | | | X | X | X |
| **B3** | **System Preparation** | | | | | | |

| 2 | CONNECTION PHASE (Part B) FT-DIESEL, HVO & FAME | Appl. | Status | Remarks | TTS | PTS | STS |
|---|---|---|---|---|---|---|---|
| 3.1 | Transfer system tested and ready for use in accordance with an approved bunkering procedure | RV | | | X | X | X |
| 3.2 | Agreement on bunkering schedule & rates | | | | X | X | X |
| 3.3 | Control valves are in the correct initial positions | RV | | | X | X | X |
| 3.4 | Vapour return system tested and ready for use | BV/RV | | | | | X |
| 3.5 | Keep all doors to non-hazardous spaces closed. | RV | | | X | X | X |
| 3.6 | Consider measures to operate ventilation systems to reduce gas ingress into non-hazardous spaces | RV | | | X | X | X |
| 3.7 | Avoid internal transfers between FTDH tanks | RV | | | | | X |
| **B4** | **Agreement Points - To be Recorded & signed off in a Safety Meeting** | | | | | | |
| 4.1 | Master to confirm permission for barge to come alongside | RV | | | | | X |
| 4.2 | Safety data sheets are available and reviewed | BV/RV | | | X | X | X |
| 4.3 | Hazardous properties of the product to be transferred identified in the safety data sheet are discussed | BV/RV | | | X | X | X |
| 4.4 | Personnel transfer and lifting to follow ship's procedures for the same including risk assessments as required | RV | | | X | X | X |
| 4.5 | Responsible Engineer to confirm barge soundings | RV | | | X | X | X |
| 4.6 | Bunker watch is established | BV/RV | | | X | X | X |
| 4.7 | Bunker tanks to be loaded (in m3) with tank number, capacities (before, free volume and final volumes) are to be agreed. | BV/RV | | | X | X | X |
| 4.8 | Smoking restrictions and designated smoking areas are established | BV/RV | | | X | X | X |
| 4.9 | Naked light restrictions are established | BV/RV | | | X | X | X |
| 4.10 | Discuss and complete standard Bunker Checklist (for e.g. ISGOTT for tankers) | RV | | | X | X | X |

# Transfer Phase (Part C)

Table 10-14 Checklist for the Transfer Phase for bunkering of FT-diesel, HVO & FAME.

| 3 | TRANSFER PHASE (Part C) FT-DIESEL, HVO & FAME | Appl. | Status | Remarks | TTS | PTS | STS |
|---|---|---|---|---|---|---|---|
| | **Requires repetitive checks with frequency of checks to be agreed (for example every 30 mins)** | | | | | | |
| **C1** | **Vessel Approach & positioning** | | | | | | |
| 1.1 | Weather conditions are within limits agreed upon in Part A | | | | X | X | X |
| 1.2 | Mooring arrangement is secure | BV/RV | | | | | X |
| 1.3 | Fenders are in place and functional | BV/RV | | | | | X |
| 1.4 | Access between vessels is adequate | BV/RV | | | | | X |
| 1.5 | Communication is functioning | BV/RV | | | X | X | X |
| 1.6 | In the case of nighttime operations the lighting is sufficient for the bunker area to be well illuminated | | | | X | X | X |
| 1.7 | Doors to non-hazardous spaces are closed and measures are taken to operate ventilation systems to reduce potential gas ingress into these spaces. | | | | X | X | X |
| 1.8 | Steering and propulsion of Bunker/Receiving vessel can be readily deployed so the vessel can sail under its own power in a safe and non-obstructed direction | BV/RV | | | | | X |
| **C2** | **Safety and Operational Procedures** | | | | | | |
| 2.1 | Ensure that the designated zones maintained | | | | X | X | X |
| 2.2 | Ensure that all electrical equipment used within hazardous zones is explosion-proof (Ex-proof) to prevent ignition. | | | | X | X | X |
| 2.3 | Emergency procedures and plans are in place, including emergency contact list, incident management planning, and emergency shut down and release procedures | | | | X | X | X |
| 2.4 | Firefighting systems are in place and functional | | | | X | X | X |
| 2.5 | Ensure availability of PPE | | | | X | X | X |
| 2.6 | Ignition sources are under control | BV/RV | | | X | X | X |
| 2.7 | Toxic fumes are managed | BV/RV | | | X | X | X |
| **C3** | **Watchkeeping** | | | | | | |
| 3.1 | Ensure monitoring of all connections and bunker lines for potential leakages, line pressure, and levels of non-nominated FTDH tanks | | | | X | X | X |
| 3.2 | Naked light restrictions are complied with | | | | X | X | X |
| 3.3 | Smoking restrictions and designated smoking areas are maintained | | | | X | X | X |
| 3.4 | Save-all, drains and scuppers are plugged | | | | X | X | X |
| 3.5 | Bunker Sounding Log at half hour intervals | | | | X | X | X |
| 3.6 | Compare with supplier's figures | | | | X | X | X |
| 3.7 | Responsible Officer to Inform bunkering facility when bunkered tanks reach agreed levels (for e.g. 70% or 75%) | | | | X | X | X |
| 3.8 | Relevant restrictions are in place during SIMOPS (see Part E) | RV | | Ref. Part E | X | X | X |

# Disconnection of bunkering equipment (Part D)

Table 10-15 Checklist for the Post Transfer Operations for bunkering of FT-diesel, HVO & FAME.

| 4 | DISCONNECTION PHASE (Part D) FT-DIESEL, HVO & FAME | Appl. | Status | Remarks | TTS | PTS | STS |
|---|---|---|---|---|---|---|---|
| **D1** | **Prior to disconnection** | | | | | | |
| 1.1 | Ensure adjusted loading rate during top off of tanks and open additional tanks if relevant | RV | | | X | X | X |
| 1.2 | Provide adequate notice to the bunker supplier to allow them to adjust their loading operations accordingly. | RV | | To be logged | X | X | X |
| 1.3 | System Preparation: Relevant bunker hoses, vapour return lines, fixed pipelines and manifolds are: | BV/RV | | | X | X | X |
| 1.3.1 | Purged | | | | X | X | X |
| 1.3.2 | Inerted | | | | X | X | X |
| 1.3.3 | Depressurized | | | | X | X | X |
| 1.3.4 | Liquid free/ drained (if local rules permit, blow through transfer hoses) | | | | X | X | X |
| 1.3.5 | Ready for disconnection | | | | X | X | X |
| 1.4 | All remotely and manually operated valves are closed as required for safe disconnection | BV/RV | | To be logged | X | X | X |
| 1.5 | Advise Officer on Watch (OOW) when bunkering complete | BV/RV | | To be logged | X | X | X |
| 1.6 | Bunker/Receiving vessel is notified on “ready to disconnect” | BV/RV | | | | | X |
| 1.6.1 | Disconnect transfer hose | | | | | | X |
| 1.6.2 | Transfer any oil collected in fixed or portable containment | | | | | | X |
| **D2** | **Post disconnection** | | | | | | |
| 2.1 | Bunker area on the vessel is cleared and restored to standard condition | BV/RV | | | X | X | X |
| 2.2 | Manifold blanks are replaced | | | | X | X | X |
| 2.3 | Relevant documents are signed and exchanged | BV/RV | | To be logged | X | X | X |
| 2.3.1 | Sign bunker delivery notes (BDN) after verifying Quantities shown/BDN details (Chemical contents etc.) | | | | X | X | X |
| 2.3.2 | Apply temperature and density corrections to convert: Gross to net volume/ Net volume to weight | | | | X | X | X |
| 2.3.3 | Update logbooks in accordance with vessel procedures | | | | X | X | X |
| 2.4 | Competent authorities are notified on the completion of the bunker operation | BV/RV | | To be logged | X | X | X |
| 2.5 | Near misses and incidents are reported to competent authorities | BV/RV | | To be logged | X | X | X |

# Simultaneous Operations – SIMOPS (Part E)

Table 10-16 Checklist for Simultaneous Operations when bunkering of FT-diesel, HVO & FAME.

| 5 | SIMOPS (Part E) FT-DIESEL, HVO & FAME | Appl. | Status | Remarks | TTS | PTS | STS |
|---|---|---|---|---|---|---|---|
| | **SIMOPS should be avoided as far as practicable and to be done only if absolutely necessary.** | | | | | | |
| **E1** | **Operational restrictions** | | | | | | |
| 1.1 | Ensure no stores or garbage handling during bunker operations & other operations such as oily bilge/sludge, transfer, loading and unloading of stores, etc. | RV | | Most applicable for STS | X | X | X |
| 1.2 | Any labour-intensive tasks to be done in parallel with bunkering to be risk assessed | RV | | applicable for STS | X | X | X |
| 1.3 | No cargo operations to be planned when bunkering but if unavoidable a separate risk assessment to be done | RV | | | X | X | X |
| 1.4 | Avoid scheduling vetting, charterers, Flag State or other inspection or audit | RV | | | X | X | X |
| 1.5 | Ensure compliance with procedures for internal transfer of bunker/cargo | RV | | | X | X | X |
| 1.6 | Clear protocols for: information sharing, coordination, and emergency response | BV/RV | | | X | X | X |
| 1.7 | Clear communication channels are established between all parties involved | BV/RV | | | X | X | X |
| 1.8 | Permit-to-work system is implemented for critical activities during SIMOPS | BV/RV | | | X | X | X |
| **E2** | **SIMOPS Planning** | | | | | | |
| 2.1 | Planned SIMOPS are in accordance with the safety procedures and risk mitigation in ship's operational documentation for Receiving Vessel. | RV | | To be logged | X | X | X |
| 2.2 | Ensure that SIMOPS are compliant with local regulations and restrictions | RV | | To be logged | X | X | X |
| **E3** | **Safety considerations** | | | | | | |
| 3.1 | Safety procedures and risk mitigation for SIMOPS are made aware of to all parties concerned | RV | | To be logged | X | X | X |
| 3.1.1 | Establish a safe working area for bunkering operations, free from obstructions and potential hazards. | RV | | | X | X | X |
| 3.1.2 | Strict zoning is implemented: operations are segregated, areas for bunkering, cargo handling, and personnel movement is clearly defined | RV | | | X | X | X |
| 3.1.3 | Ignition source control: equipment ex-certified for zone 1 is used, and inspections are carried out regularly | RV | | | X | X | X |
| 3.1.4 | Surveillance and monitoring of bunkering and cargo operations are increased during SIMOPS | BV/RV | | | X | X | X |
| **E4** | **Continuous monitoring** | | | | | | |
| 4.1 | Ignition source & toxicity restrictions are observed Ex-proof in Haz zones, EEBD, PPE, Gas detection, use of antidotes/Medical assistance on board | RV | | | X | X | X |
| 4.2 | Areas with potential gas accumulation are particularly checked | RV | | | X | X | X |

| 5 | SIMOPS (Part E) FT-DIESEL, HVO & FAME | Appl. | Status | Remarks | TTS | PTS | STS |
|---|---|---|---|---|---|---|---|
| 4.3 | SIMOPS restrictions are observed | RV | | To be logged | X | X | X |
| 4.4 | Maintain adequate separation between bunkering operations and cargo handling activities to prevent interference and potential hazards. | BV/RV | | | X | X | X |
| 4.5 | Be aware of how ship movement due to cargo operations may affect bunkering stability and prevent overflows. | RV | | | | | X |
| 4.6 | Address potential dust issues from cargo operations and the impact of weather conditions on dust movement. | RV | | | X | X | X |
| 4.7 | Dedicated personnel are assigned to oversee SIMOPS activities | RV | | | | | X |
| 4.8 | Dedicated personnel have specific training in managing SIMOPS and coordinating with the bunker team | RV | | | | | X |

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