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Baltic Ports Bunkering Guidebook

Methanol and Ammonia
as Marine Fuels

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Executive Summary

The transition to climate-neutral port operations in the Baltic Sea region requires a clear and coherent approach for the safe use of hydrogen-derived fuels. Methanol and ammonia are emerging as key energy carriers for maritime decarbonisation. However, port regulations, permitting procedures, and safety requirements vary widely between countries and individual ports, creating challenges for operators, regulators, and infrastructure developers planning for large-scale deployment of these alternative fuels.

The Interreg H2 Derivatives @ Baltic Sea Ports project, through Work Package 1.3, addresses this challenge by developing a harmonised framework for methanol and ammonia operations, presented in this Port Safety Handling Guidebook for Methanol and Ammonia as Marine Fuels. By reviewing EU, IMO, and other relevant international regulations, identifying best practices, and engaging partner ports, this work supports the safe, consistent, and scalable adoption of methanol and ammonia across the region.

This document serves primarily as an implementation guide for ports and port authorities, providing a practical framework to establish and maintain safe bunkering operations for ammonia and methanol within their jurisdiction. It provides core knowledge on bunkering, as well as fuel-specific considerations, to assist ports in achieving compliance with safety standards and best practices. It does not replace, amend, or supersede national legislation, port by-laws, or mandatory regulatory requirements, and is neither a design manual nor a legal interpretation. The guide is written from the port perspective, outlining the responsibilities and actions required by the port authority, while also addressing the roles and obligations of stakeholders such as ship operators, fuel suppliers, and terminal operators who wish to conduct bunkering operations.

The guide is intended for those directly responsible for bunkering safety and operations, including port safety officers and their safety teams. It will also be of value to national and local authorities, emergency response and support services, terminal operators, and other stakeholders as fuel suppliers and ship operators involved in bunkering or receiving ammonia and methanol fuels, providing them with clear guidance on what is expected when operating in the port.

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Abbreviations

ADR – European Agreement concerning the International Carriage of Dangerous Goods by Road
AEA – Ammonia Energy Association
AEGL – Acute Exposure Guideline Levels
AEGL-1 / AEGL-2 / AEGL-3 – Acute Exposure Guideline Level bands
BSL – Bunkering Safety Link
BSV – Bunker Supply Vessel
CFD – Computational Fluid Dynamics
EPA – Environmental Protection Agency (United States)
ERC – Emergency Release Coupler
EMSA – European Maritime Safety Agency
ESD – Emergency Shutdown
GHG – Greenhouse Gas
HAZID – Hazard Identification
HAZOP – Hazard and Operability Study
IBC Code – International Code for the Construction and Equipment of Ships Carrying Dangerous Chemicals in Bulk
IACS – International Association of Classification Societies
IDLH – Immediately Dangerous to Life or Health
IGC Code – International Code for the Construction and Equipment of Ships Carrying Liquefied Gases in Bulk
IGF Code – International Code of Safety for Ships Using Gases or Other Low-Flashpoint Fuels
IMDG Code – International Maritime Dangerous Goods Code
IMO – International Maritime Organization
IAPH – International Association of Ports and Harbors
ISGOTT – International Safety Guide for Oil Tankers and Terminals
ISO – International Organization for Standardization
JBP – Joint Bunkering Plan
JPBO – Joint Plan of Bunkering Operation
LCA – Life-Cycle Assessment
LEL – Lower Explosive Limit
LFL – Lower Flammable Limit
MGO – Marine Gas Oil
MIE – Minimum Ignition Energy
MI – Methanol Institute
OCIMF – Oil Companies International Marine Forum
OELs – Occupational Exposure Limits
PIC – Person in Charge
POAC – Person in Overall Advisory Control
PPE – Personal Protective Equipment
PRL – Port Readiness Level (IAPH PRL for Marine Fuels)
PRV – Pressure Relief Valve
QCA – Quantitative Consequence Assessment
QRA – Quantitative Risk Assessment
QualRA – Qualitative Risk Assessment
SCBA – Self-Contained Breathing Apparatus
SCR – Selective Catalytic Reduction

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SGMF – Society for Gas as a Marine Fuel
SIGTTO – Society of International Gas Tanker and Terminal Operators
SIMOPs – Simultaneous Operations
SIRE – Ship Inspection Report Programme
STS – Ship-to-Ship
STEL – Short-Term Exposure Limit
TWA – Time-Weighted Average
VTS – Vessel Traffic Services

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Introduction

The transition toward low- and zero-carbon shipping requires ports to adopt safe, practical, and consistent approaches to alternative fuel handling. As methanol and ammonia gain prominence as hydrogen-derived marine fuels, ports should be prepared to manage their bunkering safely and in alignment with evolving regulatory expectations. The Baltic Ports Bunkering Guidebook for Methanol and Ammonia as Marine Fuels has been developed to support this transition by providing a clear implementation framework tailored to port authorities and their stakeholders.

The guide recognises that ports are at different stages of readiness and face varying regulatory environments, infrastructure constraints, and commercial drivers. The Guidebook does not seek to prescribe a single approach or replace national regulations or international standards. Instead, it provides ports with a coherent framework, shared terminology, and practical guidance to help them make informed, defensible decisions when enabling methanol and ammonia bunkering.

Central to the Guidebook is a staged **Ports Roadmap to Bunkering**, which supports ports in progressing from early strategic intent through pilot operations to business-as-usual bunkering. The guidance emphasises risk-based decision-making, use of existing industry standards and tools, and early engagement with stakeholders and regulators. By applying this Guidebook, ports can build confidence, consistency, and transparency in how methanol and ammonia bunkering is assessed, authorised, and managed within the port environment.

Clarification on the Use of the Term “Port”

This Guidebook addresses the role of “ports” in the introduction and oversight of alternative fuel bunkering operations. However, it is recognised that the legal responsibilities, statutory powers, enforcement capability, and organisational structures of ports vary significantly across jurisdictions. Different legal systems use different terminology and institutional arrangements, such as port authority, harbour authority, harbour master, maritime administration, terminal operator, municipal authority, or other designated competent authority.

In some jurisdictions, the port authority is a public-law body with statutory powers. In others, the port operator may be a private entity acting under concession, while regulatory oversight is exercised by a separate national maritime administration or transport ministry. The harbour master may hold specific powers relating to navigational safety and operational control within port limits. Environmental, occupational health and safety, and major hazard regulations may be enforced by separate national or regional authorities.

Acknowledging these differences, this Guidebook cannot prescribe jurisdiction-specific governance models. **The term “port” is therefore used in a functional sense**, referring to the entity or group of entities that hold responsibility and accountability within a given jurisdiction for authorising, overseeing, and enforcing bunkering activities within port limits. **Each jurisdiction should define, within its own legal and regulatory framework, which authority or combination of authorities fulfils this role.**

As responsibilities may be shared between multiple organisations. Clear identification of roles, statutory powers, and decision-making responsibilities within each jurisdiction is therefore essential before implementing methanol or ammonia bunkering operations.

Use of this Guidebook – Structure and Approach

This Guidebook is structured to support ports at different stages of readiness for methanol and ammonia bunkering, from early strategic consideration through to business-as-usual operations.

It is organised into five complementary chapters:

- **Ports Roadmap to Bunkering**, which provides a staged, decision-gated pathway;
- **Key Bunkering Knowledge**, covering foundational concepts applicable across fuels and supply scenarios;
- **Fuel Knowledge**, addressing methanol and ammonia characteristics, hazards, and risk drivers;
- **Implementation Guidance**, offering practical direction for ports on governance, site selection, risk assessment, licensing, operations, training, and emergency preparedness;
- **Appendices**, providing tools, checklists, and reference material to support application in practice.

The Guidebook is intended to be used flexibly. Ports may focus on the sections most relevant to their current readiness level and return to others as their framework and experience evolve.

Disclaimer

This Guidebook provides non-binding guidance intended to support ports and port authorities in the safe planning and implementation of methanol and ammonia bunkering operations. It does not replace, amend, or supersede national legislation, port by-laws, or mandatory regulatory requirements, and is neither a design manual nor a legal interpretation. Ports are expected to integrate the guidance contained in this document into their own local regulatory frameworks, procedures, and authorisation processes, in accordance with applicable national laws and the requirements of the competent authorities. Where differences arise, national legislation and port-specific rules shall prevail.

Methodology

This Guidebook has been developed through a structured, collaborative and iterative process combining research, practitioner input and partner review.

The work began with background research and the development of a proposed chapter structure and content list. This initial phase included a review of existing regulatory instruments, relevant industry guidance, and emerging practices related to methanol and ammonia bunkering, together with experience drawn from LNG implementation in ports. The objective was to establish a solid analytical foundation and identify the key themes requiring structured guidance.

A structured workshop was subsequently convened with project partners and invited stakeholders. Participants were invited to comment on and refine the proposed content list, identify priority risk areas, highlight governance challenges, and share practical port-level constraints and lessons learned from pilot and early-stage projects. These discussions were instrumental in shaping the overall architecture of the Guidebook and ensuring that it addressed concrete operational and regulatory questions rather than theoretical considerations.

Following the workshops, the authors undertook detailed research and drafting. This phase combined further review of international instruments and standards, analysis of existing bunkering frameworks including LNG, assessment of fuel-specific hazard characteristics for methanol and ammonia, and the direct professional experience of the authors in alternative fuel projects. The drafting process sought to translate these inputs into a coherent roadmap and governance framework applicable across jurisdictions.

A full draft was then circulated to all project partners for structured review. Comments were consolidated, discussed and systematically addressed, with particular attention given to technical accuracy, regulatory neutrality and practical applicability across different legal and institutional contexts.

Finally, a dedicated review meeting with core partners was held to validate the near-final draft. This meeting ensured alignment on terminology, scope, governance assumptions and the overall balance between flexibility and clarity. Final refinements were incorporated prior to issue.

Throughout the development process, inputs from formal research and the practical experience of partners and authors were continuously integrated.

Rationale for a roadmap and framework approach

The decision to structure the Guidebook around a staged roadmap and implementation framework reflects the current state of industry development.

Ports and regulators are still in an experience-building phase for methanol and ammonia bunkering. Unlike conventional fuels, and unlike LNG today, there is not yet a consolidated body of widely accepted “best practice” for these fuels. Operational data, life-cycle evidence, and long-term case studies remain limited.

In this context, prescribing fixed models, detailed checklists or uniform technical solutions would be premature. Instead, the Guidebook adopts:

- a staged roadmap with defined decision gates;
- a governance and risk-based framework;
- a scalable implementation logic.

The roadmap provides structure without rigidity. It enables ports to:

- build internal capability;
- engage stakeholders progressively;
- validate feasibility through risk assessment;
- move from pilot to business-as-usual in a controlled manner.

This approach reflects several three underlying realities:

- First, responsibilities for bunkering oversight are often shared across multiple entities. In many jurisdictions, port authorities, harbour masters, national regulators, environmental agencies, terminal operators and emergency services each hold defined roles. A framework-based approach helps to clarify interfaces, decision-making responsibilities and escalation pathways without imposing a single governance model that may not align with national legal structures.
- Second, methanol and ammonia present distinct hazard profiles. Differences in flammability, toxicity and dispersion behaviour mean that controls cannot be assumed transferable from one fuel to another without analysis. A structured framework ensures that operational envelopes, safety zones and documentation requirements are derived from fuel-specific risk assessment rather than presumed equivalence.
- Third, regulatory expectations continue to develop at both national and international levels. A flexible framework enables ports to align with existing legislation, incorporate evolving standards, and adapt to new guidance without requiring fundamental restructuring of their governance model. In this way, the roadmap and framework together provide a stable yet adaptable foundation for safe implementation during a period of technical and regulatory evolution.

Fuel-Agnostic Design with LNG as Reference

Although this Guidebook focuses on methanol and ammonia, the roadmap and overarching framework are intentionally fuel-agnostic. The governance logic, staged development model, risk-based control philosophy, and documentation structure are designed to be applicable to other alternative marine fuels, as this follows international established practise. In this respect, the framework establishes a transferable decision-making architecture rather than a fuel-specific technical manual.

The LNG implementation pathway has been used as a reference point, as LNG represents the most mature example of alternative fuel integration within port environments. Its evolution from pilot projects to routine operations provides valuable lessons in staged development, permitting structures, risk assessment methodologies, and the progressive refinement of documentation and oversight.

At the same time, the Guidebook does not assume direct equivalence between LNG and methanol or ammonia. The distinct physical, chemical and toxicological characteristics of these fuels have been explicitly presented within the framework, and fuel-specific differences are addressed where they materially affect risk assessment, operational controls or emergency preparedness.

Summary

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The methodology combines structured research, multi-stakeholder input, expert drafting, iterative review, and validation. The resulting roadmap and framework reflect the current transitional phase of methanol and ammonia bunkering:

- structured, but not prescriptive;
- risk-based, but proportionate;
- scalable, but defensible;
- fuel-agnostic in structure, yet fuel-specific in hazard treatment.

This approach enables ports to progress safely from strategic consideration to pilot operations and ultimately to business-as-usual bunkering, while remaining adaptable to evolving regulation and operational experience.

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Ports Roadmap to Bunkering 1.

This ports roadmap provides a practical, step-by-step pathway to support the introduction of methanol and ammonia bunkering, from initial consideration through to routine, business-as-usual operations (see figure 1-1 and appendix E).

It is intended as practical tool to supports ports that are progressing from pilot projects to mature operations.

While the steps are presented in a logical sequence, ports may adapt the order, revisit steps, or progress in parallel depending on local context, regulatory frameworks, and commercial drivers.

Ports Roadmap to Bunkering	
<p>CHECKLIST for steps and decision gates for alternative fuels bunkering</p> <p>The ports roadmap is structured into 15 implementation steps, grouped into four development phases, and punctuated by four decision gates.</p>	
<p>Phase A – Strategic foundation (Steps 1–4 Gate 1)</p>	
Step 1 – Assess the business case and strategic rationale	Clarify why alternative fuel bunkering is relevant to the port, which fuels are in scope, and over what timeframe.
Step 2 – Build internal knowledge and assign ownership	Establish baseline fuel knowledge and assign clear internal responsibility across safety, marine, environment, and permitting functions.
Step 3 – Establish governance and competent authority roles	Define decision authority, escalation paths, and internal risk acceptance principles.
Step 4 – Understand the regulatory and standards landscape	Identify applicable national and international regulations, standards, and guidance, and where early regulator engagement is needed.
<p>Gate 1 – Strategic Readiness and Internal Alignment</p> <p>Decision focus: Is there a clear strategic case and sufficient internal alignment to proceed?</p> <p>Confirms that:</p> <ul style="list-style-type: none"> A strategic rationale and indicative timeline are defined Internal ownership and governance are clear Regulatory context is understood at a high level No fundamental barriers are evident 	
<p>Phase B – Feasibility and alignment (Steps 5–8 Gate 2)</p>	
Step 5 – Wider stakeholder and public engagement	Engage regulators, terminals, emergency services, port users, and - where relevant - local authorities and the public.
Step 6 – Identify potential bunkering locations	Proactively screen and shortlist candidate locations based on navigational, spatial, and emergency response considerations.
Step 7 – Define bunkering scenarios and fuel suitability	Identify feasible supply modes and fuel-specific constraints for each candidate location.
Step 8 – Undertake risk assessments and define controlled areas	Review risk assessments to define safety zones, toxic areas (where applicable), SIMOPs constraints, and operational limits.
<p>Gate 2 – Strategic feasibility and stakeholder alignment check</p> <p>Decision focus: Can bunkering be supported in principle within the port's operational, regulatory, and social context?</p> <p>Confirms that:</p> <ul style="list-style-type: none"> Stakeholders and regulators are broadly aligned Feasible locations and bunkering scenarios are identified Risks can be managed within agreed criteria No prohibitive constraints remain 	
<p>Phase C – Implementation and authorisation (Steps 9–13 Gate 3)</p>	
Step 9 – Infrastructure development	Address any physical, spatial, or access constraints needed to support controlled bunkering.
Step 10 – Licensing, permitting, and authorisation processes	Establish proportionate licensing and approval processes aligned with national requirements.
Step 11 – Documentation and operational controls	Define documentation requirements to support safe operations and oversight.
Step 12 – Training and competence	Ensure port personnel, terminals, contractors, and emergency services are trained and prepared.
Step 13 – Emergency preparedness and response	Integrate fuel-specific scenarios into port emergency planning and conduct joint exercises.
<p>Gate 3 – Operational authorisation decision</p> <p>Decision focus: Can the port authorise first or pilot bunkering operations under controlled conditions?</p> <p>Confirms that:</p> <ul style="list-style-type: none"> Infrastructure, procedures, and controls are in place Roles and responsibilities are clear Personnel and responders are trained Emergency arrangements are tested 	
<p>Phase D – Operation and scale-up (Steps 14–15 Gate 4)</p>	
Step 14 – Pilot operations and controlled introduction	Conduct first or pilot operations with enhanced oversight to validate assumptions and controls.
<p>Gate 4 – Pilot validation and scale-up decision</p> <p>Decision focus: Can operations transition beyond pilots?</p> <p>Confirms that:</p> <ul style="list-style-type: none"> Pilot operations have validated assumptions Procedures and controls work in practice Lessons learned are embedded 	
Step 15 – Transition to business-as-usual operations	Progressively integrate bunkering into routine port operations, maintaining a risk-based approach.

Figure 1-1: Checklist for Roadmap to bunkering (see Appendix E)

How to Use the Ports Roadmap to Bunkering 1.1

The ports roadmap is structured into 15 implementation steps, grouped into four development phases, and punctuated by four decision gates.

The steps reflect how ports typically develop new operational activities in practice: starting with strategic intent and basic knowledge, then building governance, stakeholder alignment, technical understanding, operational controls, and emergency preparedness before moving into pilots and scale-up.

Structure of the roadmap 1.1.1

- **15 steps** describe what ports typically need to do, in logical sequence.
- **4 gates** provide structured decision points where ports pause, review progress, and decide whether to proceed, adjust, or stop.
- Each gate represents an increasing level of commitment, resource use, and operational responsibility.

The roadmap is not prescriptive. Ports may:

- adapt the order of steps,
- revisit earlier steps,
- progress in parallel,
- or repeat steps as experience grows or scope changes.

Link to IAPH Port Readiness Levels (PRL) 1.1.2

The IAPH Port Readiness Level for Marine Fuels (PRL-MF) framework is recognised in this guidebook. There is no intention to substitute, replicate or replace that framework.

This guidebook primarily addresses the early stages of preparation and is particularly suited to supporting ports operating at the early to mid PRL-MF levels. It provides structured knowledge and practical guidance to support implementation. The Roadmap presented in Chapter 1 offers one possible approach for these early stages; however, ports remain free to select any methodology to achieve operational readiness. None of the approaches referenced in the document are mandatory.

Where a port elects to use the PRL-MF framework as its primary assessment tool, the technical information and guidance provided in Chapters 2, 3, 4 and the Appendices remain fully applicable and can support progression through the PRL levels.

The mapping presented between the two approaches (see Table 1-1) is explicitly described as indicative rather than prescriptive. There is no intention to formally align or merge the two systems. They can coexist, and a port may choose to apply one approach over the other.

Table 1-1 Ports Roadmap Vs IAPH PRLs

Ports Roadmap Steps & Gates	IAPH Phases and PRLs	
Step 1 – Assess the Business Case and Strategic Rationale	Research	PRL 1 Foundational background information
Step 2 – Build Internal Knowledge and Assign Ownership		
Step 3 – Establish Governance and Competent Authority Roles		
Step 4 – Understand the Regulatory and Standards Landscape		PRL 2 Stakeholder interest and feasibility assessment
GATE 1 – Strategic Readiness and Internal Alignment		
Step 5 – Wider Stakeholder and Public Engagement		PRL 3 Detailed research, analysis and conclusions
Step 6 – Identify Potential Bunkering Locations		
Step 7 – Define Bunkering Scenarios and Fuel Suitability		
Step 8 – Undertake Risk Assessments and Define Controlled Areas		PRL 4 Framework for bunkering of target fuel drafted, timeline developed
GATE 2 – Strategic Feasibility and Stakeholder Alignment Check	Development	
Step 9 – Infrastructure Development and Readiness		PRL 5 Framework for bunkering of target fuel implemented and tested
Step 10 – Develop Licensing, Permitting, and Authorisation Processes		
Step 11 – Define Documentation and Operational Controls		PRL 6 Pilot-scale demonstration of bunkering of target fuel
Step 12 – Training and Competence		
Step 13 – Establish Emergency Preparedness and Response		PRL 7 Bunkering of target fuel established on project basis
GATE 3 – Operational Readiness and Commitment Check		
Step 14 – Pilot Operations and Controlled Introduction		PRL 8 Full capabilities for bunkering of target fuel
GATE 4 – Pilot Validation and Scale-Up Decision	Deployment	
Step 15 – Transition to Business-as-Usual Operations		PRL 9 Market penetration and growth for bunkering of target fuel
<ul style="list-style-type: none"> • The mapping is indicative rather than prescriptive. • The roadmap provides actionable steps to help ports progress through PRLs, while the IAPH PRL framework provides the maturity benchmark. • The roadmap places particular emphasis on the early phases of readiness, helping ports build strategic intent, internal capability, stakeholder alignment, and a robust foundation for safe implementation. • Progression is evidence-based, not automatic - each gate supports a deliberate decision to move forward. 		

How the roadmap works with this guidebook 1.1.3

This roadmap is a navigation tool, not a standalone instruction manual.

- Each step in the roadmap refers to specific sections and appendices of this Guidebook.
- Those sections provide detailed guidance, technical considerations, checklists, and examples relevant to that step.
- Ports are encouraged to use the roadmap to identify what they need to address next, then consult the referenced sections for how to do it.

Used together, the roadmap and the Guidebook allow ports to:

- progress in a structured, risk-based manner;
- avoid unnecessary duplication or premature investment;
- build confidence with regulators, operators, emergency services, and the public;
- transition safely from pilot activities to business-as-usual methanol and ammonia bunkering.

Step 1 – Assess the Business Case and Strategic Rationale

Ports should begin by understanding why methanol and/or ammonia bunkering is relevant to their port.

Key drivers may include:

- Expected demand from shipping lines and fuel suppliers;
- National or regional decarbonisation strategies and regulatory drivers;
- Positioning the port as a clean fuel hub or early mover;
- Alignment with existing cargo flows (e.g. methanol or ammonia already handled as cargo);
- Competitive positioning relative to neighbouring ports.

At this stage, the focus is strategic, not technical. The outcome should be a clear internal view on:

- which fuels are of interest (methanol, ammonia, or both);
- the anticipated timeframe (near-term pilots vs medium-term deployment);
- whether the port intends to actively facilitate bunkering or simply enable it under defined conditions.

Step 2 – Build Internal Knowledge and Assign Ownership

Before engaging externally, ports should establish a minimum internal knowledge base.

Actions typically include:

- Assigning a dedicated lead or small cross-functional team responsible for alternative fuel bunkering;
- Ensuring baseline understanding of methanol and ammonia properties, hazards, and operational implications;
- Clarifying internal roles across safety, marine operations, environment, permitting, legal, and communications.

Fuel-specific background knowledge is provided in:

- Chapter 3 – Fuel Knowledge

This step is critical to ensure that early decisions are informed and consistent, and that the port can engage credibly with regulators, suppliers, and vessel operators.

Step 3 – Establish Governance and Competent Authority Roles

Ports should define how decisions will be made and who holds authority.

This includes:

- Clarifying whether the port authority acts as competent authority in full or in part;
- Defining decision-making responsibilities and escalation paths;
- Establishing internal risk acceptance principles;

Guidance on governance and stakeholder roles is provided in:

- Section 2.2 - Stakeholders identification
- Section 4.1.1 – Role of ports across the four stages for vessel operators
- Section 4.1.2 – Link to the IAPH port readiness level framework

Early clarity on governance avoids delays and inconsistent decisions later.

Step 4 – Understand the Regulatory and Standards Landscape

Ports should identify which regulatory instruments apply and where gaps may exist.

This includes:

- National legislation and port permit conditions;
- International conventions and IMO instruments;
- Applicable ISO standards and industry guidelines.

At this stage, ports should not attempt to create new rules, but rather understand:

- what already applies;
- what may need to be adapted;
- where regulators need to be engaged early.

Relevant material is covered in:

- Section 2.1 - International Regulatory Framework & Guidelines

GATE 1 – Strategic Readiness and Internal Alignment

Gate 1 marks the point at which a port decides whether it is appropriate to move beyond internal exploration and proceed towards structured engagement and implementation planning for methanol and/or ammonia bunkering. Up to this stage, activities are primarily internal, exploratory, and strategic in nature, with limited external engagement.

Up to this point steps are intentionally non-technical and non-committal, focusing on strategic fit, internal capability, and regulatory awareness rather than detailed design or operational decisions.

Gate 1 Decision Focus

Before proceeding beyond Gate 1, the port should confirm that:

- There is a clear strategic rationale for considering methanol and/or ammonia bunkering, aligned with port objectives and market signals.
- An indicative timeline has been established (e.g. near-term pilots, medium-term deployment).
- Internal ownership and accountability are defined, with named leads or teams.
- Governance arrangements and competent authority roles are sufficiently clear to support further work.
- The port has a baseline understanding of:
 - fuels properties and risks, and
 - applicable regulations, standards, and guidance.
- Initial engagement with national regulators or competent authorities, where necessary, has confirmed that no fundamental barriers are evident at this stage.

Constraints and Commitments at Gate 1

At Gate 1:

- External engagement is typically limited to high-level discussions with national administrations, regulators, or matter experts.
- Financial exposure is minimal, generally limited to internal resources, desk studies, or advisory support.
- There is no commitment to permit bunkering operations or invest in infrastructure.
- Decisions remain reversible, allowing the port to pause, defer, or exit without material consequence.

Gate 1 Output

Successful completion of Gate 1 should result in:

- A documented strategic position on methanol and/or ammonia bunkering.
- Agreement to proceed to structured stakeholder engagement, site screening, and risk-based assessment in subsequent stages.
- Confirmation that the port has the resources, capacity, and mandate to move forward.

Only once Gate 1 is passed should the port proceed to more outward-facing activities, including wider stakeholder engagement, site identification, and preparatory risk assessment work.

Step 5 – Wider Stakeholder and Public Engagement

Once the regulatory landscape and governance framework are understood, ports should initiate early engagement with wider stakeholders, including:

- national and local regulators;
- terminal operators and berth owners;
- shipowners and bunkering suppliers;
- emergency services;
- neighbouring industries and port users;
- where relevant, local authorities and the public.

Early, transparent engagement:

- builds trust and social acceptance;
- reduces the risk of late objections or misunderstandings;
- helps align emergency planning and operational expectations.

Relevant material is covered in:

- Section 4.1.3 – Stakeholder engagement

This step is particularly important for ammonia, given its toxicity and public perception.

Step 6 – Identify Potential Bunkering Locations

Rather than assessing each request ad-hoc, ports are encouraged to proactively identify candidate locations.

This typically involves:

- Screening berths, quays, anchorages, and interfaces;
- Considering navigation, traffic, and manoeuvring constraints;
- Reviewing proximity to people, buildings, and sensitive receptors;
- Understanding emergency response access and limitations;
- Recognising that some locations may be suitable for one fuel but not another.

At this stage, locations may be identified as:

- suitable,
- potentially suitable with constraints,
- or not suitable / require further development.

Guidance is provided in:

- Section 4.2.1 – Site identification, design and risk assessment
- Section 4.2.2 – Port bunkering map
- Appendix B – Bunkering site identification process

This step is typically carried out in conjunction with steps 7 and 8 below.

Step 7 – Define Bunkering Scenarios and Fuel Suitability

For each candidate location, ports should identify:

- feasible bunkering supply scenarios (ship-to-ship, shore-to-ship, mobile-to-ship);
- physical constraints (hose reach, manifold access, road access);
- fuel-specific limitations (flammability for methanol, toxicity for ammonia).

Guidance is provided in:

- Section 2.3 – Bunkering supply scenarios
- Section 2.5 – Bunker transfer system

This step ensures that later risk assessments are focused and realistic.

Step 8 – Undertake Risk Assessments and Define Controlled Areas

Risk assessment forms the analytical foundation for all subsequent decisions.

From a port perspective, this includes:

- Qualitative and quantitative risk assessments;
- Consequence and dispersion analyses;
- HAZID / HAZOP
- SIMOPs studies;
- Definition of hazardous areas, safety zones, toxic areas (where applicable), and marine exclusion zones.

Ports typically review and approve these assessments rather than produce them.

Key port actions and decisions at this stage include confirming, in coordination with the national regulator and other competent authorities:

- **Regulatory expectations**, including:
 - the type(s) of risk assessment required;
 - applicable risk acceptance criteria;
 - applicable toxic exposure limits for methanol and ammonia.
- **Assessment assumptions**, specifically for the purpose of defining safety and toxic areas:
 - credible release scenarios;
 - representative release or hole sizes.
- **Operational boundaries**, including:
 - limitations and constraints arising from port layout, neighbouring activities, and navigation;
 - the definition of an assessment zone within which bunkering may be evaluated or conditionally permitted.

The outputs of this step underpin permitting decisions, controlled-area enforcement, SIMOPs management, and emergency preparedness planning, and should be documented in a manner that supports consistent and defensible decision-making by the port.

Guidance is provided in:

- Section 2.6 – Hazardous area, toxic area, safety zones and SIMOPs
- Section 4.3 – Risk assessment framework and controlled areas
- Section 4.4 – Fuel-specific safety zone determination
- Appendix C – Port checklist: reviewing a proposed safety zone
- Appendix D - Further considerations on HAZID, HAZOP and SIMOPs

GATE 2 – Strategic Feasibility and Stakeholder Alignment Check

By this stage, the port has moved beyond internal scoping and has engaged with a wider group of external stakeholders, including regulators, terminals, emergency services, port users, and-where relevant-the public. Activities undertaken between Steps 5 and 8 are resource-intensive and mark a transition from strategic intent to practical feasibility.

Gate 2 provides a structured pause to confirm whether the port is ready to proceed further.

At Gate 2, the port should confirm that:

- **Stakeholder alignment has been established**
 - Key national and local regulators have been engaged and their expectations understood.
 - Terminal operators, berth owners, and emergency services are aligned with the proposed approach.
 - For ammonia in particular, public and local authority concerns have been identified, addressed, or appropriately managed.
 - There is a shared understanding of roles, responsibilities, and escalation pathways.
- **Technical feasibility is sufficiently understood**
 - Candidate bunkering locations have been identified and screened.
 - Feasible bunkering scenarios and fuel suitability have been defined.
 - Risk assessments have demonstrated that risks can be managed within acceptable criteria through defined controls and operational limits.
 - Controlled areas (hazardous areas, safety zones, toxic areas where applicable, marine exclusion zones) are broadly compatible with port layout and operations.
- **Regulatory and risk acceptance clarity has been achieved**
 - The type and depth of risk assessments required are agreed with the competent authority.
 - Risk acceptance criteria and applicable exposure thresholds are defined.
 - No fundamental regulatory barriers have been identified that would prevent progression.
- **Organisational readiness is adequate**
 - The port has sufficient internal capability, knowledge, and resources to move into more detailed design, permitting, and implementation activities.
 - Interfaces between departments (marine, safety, environment, permitting, communications) are functioning effectively.
- **Financial exposure remains controlled**
 - Costs and resource commitments are higher than at Gate 1 but remain proportionate and manageable.
 - No irreversible infrastructure or contractual commitments have been made at this stage.



Decision at Gate 2

At Gate 2, the port should make an explicit decision to:

- proceed to detailed implementation planning, licensing, infrastructure development, and training;
- pause to address identified gaps or stakeholder concerns; or
- revise scope (e.g. fuel type, locations, or timelines) based on findings.

Gate 2 – Output

Successful completion of Gate 2 should result in the following tangible outputs:

- A shared understanding with regulators and key stakeholders of what is feasible and under which conditions methanol and/or ammonia bunkering may proceed.
- A port bunkering map, with locations classified as:
 - suitable,
 - conditionally suitable, or
 - not suitable / require further development.
- A clear definition of feasible bunkering scenarios and fuels for each candidate location.
- Agreed principles for risk assessment, including:
 - risk assessment type(s);
 - risk acceptance criteria;
 - exposure thresholds;
 - credible release scenarios.
- Preliminary definition of controlled areas and operational constraints sufficient to support permitting and emergency planning.
- A go / pause / revise decision by the port authority on whether to proceed to:
 - licensing and permitting,
 - infrastructure development,
 - training and operational readiness.

Passing Gate 2 indicates that methanol and/or ammonia bunkering is credible, achievable, and supportable within the port's regulatory, operational, and social context, and that the port can move forward with confidence toward controlled implementation and business-as-usual operations.

Step 9 – Infrastructure Development and Readiness

Following the previous steps and the development of the port bunkering map, some locations may be identified as conditionally suitable or as requiring further development before bunkering can be safely permitted.

Infrastructure considerations may include, as applicable:

- Berth and quay strength, layout, and load-bearing capacity;
- Available quay space and the ability to establish and enforce safety and segregation zones;
- Access arrangements for bunker supply vessels, barges, or road tankers;
- Availability and adequacy of utilities, including power, lighting, communications, drainage, and containment;
- Emergency access and egress routes for responders and evacuation;

- Need for fixed or temporary infrastructure, such as bunding, barriers, monitoring systems, or traffic controls.

Not all locations need to be fully developed at the outset. Some areas may be unsuitable for bunkering initially but could be adapted or upgraded over time as operational experience grows, demand increases, and the port transitions from pilot activities to business-as-usual operations. Ports are therefore encouraged to view infrastructure readiness as a progressive and scalable process, aligned with their overall bunkering roadmap and Port Readiness Level.

Step 10 – Develop Licensing, Permitting, and Authorisation Processes

Based on the risk assessment outcomes, ports should establish a proportionate licensing framework.

Key principles include:

- Alignment with national permits;
- Clear requirements for bunker suppliers;
- Avoiding duplication of existing industry documentation;
- Using recognised frameworks (e.g. IAPH, SGMF) where possible.

Guidance is provided in:

- Section 4.2.3 - Bunkering licensing process

Step 11 – Define Documentation and Operational Controls

Ports should specify which documents are required and how they are used.

This includes:

- Bunkering Management Plans;
- Compatibility assessments;
- Joint Plan of Bunkering Operation;
- Bunkering checklists.

Guidance is provided in:

- Section 2.7 - Bunkering Documentation
- Section 4.5 – Core operational controls
- Appendix A – Bunkering documentation for ports

Clarification Note – Documentation Requirements:

Step 11, from a port perspective, focuses on defining the documentation requirements that operators should submit in order to obtain authorisation for bunkering (see Step 10). Ports do not typically prepare operational bunkering documents themselves; rather, they specify, review, and evaluate the documentation submitted by bunker suppliers, terminals, and receiving vessels.

Section 2.7 of this Guidebook provides an overview of the types of documents typically required to support safe bunkering operations. Appendix A provides a more detailed review of the documentation elements, including guidance on what ports should request, review, and verify as part of their approval process.

Step 12 – Training, Competence

Before bunkering operations commence, ports should ensure that all relevant personnel are trained, competent, and prepared to safely manage, supervise, and respond to methanol and ammonia bunkering activities.

This includes, as applicable:

- Training port authority personnel, including safety officers, harbour masters, VTS, and enforcement staff;
- Ensuring terminal staff and contractors involved in or exposed to bunkering operations are appropriately trained;
- Ensuring emergency response services are trained, equipped, and familiar with fuel-specific hazards and response procedures;
- Conducting joint drills and exercises, involving ships, bunker suppliers, terminals, port services, and emergency responders, where appropriate.

Training requirements should be proportionate to the fuel type, with enhanced emphasis for ammonia, and should reflect:

- bunkering frequency and operational complexity;
- proximity to populated or sensitive areas;
- the port's role as competent authority.

Guidance is provided in:

- Section 4.5.6 – Training requirements and safety drills

Training and competence form a critical prerequisite for authorisation and should be reviewed and refreshed as operations evolve, lessons are learned, and bunkering transitions from pilot activities to business-as-usual operations.

Clarification Note – Training Responsibilities:

Section 4.5.6 clarifies that ports are responsible for training their own personnel to a level commensurate with their authority and operational responsibilities. Personnel employed by operators, suppliers, terminals or contractors remain the responsibility of their respective employers.

However, as part of the bunkering licensing and authorisation process, ports should verify that all parties involved demonstrate appropriate training and competence. Ports may define minimum

training standards for stakeholders operating within their jurisdiction and require evidence of compliance during permitting.

Where training is not explicitly mandated by national or international regulation, ports may still establish minimum competence requirements as a condition of authorisation, ensuring safe and consistent operational practices.

Step 13 – Establish Emergency Preparedness and Response

Before bunkering operations commence, ports should ensure that emergency preparedness and response arrangements are established and integrated into the port's existing emergency management framework.

This includes, as applicable:

- Emergency response planning addressing methanol and ammonia scenarios, including spills, fires, toxic releases, and escalation pathways;
- Coordination with external response organisations, including fire brigades, medical services, coastguard, and Vessel Traffic Services (VTS);
- Training and drills, including fuel-specific response scenarios and joint exercises with relevant stakeholders;
- Clear communication, notification, and escalation procedures, ensuring rapid decision-making and coordinated action.

Emergency preparedness should reflect the port's role as competent authority and be proportionate to the fuels handled, operational frequency, and proximity to populated or sensitive areas.

Guidance is provided in:

- Section 4.5.6 – Training requirements and safety drills
- Section 4.6 – Emergency management and response

GATE 3 – Operational Readiness and Commitment Check

Gate 3 represents the transition from feasibility and framework development to operational readiness. By this stage, the port has moved beyond concept and assessment and has made tangible commitments in terms of infrastructure, organisation, procedures, and preparedness.

Activities leading to Gate 3 (Steps 9–13) typically involve financial investment, organisational change, and increased operational responsibility. Gate 3 therefore provides a formal decision point to confirm that the port is ready to authorise and support first bunkering operations in a controlled and safe manner.

Gate 3 – Readiness Verification

At Gate 3, the port should confirm that the following are in place:

- **Infrastructure and Physical Readiness**
 - Bunkering locations are either fully ready or clearly defined as conditionally suitable with documented constraints.
 - Any required infrastructure upgrades (fixed or temporary) have been completed or formally approved.
 - Safety zones, segregation arrangements, access control, drainage, and emergency access routes are practical and enforceable.
- **Licensing, Permitting, and Governance**
 - A licensing and authorisation framework is established and aligned with national permits, regulatory requirements, and risk assessment outcomes.
 - Roles and responsibilities between the port authority, bunker suppliers, terminal operators, and receiving vessels are clearly defined.
 - The port organisation is ready to administer licences, permits, and compliance monitoring.
- **Documentation and Operational Controls**
 - Documentation requirements are defined, proportionate, and published, including Bunkering Management Plans, compatibility assessments, Joint Plans of Bunkering Operation, and bunkering checklists.
 - Documentation supports safe operations and oversight without unnecessary duplication.
 - Clear processes exist for review, approval, and updates.
- **Training and Human Readiness**
 - Port personnel, terminal staff, contractors, VTS, and emergency services are trained and competent for their respective roles.
 - Joint drills and exercises have been conducted or scheduled.
 - Training records, competence tracking, and refresher arrangements are in place.
- **Emergency Preparedness and Response**
 - Emergency response plans for methanol and ammonia are complete and integrated into the port's emergency framework.
 - Coordination with external responders is tested and understood.
 - Communication, notification, and escalation procedures are clear and rehearsed.

Gate 3 – Output

Successful completion of Gate 3 should result in:

- Formal readiness to authorise first bunkering operations, under controlled conditions.
- Approved bunkering locations with defined operational envelopes and constraints.
- Operational licensing and permitting processes in force.
- Trained and competent personnel across the port, terminals, and emergency services.
- Emergency preparedness arrangements validated through exercises or drills.
- A clear decision to proceed with:
 - pilot or first-of-kind operations, or
 - limited business-as-usual operations under defined conditions.

Passing Gate 3 confirms that the port has moved from planning to execution readiness, with the capability to safely manage methanol and/or ammonia bunkering operations and to respond effectively should incidents occur.

Step 14 – Pilot Operations and Controlled Introduction

Many ports will initially introduce methanol and ammonia bunkering through pilot or first-of-kind operations, supported by enhanced oversight and conservative operational controls.

These early operations may involve:

- operation-specific approvals or permits;
- additional constraints on locations, volumes, or simultaneous operations;
- increased monitoring and reporting requirements.

Pilot operations should be used to:

- validate risk assessment assumptions;
- test procedures, documentation, and coordination mechanisms;
- identify gaps, improvements, and lessons learned.

GATE 4 – Pilot Validation and Scale-Up Decision

Gate 4 represents the decision point between controlled pilot operations and the transition to business-as-usual bunkering.

At Gate 4, the port should confirm that:

- Pilot or first-of-kind operations have been completed without unacceptable incidents or unmanaged risks.
- Risk assessment assumptions, safety zones, SIMOPs controls, and emergency arrangements have been validated in practice.
- Procedures, documentation, communication, and coordination mechanisms function effectively under real operating conditions.
- Lessons learned have been captured, reviewed, and incorporated into updated procedures, permits, and training.
- Stakeholders, regulators, and emergency services remain aligned and supportive.

Gate 4 – Output

Successful completion of Gate 4 results in:

- A clear decision to scale up, maintain, or pause methanol and/or ammonia bunkering activities;
- Agreement on whether operations may transition from operation-specific approvals to general or standing licences;
- Confirmation that the port is ready to move from pilot controls to business-as-usual operations, while maintaining a risk-based approach.

Passing Gate 4 confirms that methanol and/or ammonia bunkering is no longer experimental for the port, but an established activity supported by operational experience and continuous improvement.



Step 15 – Transition to Business-as-Usual Operations

As operational experience increases and confidence is established, ports may progressively transition methanol and ammonia bunkering to business-as-usual operations.

This transition may include:

- streamlining and consolidating documentation;
- expanding the range of approved bunkering locations and scenarios;
- moving from operation-specific approvals to general or standing licences;
- reducing administrative burden while maintaining robust safety controls.

This evolution should remain risk-based, supported by evidence from operational experience, and aligned with national regulatory expectations and port governance arrangements.

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Key Bunkering Knowledge 2.

SCOPE AND INTENT:

This chapter provides the **foundational bunkering knowledge** applicable to both methanol and ammonia. It introduces the regulatory framework, key stakeholders and roles, bunkering supply scenarios, transfer systems, safety zones, SIMOPs, and core documentation. This Part establishes common terminology, concepts, and processes that are referenced throughout the Guidebook. It is intended to give ports and stakeholders a shared understanding of how bunkering operations are structured before considering fuel-specific characteristics or implementation actions.

International Regulatory Framework & Guidelines 2.1

This section outlines the current international regulatory landscape for methanol and ammonia as marine fuels. Both fuels remain in an experience-building phase, with regulators and industry collecting operational lessons from early adopters. Methanol already has growing practical use within the fleet, while ammonia is at an earlier stage, with activity focused on research, risk assessments, and pilot projects. As experience increases, the regulatory framework is expected to evolve rapidly. Until dedicated provisions are fully developed, the established LNG regulatory framework provides a useful reference, recognising that the specific properties and risks of methanol and ammonia differ and should be addressed accordingly (see Chapter 3).

KEY TAKEAWAYS:

1. **Methanol and ammonia are emerging marine fuels**, but both remain in an **experience-building phase**, meaning regulations are still evolving as practical knowledge increases.
2. Both fuels fall under the **IMO IGF Code** for low-flashpoint fuels; however, **fuel-specific provisions are incomplete**, and IMO currently relies on **interim guidelines** for methanol/ethanol (MSC.1/Circ.1621) and ammonia (MSC.1/Circ.1687).
3. Ships transporting methanol or ammonia **as cargo and using it as fuel** are regulated separately under the **IGC or IBC Code**.
4. **ISO standards are being developed** to support methanol and ammonia fuel systems; ISO 6583:2024 is already published for methanol. LNG standards ISO 20519, ISO/TS 16901 and ISO/TS 18683 provide a **useful reference** until dedicated standards mature.
5. **National and regional regulations vary widely** and may impose additional requirements on chemical storage, hazardous-substance handling, land-use constraints, occupational safety, and road transport (e.g., ADR). Ports should confirm all applicable national rules.
6. Ports should **ensure national requirements are reflected in port specific procedures** including risk assessments, safety-zone definitions, SIMOPs management, permitting, and operator guidance.
7. A broad range of industry guidelines is available to support implementation, including:
 - **EMSA** studies on ammonia safety and alternative fuels;
 - **IAPH** port readiness frameworks for alternative fuels;
 - **SGMF** bunkering guidelines for methanol and ammonia;
 - **OCIMF – ISGOTT and SIRE 2.0** safety and assurance for vessels and terminals;
 - **IACS/classification societies** rules for alternative-fuel ship design;
 - **SIGTTO** guidance for gas carriers and gas-handling safety;

- **Methanol Institute and Ammonia Energy Association** publications on safe production, handling, and use.
8. Until fuel-specific rules are fully developed, LNG regulatory frameworks can be used as a baseline reference, provided methanol- and ammonia-specific properties and risks are properly accounted for.

CHALLENGES AND GAPS:

1. The international regulatory framework remains fragmented, reflecting the early experience-building phase. It will take time-potentially several years-before requirements converge and a fully consolidated set of rules emerges. This is not unusual: LNG followed a similar path in its early adoption, with gradual alignment achieved only after sufficient operational experience was gained.
2. Ongoing regulatory, standards, and guideline development is focused primarily on ship design and operations, while gaps remain in related areas such as training, and competence requirements. These are expected to be addressed as experience grows and as IMO, ISO, and industry bodies incorporate lessons learned over the next two to three years.
3. Baseline knowledge and competence are still developing across the sector. Methanol and ammonia introduce new risk profiles-flammability, toxicity, corrosivity-and require improved understanding from all stakeholders. Ports should therefore invest early in familiarisation, training, and capacity building as part of their preparation for alternative-fuel bunkering.

IMO regulatory framework 2.1.1

<https://imo-e-publications.org/>

IGF Code

Under the IMO safety framework, methanol and ammonia fall within the International Code of Safety for Ships Using Gases or Other Low-Flashpoint Fuels (IGF Code). As low-flashpoint fuels, but their specific regulatory provisions are still under development.

At present, IMO has issued interim guidelines, recognising the ongoing experience-building phase. These guidelines are not yet mandatory; however, as operational experience grows, new provisions are expected to be developed, adopted and, where appropriate, incorporated into the mandatory requirements of the IGF Code.

Ammonia: Interim guidelines for ships using ammonia as fuel - MSC.1/Circ.1687

Methanol/Ethanol: Interim guidelines for ships using methyl/ethyl alcohol as fuel - MSC.1/Circ.1621

<https://futurefuels.imo.org/safety-guidelines/>

IGC and IBC Codes

A particular case applies to ships using cargo as fuel. Vessels carrying methanol or ammonia that also use these products as fuel are often among the first adopters. Their safety requirements fall primarily under the IGC Code (for liquefied gases) and the IBC Code (for chemical cargoes).

International standards 2.1.2

Work is also progressing under the International Organization for Standardization (ISO) to support the safe use of methanol and ammonia as marine fuels. At present, the following standard has been published:

1. *ISO 6583:2024* - Methanol as a fuel for marine applications: General requirements and specifications.

The following standards are currently under development:

2. *ISO/CD 24941* - Ships and marine technology: Piping and machinery - Safety guidelines for engine rooms of ammonia-fuelled vessels.
3. *ISO/DIS 23397* - Ships and marine technology: Ammonia fuel systems for ships - Vocabulary.

Further ISO work is expected as operational experience increases. In addition, *ISO 20519:2021 - Specification for bunkering of liquefied natural gas fuelled vessels* provides a well-established reference for the design and operation of bunker systems and bunkering procedures. Although ISO 20519 is specific to LNG, its principles and functional requirements for bunkering system configuration, safety management, and operational control are broadly applicable and can be adapted for methanol and ammonia bunkering, taking into account the distinct properties and hazards of these fuels.

Of particular relevance from a port perspective, *ISO/TS 16901:2022 - Guidance on performing risk assessment in the design of onshore LNG installations including the ship/shore interface* provides a structured approach to risk assessment at the interface between vessels and shore-based installations. While developed for LNG, the standard offers a useful methodological reference for ports assessing fixed or semi-fixed methanol and ammonia bunkering installations, especially where ship–shore interfaces, onshore storage, and transfer systems are involved.

Finally, although not developed specifically for methanol or ammonia, *ISO/TS 18683 - Guidelines for safety and risk assessment of LNG fuel bunkering operations* provides a robust methodological framework for assessing bunkering risks, safety distances, and hazard zones. This framework can be tailored to methanol and ammonia bunkering, provided that fuel-specific characteristics and risks are duly considered.

National and regional regulations 2.1.3

National and regional regulations governing the use, handling, storage, and bunkering of methanol and ammonia vary significantly between countries and even between individual ports. These requirements reflect local legislation on chemical safety, environmental protection, occupational health, hazardous-substance storage, and transport. As such, they are port-specific and are not covered in this Guidebook. However, several general considerations and recommendations are provided to support port authorities in identifying and complying with applicable national requirements.

General requirements (varying by country/region)

Port authorities should be aware that national and regional regulations may include:

- Chemical safety and environmental protection rules governing the handling of toxic and hazardous substances.



- Permitting and licensing requirements for the onshore storage of methanol and ammonia, including quantity thresholds and Seveso-type regulations.
- Occupational health and safety (HSE) obligations, particularly regarding exposure limits, ventilation, leak detection, and emergency equipment.
- Transport regulations such as national legislation related to the ADR for road vehicles carrying dangerous goods into the port (e.g. tank trucks or mobile fuel units).
- Land-use planning constraints, including maximum permissible distances from populated areas or environmentally sensitive zones.
- National criteria for individual and societal risk, which may influence the definition of safety zones and separation distances for bunkering operations (see Section 4.4).

Specific considerations for bunkering operations

- Regulations may apply differently depending on the bunkering method:
 - Ship-to-ship bunkering may fall primarily under maritime legislation and port bylaws.
 - Shore-to-ship bunkering may require additional compliance with national chemical storage, industrial-safety, and fixed-installation requirements.
 - Mobile-to-ship bunkering (e.g. truck-to-ship, ISO tank, portable container) should comply with ADR and equivalent national transport rules, including driver certification, vehicle design, tank approval, labelling, and documentation.
- Temporary fuel storage onshore may trigger additional permitting, hazard studies, or quantity limitations.

Recommendations for port authorities

Port authorities should:

- Consult their national maritime administration, HSE authorities, and environmental agencies to identify applicable requirements for methanol and ammonia.
- Verify whether national rules impose limits or conditions on onshore storage of these substances, including fixed and temporary installations.
- Inform bunkering operators of national transport requirements (e.g. ADR) that apply to vehicles bringing methanol or ammonia into the port area.
- Ensure that national regulatory criteria are integrated into local risk assessments, the definition of safety zones, and SIMOPs management (see Section 4.3).
- Ensure that national/regional obligations are integrated with the recommendations within this document as port specific procedures are established.

Note – Mobile-to-Ship (Truck-to-Ship) Bunkering: Interface Between Road and Marine Regulations:

For mobile-to-ship bunkering, and in particular truck-to-ship (TTS) operations, ports should recognise that two distinct regulatory regimes interface: the road transport domain and the maritime domain.

This interface can create uncertainty or tension if responsibilities and applicable rules are not clearly defined. In practice, many authorities and port operators address this by defining operational domains and assigning the governing regulatory framework accordingly.

Road Domain (ADR-led – truck side)

Applies up to a clearly defined transfer boundary, typically including:

- Truck tank and associated equipment;
- Truck-mounted pump and transfer systems on the vehicle;
- Truck-side emergency systems;
- Driver responsibilities and certification;
- Parking arrangements, wheel chocks, traffic management, and vehicle control.

Within this domain, the European Agreement concerning the International Carriage of Dangerous Goods by Road (ADR) and relevant national road transport regulations normally apply, even though the vehicle is physically located within the port area.

Marine Domain (Marine-led – ship side)

Applies from the ship's manifold inwards, typically including:

- Ship manifold and onboard piping systems;
- Shipboard valves and control systems;
- Shipboard Emergency Shutdown (ESD) systems;
- Crew responsibilities;
- Ship Safety Management System (SMS) under SOLAS/ISM Code.

Within this domain, maritime legislation, flag-state requirements, port by-laws, and applicable IMO instruments apply.

Port Consideration

The transfer interface (hose connection, coupling, or emergency release arrangement) represents a shared responsibility domain and should be clearly defined in procedures, compatibility assessments, and risk assessments. Ports are encouraged to:

- Clearly define the regulatory boundary in licensing and permitting documentation;
- Ensure coordination between maritime authorities and national road transport authorities;
- Avoid imposing conflicting or duplicative requirements;
- Address the interface explicitly in HAZID/HAZOP, compatibility assessments, and operational checklists.

A clear allocation of responsibilities between the road and marine domains reduces regulatory ambiguity, supports enforcement, and improves operational safety during mobile-to-ship bunkering.

Industry guidelines 2.1.4

Several industry bodies and associations have already begun to develop frameworks of guidelines for the safe use, handling, and bunkering of methanol and ammonia as marine fuels. The following are some of the key reference sources recognised by the maritime industry:

European Maritime Safety Agency (EMSA)

<https://www.emsa.europa.eu/sustainable-shipping/alternative-fuels.html>

EMSA maintains a dedicated programme on alternative fuels and power sources for shipping, covering synthetic fuels (e.g., e methanol, e ammonia), ammonia, biofuels, hydrogen, battery and energy storage systems, and shore side electricity.

Of particular relevance is EMSA's report "Study Investigating the Safety of Ammonia as Fuel on Ships", which provides an analysis of ammonia as a marine fuel. The study addresses fuel properties, toxicity, and corrosivity; system reliability; hazard identification (HAZID) and risk assessments for both generic and specific ship designs; leak-consequence modelling; and port-level considerations, including SIMOPs and bunkering operation scenarios.

International Association of Ports and Harbors (IAPH)

<https://fuelreadyports.org/>

IAPH has been active in assessing port readiness for alternative fuels, and developed a tool to provide a port-level perspective (infrastructure, operations, regulatory alignment) to support safe adoption of methanol and ammonia bunkering. Several other industry guidelines and technical references often cite IAPH's port readiness criteria as relevant baseline for ports considering bunkering operations.

The Society for Gas as Marine Fuel (SGMF)

<https://sgmf.info/shop/>

SGMF has published dedicated "Bunkering Guidelines for Methanol" and "Bunkering Guidelines for Ammonia", along with an Emergency Response Guide for Ammonia. These provide practical guidance on bunkering procedures, hazard mitigation, and safety zones for low-flashpoint fuels.

OCIMF – ISGOTT and SIRE

<https://www.ocimf.org/programmes/sire-2-0>

Guidance developed by the Oil Companies International Marine Forum (OCIMF) is widely used in ports and terminals and remains relevant to methanol and ammonia bunkering, particularly where liquid transfer operations take place at berths or terminals.

The International Safety Guide for Oil Tankers and Terminals (ISGOTT) provides established industry guidance for the safe handling of Oil and petro products including transfer between ships and terminals. Although primarily focused on petroleum products, many of its principles—such as ship–shore communication, transfer management, SIMOPs control, emergency shutdown arrangements, and human-factor considerations—are directly applicable to methanol bunkering and, with appropriate adaptation, to ammonia bunkering.

The Ship Inspection Report Programme (SIRE) 2.0 is a widely used vessel inspection scheme that supports assurance of tanker safety management, vessel condition, and crew competence. While not a

regulatory requirement, SIRE may be used by terminals and ports as a complementary tool when assessing the suitability of bunker vessels or fuel carriers involved in methanol or ammonia bunkering.

ISGOTT and SIRE should be applied as supporting industry references and adapted to reflect the specific hazards of methanol and ammonia. They do not replace fuel-specific regulations, risk assessments, or port-level requirements.

IACS and classification societies

<https://iacs.org.uk/>

IACS and classification societies, are updating and issuing technical requirements for ships using methanol and ammonia as fuels. These requirements complement, and further elaborate on, the interim guidelines published by IMO, providing more detailed design and construction provisions. Their role is particularly important during this experience-building phase, as classification society rules often serve as the practical bridge between evolving IMO regulations and the needs of early adopters.

The Society of International Gas Tanker and Terminal Operators (SIGTTO)

<https://www.sigtto.org/publications/>

SIGTTO provides guidance primarily for vessels transporting liquefied gases, including methanol and ammonia when carried as cargo. As such, its publications are also relevant for bunkering vessels handling these fuels. SIGTTO's experience with gas carrier safety, cargo handling, and terminal operations offers a well-established reference framework that supports the development of safe bunkering practices for alternative fuels.

Methanol Institute, Ammonia Energy Association and International Methanol Producers and Consumers Association

The Methanol Institute (MI) and the Ammonia Energy Association (AEA) focus primarily on developing the global markets for methanol and ammonia. While their mandates are largely commercial, both organisations actively contribute technical knowledge on the safe production, handling, and use of these products across various industrial sectors. They have published several reports and guidance documents relevant to the maritime sector, making their material a useful complement to the more formal maritime regulatory and technical frameworks produced by IMO, ISO, SGMF and others.

The International Methanol Producers and Consumers Association (IMPCA) represents global methanol producers and consumers and provides market data, best practice guidance, and industry coordination. Although not a maritime regulatory body, IMPCA publications and technical resources on methanol properties, handling, logistics, and safety may support ports and operators in understanding supply chain considerations and product stewardship aspects relevant to methanol bunkering.

<https://methanol.org/marine/>

<https://ammoniaenergy.org/>

<https://impca.eu/>

Stakeholders Identification 2.2

Safe methanol and ammonia bunkering involves a broad set of organisations, each with different interests, responsibilities, and authority. These stakeholders may be involved at different stages-from design and planning to preparation and final bunkering operations.

Their roles should be clearly identified at the outset and reviewed whenever the bunkering location, supply scenario, or operational conditions change. Effective coordination and clarity on responsibilities are essential for ensuring safe, compliant, and efficient bunkering operations.

Figure 2-1 below presents a typical bunkering stakeholder relationship diagram. The roles and responsibilities of the various stakeholders illustrated are further explained in the following sections.

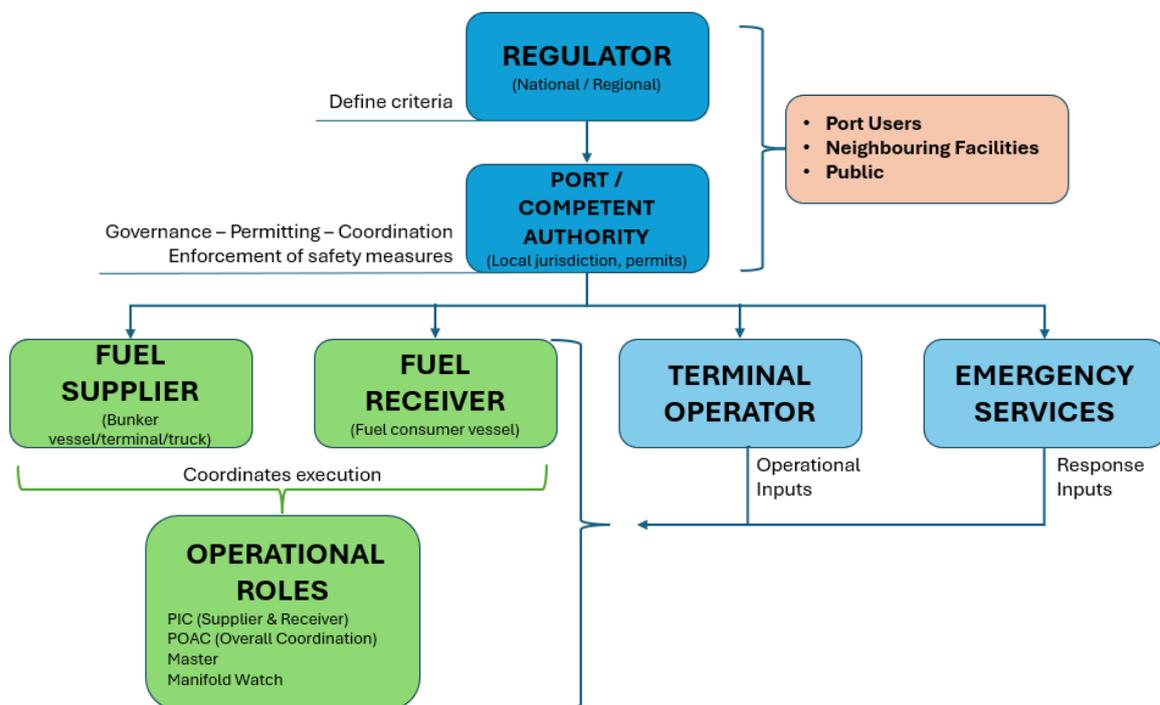


Figure 2-1: Bunkering Stakeholder Diagram

Stakeholders should be identified at each stage of the bunkering development process and whenever there are changes in:

- bunkering location
- supply scenario (ship-to-ship, shore-to-ship, mobile-to-ship)
- facility design or operating conditions

Stakeholders are identified because they may:

- directly participate in the operation
- hold jurisdiction over the area or operation
- have a legal or operational interest
- operate in proximity to the bunkering site
- be impacted directly or indirectly by the activity

All relevant organisations should therefore understand the operation, contribute their expertise, and participate consistently throughout development.

KEY TAKEAWAYS:

1. Methanol and ammonia bunkering requires multiple stakeholders, each with distinct operational, legal, and safety-related responsibilities.
2. Stakeholder identification should occur early and be updated as the project evolves.
3. Stakeholders include fuel suppliers, receiving ships, designers, regulators, port authorities, terminal operators, emergency services, port users, neighbours, and the public.
4. A competent authority may change depending on the stage of development (e.g., flag state/class during design; regulator/port authority during operations).
5. Every stakeholder should contribute information, participate in risk assessment as needed, and support the implementation of agreed mitigation measures.
6. Operational roles (e.g., Person-in-Charge, POAC, manifold watch) should be assigned to trained and competent personnel to ensure safe execution of the bunkering operation.

CHALLENGES AND GAPS:

1. The complexity of methanol and ammonia bunkering often leads to overlapping responsibilities, especially where regulatory, port, and operational authorities intersect. Clarifying stakeholder roles early is essential.
2. A lack of standardised stakeholder engagement processes across ports can lead to inconsistent expectations and interactions during planning and risk assessment.

Key stakeholder responsibility matrix 2.2.1

The following stakeholders (see table 2-1) are typically involved in the design, planning, preparation, or execution of methanol and ammonia bunkering operations (*Ref: ISO/TS 18683:2021*).

Table 2-1: Stakeholder responsibility matrix

Stakeholder		Primary role	Key Responsibilities
Fuel Supplier ^[3]	May be a bunker vessel operator, terminal operator, truck fleet operator, or producer.	Provides and operates bunkering facility or supply source	Supply-side risk assessment input; system specifications; operating procedures; ensuring safe transfer operations.
Fuel Receiver	Vessel owner, operator, or charterer.	Operates vessel receiving fuel	Vessel information; crew training; receiving procedures; participating in compatibility and risk assessment.
Designer	Includes designers of vessels, bunkering facilities, pipelines, or equipment.	Designs systems used in bunkering	Provide design criteria, equipment specifications, and engineering input to risk assessments.
Regulator	National or regional authority with jurisdiction over the bunkering location or activity.	National or regional legal authority	Defines acceptance criteria; applies relevant legislation; approves risk assessments where required.
Port Authority ^{[1] [2]}	Local authority with jurisdiction over port operations and safety.	Local authority with jurisdiction over bunkering	Port-level risk assessment; permitting; coordination with other port users; enforcement of safety measures.
Competent Authority ^[1]	May shift between Class/Flag, Regulator, and Port Authority, depending on the stage of development.	Entity with legal or operational oversight (varies by stage)	Approves designs, sets criteria, validates risk assessment, oversees operations.



Stakeholder		Primary role	Key Responsibilities
Terminal Operator	Operator of the terminal where bunkering occurs (not necessarily fuel-specific).	Manages terminal where bunkering occurs	Provide operational constraints; ensure compatibility with cargo/terminal operations; coordinate SIMOPs.
Emergency Services	Fire brigade, medical services, police, and specialised hazardous-materials teams.	Respond to incidents	Provide emergency response planning input; verify access requirements and intervention capabilities.
Port Users	Other operators within port boundaries (land or water).	Operate within the port environment	Provide operational schedules or constraints; adapt activities if required during bunkering operations.
Neighbouring Facilities and the Public	Entities located near the port who could be affected by bunkering.	Those potentially affected by operations	Provide information as needed; may require consultation depending on risk assessment outcomes.

[1] The port authority often acts, in whole or in part, as the **competent authority** for the bunkering location. The term *competent authority* refers to any organisation that has legal or operational jurisdiction over the bunkering area, the activities taking place there, or the assets involved. – The competent authority may change as the bunkering operation progresses from design to planning and then to actual operations. In some cases, more than one organisation may share competent-authority responsibilities. – Generally, during the planning and operational stages, the national regulator sets the risk-assessment acceptance criteria, while the port authority typically acts as the competent authority to ensure that the risk-assessment process and operational controls are properly implemented.

[2] See section 2.2.3 for additional insights on port authority role and responsibilities

[3] The fuel supplier may or may not be the owner of the fuel (“molecule owner”). Where commercial ownership and operational supply are separated, responsibilities for fuel quality, quantity, liability, and compliance should be clearly defined. Regardless of ownership structure, the licensed stakeholder remains accountable to the port for the safe and compliant execution of the bunkering operation.

Operational roles during bunkering 2.2.2

Safe execution of bunkering requires a set of trained, designated operational roles (see table 2-2):

Table 2-2: Bunkering operational roles

Stakeholder	Primary role	Key Responsibilities
Bunkering Organisation	The operator managing the bunkering facility (bunker vessel, terminal, truck fleet).	Responsible for executing supplier-side procedures.
Receiving Ship Operator	Operates the receiving vessel.	Ensures crew are trained and PPE and procedures are followed.
Master(s)	Ultimately responsible for the safety of the vessel (bunker vessel or receiving ship).	May delegate to an “acting master”.
Person in Charge (PIC)	Responsible for managing the bunkering operation for either supplier or receiver.	One PIC per side; both must coordinate and communicate continuously.
Person in Overall Advisory Control (POAC)	Coordinates the operation between supplier and receiver.	Typically one of the PICs; ensures synchronised, safe execution.
Manifold Watch	Personnel monitoring the transfer equipment and operation.	Reports directly to their respective PICs.

Port authority – role & responsibilities 2.2.3

The port authority is a central stakeholder in methanol and ammonia bunkering. In many cases it acts, wholly or in part, as the competent authority for the bunkering location, with jurisdiction over port waters, berths, terminals and access routes. In this role, the port authority links international and national regulatory requirements with the practical realities of local port operations and infrastructure.

Its main responsibilities span all stages of the bunkering lifecycle and typically include the following.

Governance, jurisdiction and competent-authority role

- Acting as the competent authority for the bunkering area (or sharing this role with national regulators), including:
 - interpreting and applying national legislation and port bylaws to methanol and ammonia bunkering
 - setting, or helping define, local requirements for risk assessment, safety zones and SIMOPs management
 - establishing port-specific rules and conditions for alternative fuel bunkering.



2. Developing or updating port regulations and procedures to reflect methanol and ammonia hazards, including low-flashpoint fuel handling, toxic exposure, spill control and fire response.

Location planning, risk assessment and permitting

1. Participating actively in location planning for bunkering, including:
 - assessing the suitability of proposed bunkering locations within the port (quays, anchorages, terminals)
 - considering interactions with existing port traffic, nearby terminals, public areas and environmentally sensitive zones.
2. Establishing or applying risk-acceptance criteria for methanol and ammonia bunkering and ensuring that design and operational risk assessments submitted by operators meet these criteria.
3. Reviewing and, where mandated, approving:
 - bunkering design and operational risk assessments
 - proposed safety zones, monitoring and security areas and marine exclusion zones
 - SIMOPs proposals and any restrictions on concurrent operations at the berth or terminal.
4. Operating or contributing to an accreditation, licensing and authorisation scheme for bunkering organisations and receiving ships within the port jurisdiction, including inspection and audit arrangements.

Planning and preparation of specific operations

1. During the planning and preparation stages, working with shipowners, suppliers and terminal operators to:
 - clarify applicable port requirements and approval processes
 - review the planned bunkering location, safety distances and traffic-control measures
 - validate that preparatory work by supplier and receiver reflects local conditions and constraints.
2. Ensuring that port-level SIMOPs management is in place, including rules for cargo operations, passenger movements, road traffic and other activities in proximity to the bunkering operation.

Operational oversight, authorisation and enforcement

1. Granting final authorisation (where required) for individual bunkering operations and overseeing compliance during the operation, often in coordination with the national regulator.
2. Implementing and enforcing:
 - access control to the safety zone and surrounding monitoring/security areas
 - marine exclusion zones and traffic-control measures for passing vessels
 - any temporary restrictions on port activities that could adversely affect bunkering safety.
3. Monitoring bunkering performance against port requirements and, where necessary, suspending or stopping operations if conditions deviate from the agreed plan or safety is compromised.

Emergency preparedness, response and training

1. Developing and maintaining port-level emergency response plans that cover methanol and ammonia release scenarios, fires and explosions, and coordinating these with the contingency plans of ship operators, bunker suppliers and terminals.
2. Coordinating with local emergency services (fire, medical, police, civil protection) to ensure that:
 - roles and responsibilities are clear
 - response routes, muster points and resources are compatible with bunkering locations and safety zones.
3. Ensuring that port personnel who interact with methanol- or ammonia-fuelled vessels, or with bunkering facilities, receive appropriate training and that enforcement officers and emergency responders are trained in the specific hazards of these fuels.

Communication, coordination and continuous improvement

1. Acting as a focal point for communication with other port users, neighbouring facilities and the public, informing them as appropriate about planned bunkering activities and any associated restrictions.
2. Facilitating the exchange of lessons learned from early methanol and ammonia bunkering operations, and using this feedback to refine port rules, procedures and risk-control measures over time.

In summary, the port authority's role extends beyond issuing permits: it provides the governance framework, coordinates stakeholders and ensures that methanol and ammonia bunkering is integrated safely into the wider port system throughout the design, planning, preparation and operational stages.

Clarification Note – Roles and Responsibilities of “Ports”:

Roles and responsibilities differ between ports and jurisdictions. These functions are not automatically or uniformly assigned to a port authority.

Legal responsibilities, statutory powers, enforcement capabilities and organisational structures vary significantly across jurisdictions. Different systems use different institutional arrangements and terminology, such as port authority, harbour authority, harbour master, maritime administration, terminal operator, municipal authority or other designated competent authority.

In some cases, the port authority is a public-law body with statutory powers. In others, operations may be managed by private operators under concession, with regulatory oversight exercised by separate national authorities. Environmental, occupational health and safety, and major hazard regulations may also fall under distinct agencies.

This distribution can create legal and administrative complexity, which is well recognised in the maritime sector.

Accordingly, the term “port” in this Guidebook is used in a functional sense. It refers to the entity or combination of entities holding responsibility and accountability for authorising, overseeing and enforcing bunkering activities within port limits. **Each jurisdiction should clarify and define these roles within its own legal framework.**

Bunkering Supply Scenarios 2.3

Methanol and ammonia bunkering can be carried out using three main supply scenarios: ship-to-ship, shore-to-ship, and mobile-to-ship. These scenarios differ in terms of equipment, operational constraints, and port-specific conditions. The choice of scenario depends on factors such as bunkering volume, required transfer rate, vessel manifold arrangements, SIMOPs, local traffic and weather conditions, and the availability of suitable bunkering infrastructure.

A visual overview of the three scenarios is provided in the accompanying Figure 2-2.

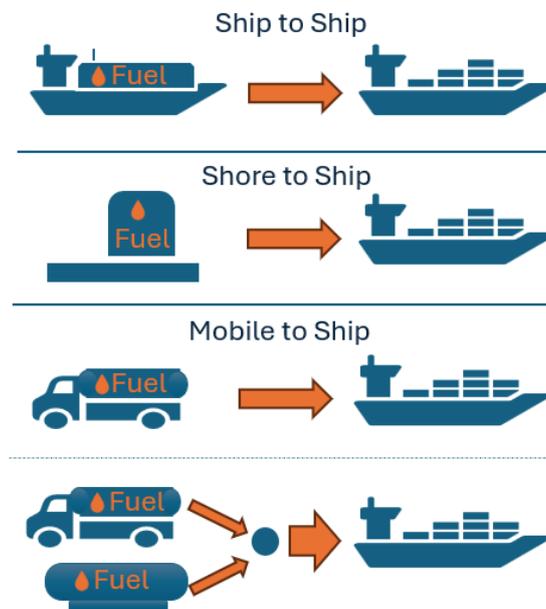


Figure 2-2: Bunkering Supply Scenarios

- **Ship-to-Ship (STS):** Fuel is transferred from a bunker vessel, barge, or floating installation to the receiving vessel.
- **Shore-to-Ship:** Fuel is supplied from a fixed facility or terminal located ashore.
- **Mobile-to-Ship:** Fuel is delivered via mobile units such as trucks, portable tanks, or ISO containers positioned quayside.

Each scenario has advantages and constraints that should be assessed for every operation. A vessel may use more than one scenario throughout its lifetime, depending on location and infrastructure availability.

This Guidebook addresses all three bunkering scenarios. Where requirements or considerations differ—for example in safety zones, equipment interfaces, or SIMOPs—these are highlighted in the relevant sections of the document.

The Four Stages Approach for Vessels Operators 2.4

The safe introduction of methanol and ammonia bunkering is best approached as a progressive, staged process. This Guidebook acknowledges a four-stage structure proposed by SGMF in their bunkering guidelines that reflects the lifecycle of bunkering development, from early concept through to operational execution.

This approach is primarily oriented toward the fuel supplier and fuel receiver, and describes how these stakeholders develop and execute bunkering operations and engage with other parties, including ports and competent authorities (*reference is made to the SGMF bunkering guidelines for methanol and ammonia*).

The four stages are:

1. **Design Stage** – where the bunkering concept, location, systems, and high-level safety framework are defined.
2. **Planning Stage** – where risk assessments, compatibility assessments, documentation, and permitting are developed and reviewed.
3. **Preparation Stage** – where operation-specific arrangements are finalised, documentation is confirmed, and readiness is verified.
4. **Operational Stage** – where bunkering is conducted under approved conditions, with oversight, monitoring, and emergency preparedness in place.

NOTE:

While this four stages framework is primarily intended to describe how vessel operators and bunker suppliers plan and execute bunkering operations, it is included here for reference, as it provides important context for how ports interact with bunkering stakeholders. The approach does not in itself describe how ports develop their internal frameworks, infrastructure, or readiness for bunkering, which is addressed separately in this Guidebook.

Bunker System (Transfer System) 2.5

The bunker system, also commonly referred to as the transfer system, is the set of equipment used to safely transfer methanol or ammonia between the fuel supplier and the receiving vessel. It forms the physical and functional link between the two parties and is a critical element of bunkering safety.

At a high level, the bunker system comprises all equipment located between the bunkering manifold flange of the supplying facility (shore installation, bunker vessel, or mobile unit) and the manifold of the receiving vessel. Depending on the supply scenario, the system may consist of hoses, rigid transfer arms, or a combination of both, together with safety, isolation, and emergency release components (see table 2-3).

While the detailed design and configuration of bunker systems vary by fuel and application, their functional purpose is the same across all bunkering operations:

1. to enable controlled fuel transfer,
2. to allow rapid isolation and disconnection of the system in abnormal conditions, and
3. to prevent uncontrolled release of fuel if operational limits are exceeded.

ISO 20519:2021 *Specification for bunkering of liquefied natural gas fuelled vessels* provides detailed definitions and configurations for LNG bunker systems. Although this standard is LNG-specific, the functional principles of the bunker system components are directly applicable to methanol and ammonia bunkering. Differences arise from the physical, chemical and safety properties of methanol and ammonia (e.g. toxicity, corrosivity, vapour behaviour), which influence material selection, sealing arrangements, safety distances, and operating procedures. These fuel-specific aspects are addressed elsewhere in this Guidebook.

Table 2-3: Bunker system key components

Component	High-level function
Bunkering Safety Link (BSL)	Provides communication between supplier and receiver ESD systems to ensure coordinated shutdown.
ESD System	Initiates safe shutdown of the bunkering operation in emergency or abnormal conditions.
Hose or Transfer Arm	Physical conduit used to transfer liquid fuel (and vapour return where applicable).
Connector (Flange or Dry-Disconnect Coupling)	Mechanical interface connecting the transfer system to the vessel manifold.
Emergency Release Coupler (ERC)	Enables rapid, safe physical separation of the transfer system to prevent fuel release if limits are exceeded.

Handling and human-factor considerations 2.5.1

The handling and operation of bunker system components require careful consideration of human-factor aspects. Hoses, transfer arms, connectors and emergency release devices may be heavy, bulky, and subject to movement due to vessel motion, tide, or weather. Their weight, reach, and manoeuvrability can directly affect safe connection, monitoring, and disconnection.

Operators should ensure that lifting arrangements, access, lighting, and working clearances are adequate, and that personnel involved are properly trained and familiar with the specific equipment used. Human-factor considerations should be addressed during system selection, risk assessment, and operational planning to reduce the risk of handling errors and unsafe working conditions.

Hazardous Areas, Toxic Areas, Safety Zones and SIMOPs 2.6

Methanol and ammonia bunkering operations require the definition and management of several distinct but related areas around the bunkering location. These areas are established to control risks associated with flammability, toxicity, and operational interactions, and to ensure that bunkering can be safely integrated into the port environment.

The definition of these areas is normally based on the outcomes of a risk assessment, taking into account fuel properties, transfer systems, bunkering scenarios, and local port conditions. While the

detailed technical definition is typically prepared by designers and operators, ports-often acting as the competent authority-play a central role in reviewing, approving, coordinating, and enforcing these areas.

The five areas commonly used are (see figure 2-3):

- Hazardous Area
- Safety Zone
- Monitoring and Security Area
- Marine Exclusion Zone
- Assessment Zone

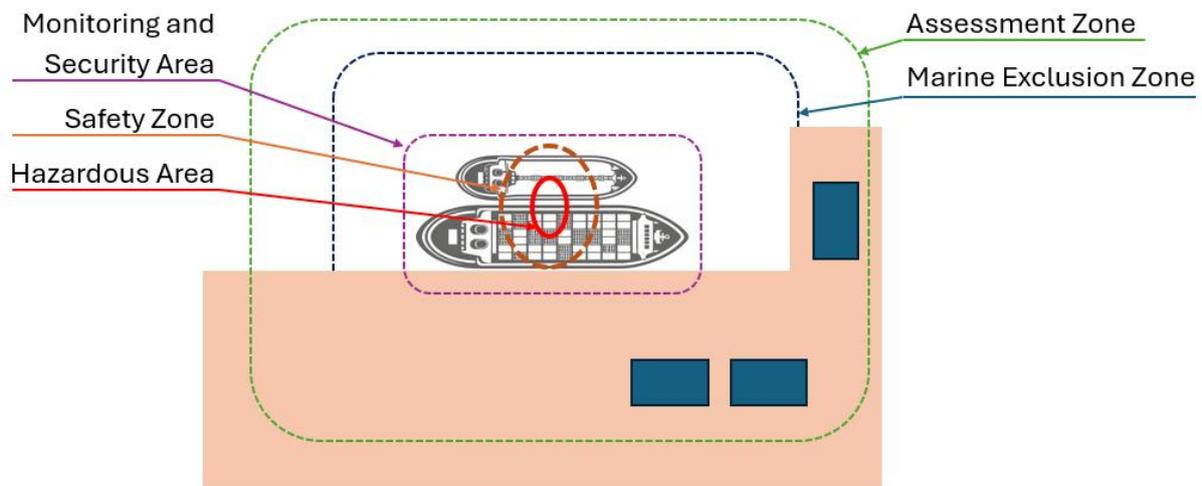


Figure2-3: Bunkering zones schematic

In addition, for fuels presenting significant health risks-particularly ammonia-a **Toxicity Area** may be defined to address potential exposure impacts beyond flammability-driven considerations.

These areas are closely linked to the management of simultaneous operations (SIMOPs) and should be considered together to ensure consistent control, communication, and enforcement during bunkering.

NOTE:

The following sections provide general information and background definitions related to Hazardous Areas, Toxic Areas, Safety Zones, and SIMOPs. It does not describe in detail how these areas are established, calculated, controlled, or monitored. For guidance on the assessment and determination of safety zones for methanol and ammonia, including methodology and practical application, please refer to Sections 4.3 and 4.4.

Hazardous area 2.6.1

The hazardous area is defined based on the potential presence of flammable atmospheres during normal operations or foreseeable abnormal conditions. For methanol bunkering, this relates primarily to the risk of vapour release and ignition. Hazardous areas are typically limited to the immediate vicinity of transfer equipment, manifolds, vents, and connection points.

For ammonia, while flammability is less dominant, hazardous areas may still be defined for equipment where specific conditions could lead to ignition but are more often influenced by toxic release considerations.

Port role:

- Understand the extent and implications of hazardous areas for port infrastructure and nearby activities.
- Ensure that ignition sources and incompatible activities are controlled within these areas.
- Confirm that hazardous-area definitions are reflected in port permits, procedures, and access rules.

Safety zone 2.6.2

The safety zone is established to protect people, assets, and port operations from the consequences of a potential incident. It is primarily driven by flammability-related hazards for methanol (e.g. jet fires, pool fires) and may be expanded for ammonia to account for toxic dispersion scenarios.

In addition to fuel-specific hazards, the definition and extent of the safety zone should also consider simultaneous operations (SIMOPs). Activities taking place within or adjacent to the bunkering location—such as cargo handling, passenger movements, maintenance work, or vessel traffic—may influence both the size of the safety zone and the operational controls required during bunkering.

The safety zone typically encompasses the hazardous area and extends beyond it to include a buffer where access is restricted and activities are controlled for the duration of the bunkering operation.

Port role:

- Review and approve the proposed safety zone as part of the risk assessment, including consideration of SIMOPs.
- Ensure the safety zone is compatible with port layout, berth use, traffic flows, and adjacent activities.
- Define and enforce access restrictions, activity limitations, and SIMOPs controls within the safety zone during bunkering.

Monitoring and security area 2.6.3

The monitoring and security area surrounds the safety zone and provides space for active supervision, detection, and response. Within this area, activities may continue but are subject to increased awareness and readiness.

Port role:

- Coordinate monitoring arrangements with terminal operators, VTS, and emergency services.
- Ensure clear communication and situational awareness during bunkering.
- Support rapid escalation if abnormal conditions are detected.

Marine exclusion zone 2.6.4

The marine exclusion zone is established on the water side to prevent unauthorised vessel movements near the bunkering operation. It reduces the risk of collision, wake effects, or interference that could compromise the safety of the transfer.

The size and shape of the marine exclusion zone depend on the bunkering scenario, vessel size, traffic density, and local navigational constraints.

Port role:

- Define and enforce marine exclusion zones, often in coordination with Vessel Traffic Services (VTS).
- Issue navigation warnings or traffic restrictions as required.
- Ensure pilots, tug operators, and other port users are informed.

Assessment zone 2.6.5

The assessment zone is a wider area considered during the risk assessment to evaluate the potential impact of worst-case scenarios, including fire escalation or toxic dispersion beyond the immediate bunkering location. Further guidance on assessment zone can be found in Section 4.3.3.

Port role:

- Use the assessment zone to understand potential off-site impacts on neighbouring terminals, public areas, and infrastructure.
- Inform land-use planning, emergency response planning, and stakeholder engagement.
- Ensure that societal risk considerations are addressed where required by national regulations.

Toxic area 2.6.6

A toxic area onboard of an ammonia fuel vessel is defined as an area in which ammonia is, or may reasonably be expected to be, present at concentrations that could pose a risk to human health. The concept of a toxic area has been introduced by the IMO through *MSC.1/Circ.1687 – Interim Guidelines for the Safety of Ships Using Ammonia as Fuel*.

The definition and application of toxic areas are specific to ships using ammonia as fuel under the remit of the IGF Code, where the interim guidelines set additional requirements to address ammonia's toxicity.

Under MSC.1/Circ.1687, the toxic area is defined using two complementary approaches:

1. **Prescriptive separation distances:** In accordance with paragraph 12bis.4.1, minimum distances are specified between ammonia fuel systems and:
 - life-saving appliances;



- emergency escape routes;
 - air intakes, outlets, and other openings into accommodation spaces;
 - service and machinery spaces;
 - control stations; and
 - other non-toxic spaces.
2. **Dispersion-based determination:** In accordance with paragraph 12bis.4.3, a gas dispersion analysis is required to determine the extent of the toxic area. The analysis should demonstrate that ammonia concentrations exceeding 220 ppm do not reach:
- air intakes, outlets, and other openings into accommodation spaces;
 - service and machinery spaces;
 - control stations;
 - other non-toxic spaces on board; and
 - any additional areas specified by the Administration.

The toxic area determined through dispersion analysis may extend beyond the minimum prescriptive distances defined in paragraph 12bis.4.1, or may require the implementation of additional mitigation measures (such as ventilation, gas detection, shutdown systems, or operational controls) to ensure compliance.

It is important to note that the toxic area threshold specified by the IMO in *MSC.1/Circ.1687 – Interim Guidelines for the Safety of Ships Using Ammonia as Fuel*, is intended for design and safety-zone purposes, rather than time-based exposure assessment.

Given the critical safety implications of toxic areas for ammonia-fuelled vessels and their interface with port operations, this topic is addressed in further detail in Section 4.4.2.

SIMOPs integration 2.6.7

The definition of hazardous areas and zones is closely linked to the management of simultaneous operations (SIMOPs). Activities within or near these zones may need to be restricted, rescheduled, or subject to additional controls during bunkering.

Port role:

- Review SIMOPs assessments and approve permitted activities during bunkering.
- Coordinate restrictions across terminals, berths, and port services.
- Ensure SIMOPs arrangements are clearly communicated and enforced.

Bunkering Documentation 2.7

Safe methanol and ammonia bunkering relies on a structured set of documents that collectively define how bunkering is planned, authorised, prepared, and executed. These documents are typically brought together under a Methanol/Ammonia Bunkering Management Plan.

The Bunkering Management Plan is not a single document, but a documented framework that consolidates all information needed to demonstrate that bunkering can be carried out safely, in compliance with applicable regulations and port requirements. It is used to support risk assessment,

compatibility assessment, permitting, and operational control, and is commonly reviewed by the port authority acting as competent authority.

While the detailed content and format may vary depending on the bunkering scenario and local requirements, the Methanol/Ammonia Bunkering Management Plan should remain proportionate, practical, and non-duplicative, avoiding unnecessary bureaucracy while ensuring that all safety-critical elements are addressed.

Key considerations for ports:

The following considerations, based on established frameworks and lessons learned from LNG bunkering, should be taken into account when defining the bunkering documentation requirements:

1. **Documentation should support safe operations:** Bunkering documentation should be structured to actively support safe planning and execution of operations. It should not become a purely bureaucratic or “tick-box” exercise, nor impose unnecessary burden on operators or port staff.
2. **Documentation should evolve with operational maturity:** During early pilot phases, it is understandable that multiple iterative assessments, approvals, and documents may be required, often covering a single operation. As bunkering moves from pilot projects to business-as-usual, documentation should be streamlined, with a single framework covering multiple operations, vessels, or scenarios-provided these remain within the defined operational boundaries and assumptions.
3. **Documentation should be proportionate to risk:** The level of detail required should reflect the fuel, bunkering scenario, location, and operational complexity. Proportionality helps ensure that attention is focused on safety-critical issues rather than excessive documentation.
4. **Use existing industry documentation wherever possible:** Ports should refrain from creating new or bespoke bunkering documents where recognised industry guidance already exists. Established frameworks and templates are available, including:
 - SGMF guidelines for methanol and ammonia bunkering;
 - SGMF guidance for bunkering compatibility assessment;
 - IAPH Clean Marine Fuels Working Group bunkering checklists.

Ports are therefore encouraged to reference and adopt existing industry documentation rather than modify or replace it. Where port-specific needs exist, these should be addressed through clearly defined additional requirements or conditions, complementing what is already in place rather than duplicating it.

Experience from the early implementation of LNG bunkering demonstrated that the proliferation of port-specific documentation requirements was widely recognised as a barrier to operators, increasing complexity without commensurate safety benefit. Avoiding unnecessary divergence is particularly important in the early stages of methanol and ammonia bunkering to support consistency, efficiency, and safe uptake across ports.

5. **Role of the Joint Bunkering Plan (JBP / JPBO):** The Joint Bunkering Plan (JBP), also referred to as the Joint Plan of Bunkering Operation (JPBO), is a key document. It should be understood as an operational document, intended to support coordination, readiness, and execution of the bunkering operation. It should focus on essential operational and safety elements and should not be treated as a permitting document.

6. **The JBP/JPBO is not the same as a Joint Plan of Operation (JPO):** a JPO is used for ship-to-ship (STS) transfers under MARPOL Annex I. A JPO is a mandatory document for STS operations, typically applies to a single transfer only, and includes requirements that go beyond those normally included in a JBP. These documents should not be confused, and ports should be clear which document is required for which purpose.

Typical documents included in the bunkering management plan 2.7.1

A typical Bunkering Management Plan for methanol or ammonia bunkering may include the following key documents:

1. Bunkering Management Plan (core document)
 - Overview of the bunkering concept, systems, procedures, and safety measures.
 - Primary reference document submitted to the competent authority during the planning stage.
2. Bunkering Procedure
 - Step-by-step description of the bunkering operation, including roles, communications, and emergency actions.
3. Joint Bunkering Plan (JBP)
 - A concise, operation-specific summary of key information for a defined vessel, location, and supply scenario.
 - Often requested by port authorities as a practical overview for operational approval and oversight.
4. Bunkering Checklist
 - Mutual checklist used by supplier and receiver during preparation and operation to verify readiness and control execution.
 - Frequently based on the IAPH bunkering checklist framework.
5. Bunkering Compatibility Assessment / Report
 - Demonstrates that the physical, operational, and safety interfaces between supplier and receiver are compatible.
 - Includes recommendations to be reflected in procedures where necessary.
6. Risk Assessment Documentation
 - Hazard identification, risk evaluation, and definition of safety zones and SIMOPs, as applicable at port level.
7. Emergency Response and Contingency Information
 - Alignment between ship, supplier, terminal, and port emergency arrangements.
8. Training and Competence Records
 - Evidence that personnel involved have received appropriate training for methanol or ammonia bunkering.



Documentation - Port review and approval 2.7.2

Ports generally do not manage the bunkering operation but verify that it can be conducted safely within the port environment. Often the Bunkering Management Plan documents are sufficient for the licensing approval during the Design & Early Planning Stage while the JBP, is sufficient for operational approval.

Documentation requirements should be proportionate to risk, avoiding duplication while ensuring transparency and traceability.

Requirements may differ by bunkering scenario (STS, shore-to-ship, mobile-to-ship) and by fuel (methanol vs ammonia).

Once the bunkering operation is becoming an established practice in the port, the JBP is often the primary operational document for ports, supported by selected Bunkering Management Plan elements.

Appendix A: Bunkering Documentation for Ports provides a summary of the typical documentation required by ports during the different stages of the bunkering process and what actions are required.

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Fuel Knowledge 3.

SCOPE AND INTENT:

This chapter provides **fuel-specific knowledge** for methanol and ammonia as marine fuels. It covers basic properties, safety aspects (fire, explosion, toxicity), use as cargo and fuel, and environmental impacts. This Part supports informed decision-making by ports and stakeholders and explains why certain risks, controls, and operational requirements differ between fuels. The content in this Part underpins the risk assessments, safety measures, and procedures discussed in later Parts.

Marine Fuels- Properties Summary 3.1

Table 3-1 provides an overview of the basic chemical and physical properties of the fuels considered, in order to support a comparative understanding of the hazards associated with each product relative to LNG, methanol, and marine gas oil (MGO). While the numerical values presented are generally consistent with commonly cited literature, it should be noted that individual values may vary slightly between publications depending on reference conditions and test methods applied. The data for MGO is subject to the highest degree of uncertainty, as MGO is not a single substance but a blend of numerous hydrocarbons with varying chain lengths and properties. Consequently, several parameters (e.g. boiling range, flash point, and vapour behaviour) are typically provided as ranges rather than as discrete values.

To ensure correct interpretation of table 3-1, the following definitions should be considered, as these terms are frequently misused or misinterpreted in practice:

- **Boiling point:** is the temperature at which a substance changes from liquid to gas at a defined pressure, typically 1 bar (atmospheric pressure). For liquefied gases such as LNG and ammonia, the boiling point explains the requirement for cryogenic or pressurised storage and the rapid phase change that occurs upon release to the atmosphere.
- **Flash point:** is the lowest temperature at which a liquid emits sufficient vapour to form an ignitable mixture with air at the liquid surface when exposed to an external ignition source. The flash point is only applicable to substances that are liquids under ambient conditions. It is therefore not a meaningful parameter for gases or liquefied gases such as LNG or ammonia. A low flash point indicates an increased likelihood of ignition during handling, transfer, and bunkering operations.
- **Auto-ignition temperature:** is the minimum temperature at which a substance will ignite spontaneously in air without the presence of an external ignition source. This parameter is independent of the flash point and is relevant for all fuels, including gases, as it characterises the inherent ignition resistance of the substance at elevated temperatures.

Table 3-1: Marine fuels - Properties comparison summary

Properties	Methanol	Ammonia	MGO	Methane (LNG)
Molar Mass	32.04 g/mol	17.03 g/mol	~250 g/mol	16.04 g/mol
Density	0.7918 kg/l @ 20°C	0.682 kg/l @ -33°C	0.860 kg/l @ 15°C	0.430 kg/l @ -160°C
Boiling Point	64.7°C	-33 °C	~250°C	-161.5°C
LFL	5.5%	15% vol	0.6%	5%
UFL	36%	28% vol	7.5%	15%
Flash Point	11°C	N / A	> 60°C	N / A
Autoignition Temperature	464°C	630 °C	~300°C	537°C
Water Solubility	Fully miscible	Highly soluble	Insoluble	Very low (sparingly soluble in water)
Energy content (LHV)	15.8 MJ/l	12.7 MJ/l	36.6 MJ/l	20.8 MJ/l

It shall be noted that different publications and sources reference present different figures due to different test conditions / standards and reference temperatures the tests are performed.

Methanol Core knowledge 3.2

General & basic properties 3.2.1

Methanol (CH_3OH) is a simple, long-established chemical compound with a high carbon-to-hydrogen ratio, which makes it an attractive hydrogen-derived fuel despite not being carbon-free. 100 litres of methanol contain approximately 10 kg of chemically bound hydrogen, based on a liquid density of 0.792 kg/l and a hydrogen mass fraction of 12.6%.

Methanol is also known by its industrial names “methyl alcohol” or “wood alcohol / wood naphtha / wood spirit”, reflecting its historic production via wood distillation. It has been manufactured at scale for more than a century and remains a cornerstone feedstock in the global chemical industry. Major applications include the production of chemicals, polymers, plastics, adhesives, solvents, and intermediates for countless industrial processes. In the energy sector, methanol is increasingly used for fuel blending, alternative marine fuel pathways, and emerging e-fuel production concepts.



The methanol industry is one of the world's largest consumers of hydrogen, accounting for roughly 30% of global hydrogen demand, making it the second-largest hydrogen-consuming sector after ammonia.

Methanol has been transported safely by sea for over 50 years, supported by mature regulatory frameworks including the IMDG Code and IBC Code. In 2023, global production reached approximately 120 million tonnes per year and is projected to rise to 140 – 150 million tonnes per year by 2030, reflecting strong demand growth, particularly in Asia.

At ambient conditions, methanol is a colourless liquid with a faintly sweet, alcoholic odour. It is classified as a highly flammable liquid and has a flash point of approximately 11 °C. Methanol has a boiling point of approximately 65 °C, which is significantly lower than that of marine gas oil (MGO). However, unlike liquefied gases such as ammonia or LNG, methanol does not undergo an immediate phase change when released at ambient temperatures. Nevertheless, methanol vapour concentrations can increase to hazardous levels in confined or poorly ventilated spaces outside closed storage and fuel-handling systems.

Safety – Fire, explosion and toxicity 3.2.2

Methanol, due to its low ignition temperature combined with its toxicological properties, represents a distinct alternative marine fuel that requires dedicated safety measures and heightened operational awareness. Importantly, the concentration thresholds at which methanol poses toxic effects to personnel are significantly lower than its lower flammability limit (LFL/LEL). Based on modelling studies under typical atmospheric conditions indicate that methanol vapour concentrations reach the LFL on open spaces only under extreme spill scenarios, as methanol does not exhibit rapid or extensive volatilisation under ambient conditions. Nevertheless, the comparatively low toxicity thresholds necessitate particular attention, and appropriate exposure-control and mitigation measures should be implemented to protect personnel during normal and abnormal operating conditions.

At the same time, methanol exhibits a wide flammability range with 5.5–36% in air and cannot be disregarded, particularly in confined or poorly ventilated spaces, where the risk of forming a flammable atmosphere increases and requires appropriate hazardous-area classification, ventilation, gas detection, and procedural safeguards.

Toxicity exposure limits for hazardous substances vary across jurisdictions, reflecting differences in national regulatory frameworks. SGMF references the U.S. EPA Acute Exposure Guideline Levels (AEGL), which are widely applied in the maritime and offshore sectors to evaluate short-term public exposure risks from airborne chemicals. AEGL values define estimated concentration thresholds at which most individuals may begin to experience adverse health effects, based on defined exposure durations, as reflected in the table below. While AEGL-3 at 10 minutes exceeds 50% of the LFL (LEL), it is essential to emphasize that AEGL-3 conditions already represent emergency-level exposure scenarios that fall well outside safe or acceptable operational envelopes. For normal methanol fuel-handling, transfer, and bunkering operations, the AEGL-1 threshold should be treated as the governing operational limit, as it defines the highest airborne concentration considered tolerable for the general public without notable discomfort or health effects, and therefore sets the safety boundary for routine operations. Further details on AEGL limits are provided in section 4.2.1.

Despite the value of AEGL as a harmonized toxicological benchmark, applicable regulatory limits will still vary. Requirements issued by local port or shore authorities, flag state regulations governing IGF/IBC vessels, as well as company and industry standards, will consistently produce non-identical limit values due to differences in legal scope, protection goals, exposure assumptions, and regulatory methodology.

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As cargo and as fuel 3.2.3

Methanol is transported by sea in accordance with the IMO IBC-Code using specialised chemical tankers, and by road in accordance with ADR regulations for tank-truck transport. The global methanol trade results in roughly 30 million tonnes per year being shipped by sea.

Under the IBC Code, specific construction and equipment requirements are limited, with the most relevant provisions relating to:

- Tank and cargo-system venting arrangements, and
- Pump-room design and configuration,

both of which are primarily driven by the toxicity and vapour-exposure risk of methanol, rather than its flammability.

From a maritime classification perspective, Methanol may be carried on IMO Type 3 chemical tankers, which represent the lowest hazard tier for ship design within the IBC Code. This reflects that Methanol, compared with many other bulk-liquid chemicals regulated under the Code, is considered a relatively low-hazard cargo with no requirement for high-integrity tank containment systems (such as Type 1 or 2).

Consequently, within the framework of the IBC Code, Methanol is generally regarded as a comparatively safe product from a design and containment perspective, which is in line with requirements of the ADR which does give any additional guidance as already stated above.

In addition to the above, OCIMF has published a guidance note specifically addressing the carriage of methanol in bulk onboard offshore supply vessels, titled “Carriage of Methanol in Bulk Onboard Offshore Vessels”, which should be read in conjunction with the OSV Chemical Code. The document includes guidance relevant to methanol transfer operations, including recommendations for truck-to-vessel transfer safety zones to support safe methanol transfer from shore-side supply chains.

It should be noted that methanol becomes corrosive to certain metals when mixed with water, particularly affecting materials such as copper, zinc, titanium, carbon steel, and some grades of stainless steel. In addition, methanol can be incompatible and degrading to O-rings, gaskets, and sealing materials made from specific elastomers, leading to swelling, embrittlement, or loss of integrity.

Methanol can be stored at ambient temperature and pressure and does not require pressure vessels or cryogenic/refrigerated storage for stability. As a liquid hydrogen derivative, methanol has a higher volumetric energy density than compressed hydrogen and a higher lower-heating value (LHV) than ammonia.

Methanol is produced in very large quantities and is safely handled in numerous industrial sectors worldwide, enabled by mature technologies and well-established global supply chains, including storage, transport, and distribution infrastructure.

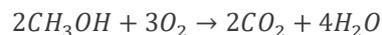
Retrofitting existing marine engines to operate on methanol is generally less complex and less invasive compared to conversions for hydrogen, ammonia, or LNG, as it typically avoids the need for high-pressure, cryogenic fuel systems, extensive tank modifications, or gas-handling machinery.

Environmental impact GHG & Pollutants 3.2.4

Methanol contains no sulphur and therefore does not emit SO_x during combustion. However, as a carbon-based molecule, the presence of a carbon atom leads to CO₂ emissions when burned.

Methanol is completely miscible with water and, unlike oil-based products, does not form a surface film or visible sheen. When released into water, it is therefore considered a locally harmful and acutely toxic substance to the marine environment, causing temporary impact to aquatic organisms. However, methanol is readily and rapidly biodegradable, one of the fastest degrading liquid marine fuels, and demonstrates low long-term environmental persistence in seawater.

The combustion of methanol can be chemically described as follows:



As noted above, the formation of CO₂ is unavoidable in this reaction. The equation reflects ideal combustion conditions, in which only CO₂ and water (H₂O) are produced. In real-world engine operation, combustion is not always ideal. Under incomplete or sub-optimal combustion conditions, by-products such as formaldehyde (CH₂O) may form and be emitted. This requires engine calibration, combustion optimization, and, where necessary, dedicated exhaust gas after-treatment systems to minimize environmental, health, and air-quality impacts. Formaldehyde is classified as a volatile organic compound (VOC) and is a relevant emission component in regulatory air-quality and occupational exposure assessments.

Ammonia Core knowledge 3.3

General & basic properties 3.3.1

Ammonia (NH₃) is a carbon-free, inorganic compound composed of one nitrogen atom and three hydrogen atoms. With 10.7 kg of hydrogen per 100 litres of ammonia, it serves as an effective and widely recognized hydrogen carrier. Ammonia has been produced via the Haber-Bosch process for more than 100 years, consuming approximately 40% of global hydrogen production, which also equates to around 60% of the world's total hydrogen demand.

Ammonia is a fundamental nitrogen source for both plants and animals. Around 80% of global ammonia production is used in agriculture, primarily as a feedstock for nitrogen-based fertilizers. These fertilizers support approximately 45% of the world's food crops, making ammonia-derived fertilizers critical to an estimated 45% of global food production.

Ammonia has been transported by sea for over 60 years and is among the most-produced chemicals in the world. Global production reached approximately 230 million tons in 2023 and is projected to grow to around 290 million tonnes by 2030.

At room temperature and atmospheric pressure, ammonia is a colourless gas with a sharp, pungent odour. It can be liquefied either by compression to roughly 8–10 bar, or by cooling to below –33 °C. Its odour detection threshold lies between 2–5 parts per million (ppm), making even small releases perceptible to the human nose.

Safety – Fire, explosion and toxicity 3.3.2

The low toxicity threshold and the exceptionally high ignition energy required to ignite ammonia set it apart from conventional maritime fuels such as methanol, LNG, and marine gasoil. Despite these inherent challenges, operators around the world have established mature, robust control frameworks and engineered safeguards that demonstrate ammonia can be managed safely when handled with appropriate risk controls and operational discipline.

Ammonia is classified as a non-flammable substance for maritime transport under both the IGC Code and the IMDG Code (noting that it may become flammable under certain concentration ranges and confinement conditions). The airborne concentration required to form a flammable atmosphere is substantially higher than that of conventional marine fuels. In addition, the minimum ignition energy (MIE) of ammonia is extremely high – roughly 10,000 times greater than that of hydrogen. It should be noted that the minimum ignition energy (MIE) differs significantly in the literature depending on the actual test setup. However, combined with a lower flammability limit (LFL) of approximately 16% by volume in air, ignition of an unconfined ammonia vapor cloud in open air is considered highly improbable. However, ammonia ignitions have been recorded in enclosed or confined spaces, where gas accumulation and localized ignition sources can create conditions capable of exceeding the LFL and overcoming the high ignition energy requirement. Therefore, the autoignition temperature is significantly higher than methanol or MGO.

Ammonia presents acute inhalation toxicity, with effects that are strongly concentration dependent. Compared to other established marine fuels, harmful concentrations occur at significantly lower levels, making toxicity the primary design driver when developing fuel supply and bunkering concepts.

Table 3-2: Ammonia concentration and effects

Concentration [ppm]	Effects
5 - 25	Odour perception
20 - 50	Mild discomfort
50 - 80 (2 hrs)	Perceptible eye and throat irritation
100 (2hrs)	Nuisance eye and throat irritation
140 (2hrs min)	Severe eye, nasal throat and chest irritation. Leave exposure area
300	No scape-impairing symptoms and no irreversible effect
500 (30 minutes)	Upper respiratory tract irritation, tearing of the eyes
700 – 1,700	Coughing, bronchospasm and chest pain with severe eye irritation and tearing
5,000 – 10,000	Rapidly lethal; chemical bronchitis and chemical burns of the skin
10,000	Promptly lethal

Table 3-2 has been compiled and refined by EMSA (European Maritime Safety Agency) following a structured review of publicly available safety data sheets and toxicological guidance. Key sources

include government agencies such as the Spanish Ministry of the Interior (Civil Protection), as well as health authorities including Public Health England and Public Health England successor guidance aligned with UK HSA frameworks, alongside industry input from chemical manufacturers' and sector associations such as CEFIC (European Chemical Industry Council) and CIAFA (Cámara de la Industria Argentina de Fertilizantes y Agroquímicos).

Exposure limits for hazardous substances differ across jurisdictions. SGMF references the U.S. Environmental Protection Agency (EPA) Acute Exposure Guideline Levels (AEGL), which are widely used to assess short-term public exposure risks from airborne chemicals. AEGL values define estimated concentration thresholds at which most individuals may begin to experience adverse health effects, based on a defined exposure duration as provided in the table below. Further details on AEGL limits are provided in section 4.4.2.

Despite the value of AEGL as a harmonized toxicological benchmark, applicable regulatory limits will still vary. Requirements issued by local port or shore authorities, flag state regulations governing IGF/IGC vessels, as well as company and industry standards, will consistently produce non-identical limit values due to differences in legal scope, protection goals, exposure assumptions, and regulatory methodology. In this respect it should be taken into account that ammonia vapor has a density ratio of 0.589 at 0°C relative to air, meaning that under ambient conditions ammonia gas is lighter than air and will tend to rise rather than settle in low areas.

However, the behaviour of ammonia following a release depends strongly on temperature, release phase, and meteorological conditions. In the case of a cold liquid release (e.g. refrigerated ammonia at approximately -33°C), the initial vapour cloud may be significantly colder and denser than the surrounding air. Under such conditions, the cloud can temporarily behave as a heavy gas, spreading laterally along the ground before warming and becoming buoyant. Similarly, aerosol releases consisting of fine liquid droplets entrained in vapour may exhibit heavier-than-air characteristics in the initial phase, particularly in low wind conditions.

As the released ammonia warms and mixes with ambient air, it will generally become lighter than air and rise. Therefore, dispersion assessments should consider the release phase (liquid, vapour, or aerosol), temperature, release rate, and local atmospheric conditions, rather than relying solely on the theoretical vapour density relative to air.

As cargo and as fuel 3.3.3

Ammonia is transported by ships, regulated under the IGC Code, and by trucks, regulated under the ADR (European Agreement concerning the International Carriage of Dangerous Goods by Road).

According to an infrastructure report by the Ammonia Energy Association, approximately 17 – 20 million tonnes of ammonia are safely transported internationally by sea each year. Marine transport is conducted using either fully refrigerated or pressurised cargo systems. The majority of global ammonia shipping is carried out under refrigerated conditions, typically on gas carriers with cargo capacities of up to 50,000 m³, while pressurised transport plays a smaller role. The largest share of this refrigerated transport is conducted on mid-size vessels with tank volumes up to 50,000 m³.

The IGC Code requirements for ammonia carriers place particular emphasis on the steel grades used for containment and cargo transfer systems, as ammonia can be corrosive to carbon-manganese and

nickel steels. This corrosion risk is accelerated by the presence of water and oxygen. To mitigate this, the IGC Code limits:

- Water content to 0.1% w/w, and
- Oxygen content to 2.5 ppm w/w.

Provided these limits are maintained, ammonia may also be transported on 2G-class gas tankers, which fall under the same IGC vessel classification used for LNG carriers (methane as defined under the IGC Code).

The ADR does not specify any additional technical requirements of relevance. However, trucks carrying these cargoes can only be parked under supervision, or may alternatively be parked without supervision in a secure depot or within secure factory premises.

Compared to other marine fuels, ammonia offers several distinct advantages. It can be stored in a liquefied state at atmospheric pressure at -33°C or in a fully pressurised state typically around 18 bar, and unlike LNG and hydrogen, it does not require cryogenic storage temperatures. Furthermore, ammonia is significantly more space-efficient than hydrogen due to its much higher volumetric energy density, which makes it easier to store and transport.

In addition, ammonia is produced in very large quantities and is safely handled across a wide range of industrial sectors, supported by mature technologies and established global supply chains.

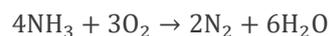
However, the use of ammonia in internal combustion engines introduces new technical challenges and requires emerging fuel-specific technologies. Pilot and demonstration projects are currently underway worldwide to validate engine concepts, combustion behaviour, and supporting safety and handling frameworks.

Environmental impact GHG & pollutants 3.3.4

Ammonia contains no sulphur and therefore does not produce SO_x emissions. It also contains no carbon, meaning that no CO₂ is emitted during combustion – a key distinction compared to methanol. Furthermore, ammonia's lack of carbon represents a significant difference to methanol, particularly given methanol's inherent carbon content, even when derived from green or blue feedstocks.

Furthermore, ammonia is highly soluble in water, where it reacts to form ammonium hydroxide (aqueous ammonia). This dissolution process occurs under exothermic conditions, meaning that heat is released when ammonia dissolves in water. In addition, ammonia exhibits acute toxicity to aquatic life, particularly to fish, even at low concentrations. The principal environmental hazard is acute ammonia toxicity rather than long-term persistence, as ammonia does not bioaccumulate and is not considered environmentally persistent.

In theory, the ideal stoichiometric combustion of ammonia produces only nitrogen and water:



As ammonia-fuelled marine engines are still under development, real-world combustion at elevated temperatures can lead to the formation of undesirable by-products, including nitrogen oxides (NO_x) and nitrous oxide (N₂O). In particular, N₂O has a global warming potential over a 100-year horizon (GWP₁₀₀) approximately 273 times higher than that of CO₂, rendering its formation counterproductive to the IMO

greenhouse-gas reduction objectives. Effective mitigation of these emissions is therefore essential and is typically achieved through the application of Selective Catalytic Reduction (SCR) after-treatment systems.

Similar to LNG-fuelled engines, ammonia engines may also exhibit fuel slip, commonly referred to as ammonia slip, particularly in four-stroke engine configurations. Although ammonia itself is not classified as a greenhouse gas, local or regional environmental regulations may impose limits on ammonia emissions due to potential impacts on air quality and ecosystems. When appropriately designed and operated, SCR systems can reduce ammonia slip to trace concentrations in the low-parts-per-million (ppm) range.

Ammonia released through slip, together with NO_x compounds formed during combustion, may further react in the atmosphere to form secondary pollutants, including fine particulate matter such as ammonium nitrate (NH₄NO₃), contributing to PM_{2.5} concentrations. Under certain atmospheric conditions, these reactions may also lead to the formation of additional N₂O.

Lifecycle Analysis for Methanol and Ammonia 3.4

Currently, less than 1% of global methanol production can be classified as blue or green, with the remaining share of ~99% produced as grey methanol (primarily from natural gas) or brown methanol (from coal). While comprehensive and standardised life-cycle assessments (LCAs) are not yet available for all methanol production pathways, it is evident that methanol derived from fossil feedstocks is unlikely to deliver greenhouse-gas (GHG) emission reductions when compared with LNG or MGO. Consequently, methanol produced via these pathways cannot be considered suitable for achieving GHG-reduction targets.

A similar situation applies to ammonia. To date, less than 1% of global ammonia production is classified as blue or green, with the vast majority, approximately 99%, still produced as grey ammonia from fossil feedstocks. Although comprehensive, standardised LCAs for ammonia are not yet fully established and reported emissions for grey ammonia vary depending on the specific production pathway, it is already apparent that the use of grey ammonia as a marine fuel would result in higher overall GHG emissions than conventional maritime fossil fuels. As such, grey ammonia is not considered suitable for its intended purpose of contributing to greenhouse-gas reduction in line with IMO targets.

Life-cycle assessments for methanol and ammonia as a marine fuel are likewise still under development, and robust, engine-specific emissions data remain limited. This is particularly the case for two-stroke marine engines, for which empirical data on the GHG-reduction performance of blue or green methanol and ammonia are not yet publicly available. The comparative overview provided by Bureau Veritas in its 2022 publication Outlook for Alternative Fuels therefore serves as a useful high-level reference but should be interpreted as indicative rather than definitive until more detailed and standardised LCA data become available as provided in figure 3-1.

TYPICAL WELL-TO-WAKE EMISSIONS OF MARINE FUELS (gCO_{2e}/kWh - GWP100)

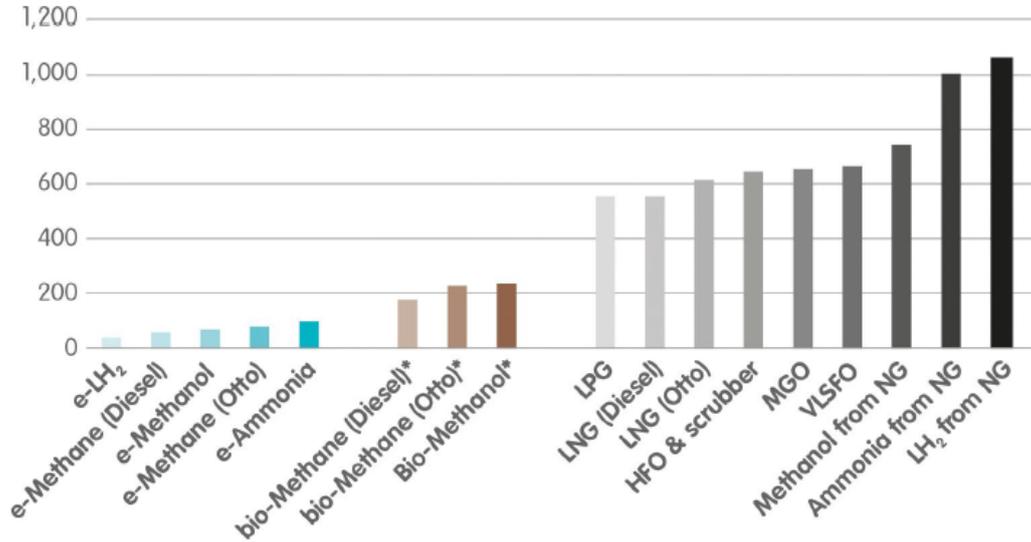


Figure 3-1: Typical fuel emission factors
Source: Bureau Veritas, Outlook for Alternative Fuels, 2022

Implementation Guidance 4.

SCOPE AND INTENT:

Chapter 4 brings together the practical elements that ports need to plan, authorise, control and oversee methanol and ammonia bunkering within their jurisdiction. Rather than describing a single linear process, the chapter is structured around the key decision areas and control functions that ports should address as bunkering moves from concept to routine operation.

How to read Chapter 4:

The chapter is organised in thematic blocks that broadly reflect how ports work in practice. The structure is designed to be practical and intuitive, allowing readers to focus on specific areas of responsibility.

The chapter complements and expands on the “Ports Roadmap to Bunkering” steps presented in Chapter 1. While Chapter 1 provides a high-level, step-by-step strategic pathway for ports to become bunkering-ready, Chapter 4 dives deeper into the operational, regulatory, safety and governance elements that underpin each of those steps.

In essence:

- Chapter 1 presents *what* needs to be done and in what sequence.
- Chapter 4 explains *how* those steps can be implemented in practice, across different port functions and stakeholder interfaces.

Chapter 4 thematic blocks:

1. **Governance and engagement** sections explain the role of the port authority across the four stages of bunkering development and how stakeholder responsibilities, communication and public engagement should be managed.
2. **Site selection and permitting** sections describe how ports identify suitable bunkering locations, integrate navigational and traffic considerations, and establish licensing and authorisation frameworks.
3. **Risk assessment and controlled areas** sections provide the analytical foundation used to define safety zones, assessment zones and SIMOPs controls, and to support consistent, defensible decision-making.
4. **Fuel-specific sections** address methanol and ammonia separately where their hazard profiles differ, particularly in relation to flammability, toxicity and dispersion behaviour.
5. **Operational control sections** describe the tools used to manage individual bunkering operations, including compatibility assessments, checklists, and emergency shutdown, and training and how ports maintain control during operations.
6. **Emergency preparedness**, sections explain how ports respond to incidents, and apply lessons learned.
7. **Special and non-routine cases**, sections address special and non-routine cases, supporting ports in managing infrequent or non-standard scenarios that fall outside business-as-usual operations but still require appropriate controls.

Readers do not need to read Chapter 4 sequentially from start to finish. Ports may focus first on the sections most relevant to their current Port Readiness Level, returning to other sections as their framework matures. Cross-references are provided throughout the chapter to support this modular approach.

Taken together, the sections in Chapter 4 are intended to support a structured yet flexible implementation pathway, allowing ports to progress from early planning and pilot operations to safe, repeatable, business-as-usual bunkering of methanol and ammonia.

Port governance, strategy and engagement 4.1

This section explains the role of the port authority across the four stages of bunkering development and how stakeholder responsibilities, communication and public engagement should be managed.

It includes guidance for:

- Role of ports across the four stages for vessel operators
- Link to the IAPH port readiness level framework
- Stakeholder engagement (internal and external)

Role of ports across the four stages for vessel operators 4.1.1

Ports play a critical role throughout all four stages (see section 2.4), often acting as, or supporting, the competent authority for the bunkering location.

Design Stage

Ports assess whether methanol or ammonia bunkering is feasible within the port environment. This includes:

- identifying suitable locations and interfaces with existing port activities,
- understanding high-level hazards and constraints, and
- engaging early with regulators, emergency services, and stakeholders.

Planning Stage

Ports focus on assurance and authorisation by:

- reviewing risk assessments, safety zones, and SIMOPs,
- assessing the Methanol/Ammonia Bunkering Management Plan, and
- establishing permit conditions and operational boundaries.

Preparation Stage

Ports verify readiness for a specific operation by:

- reviewing the Joint Bunkering Plan (JBP),
- confirming safety zones, traffic control, and communication arrangements, and
- ensuring emergency response and enforcement mechanisms are in place.



Operational Stage

Ports provide oversight and coordination by:

- enforcing approved conditions and access restrictions,
- coordinating with VTS, terminals, and emergency services, and
- responding to deviations, incidents, or abnormal situations.

Across all stages, ports ensure that bunkering is integrated safely into wider port operations.

Link to the IAPH port readiness level framework 4.1.2

The four-stage approach aligns closely with the IAPH Port Readiness Level for Marine Fuels (PRL-MF) framework.

- Design and early Planning Stages broadly correspond to PRL-MF 1–4, where ports develop foundational knowledge, assess feasibility, and establish governance and safety frameworks.
- Preparation and early Operational Stages align with PRL-MF 5–6, covering framework testing, training, and pilot-scale demonstrations.
- Repeated operations and business-as-usual bunkering align with PRL-MF 7–9, where processes are standardised, streamlined, and scaled.

This Guidebook is therefore particularly suited to supporting ports in the early to mid PRL-MF levels, while also providing a clear pathway toward mature, routine methanol and ammonia bunkering operations.

Stakeholder engagement (internal and external) 4.1.3

This section provides practical guidance for ports on identifying, engaging, and managing stakeholders involved in methanol and ammonia bunkering across the design, planning, preparation, and operational readiness stages. It focuses on port-level governance, coordination, and assurance and does not address operational roles during bunkering.

Stakeholder identification and maintenance 4.1.3.1

Ports should establish and maintain a formal stakeholder identification process covering all organisations that:

- have jurisdiction or regulatory authority over the bunkering location or activity;
- own, operate, or manage assets used for bunkering or located in proximity;
- provide emergency response, medical, or security services within the port area; or
- may be affected by bunkering activities within or adjacent to the port.

Stakeholder identification should be:

- completed at the outset of any new bunkering location or supply scenario;
- reviewed whenever there are changes to location, supply arrangement, facility design, or operating conditions; and
- documented in a stakeholder register that is updated as the project progresses.



Public and community engagement 4.1.3.2

Ports should address public engagement for methanol and ammonia bunkering through existing, well-established port communication and emergency-planning frameworks, recognising that ports form part of the wider local community.

Public engagement should:

- be proportionate to the assessed risk and potential off-site impact;
- be coordinated with local authorities and emergency services where required;
- use established channels already applied for other hazardous port activities; and
- avoid unnecessary alarm while providing clear, factual information.

Ports should consider public engagement where:

- emergency planning zones extend beyond port boundaries;
- bunkering occurs close to residential, commercial, or public-access areas; or
- national legislation requires consultation or notification.

Typical port actions may include:

- ensuring local emergency plans (including medical response and public health coordination) account for bunkering scenarios;
- aligning public information and warning arrangements with municipal emergency systems;
- designating a single port contact point for external communication; and
- supporting local authorities in responding to public enquiries, where appropriate.

Stakeholder engagement key considerations 4.1.3.3

Engagement aligned to development stage:

Ports should align stakeholder engagement with the stage of bunkering development, ensuring that the right organisations are involved at the right time.

1. Design and early planning
 - confirm applicable national and local legislation, standards, and acceptance criteria;
 - identify the competent authority or authorities for each stage;
 - agree expectations for risk assessment scope, modelling assumptions, and safety zone definitions; and
 - identify port-specific constraints, sensitivities, and interface risks.
2. Planning and preparation
 - review submitted risk assessments and safety concepts with relevant stakeholders;
 - confirm emergency response assumptions, including fire, medical, and evacuation considerations;
 - verify access routes for emergency vehicles, including ambulances; and
 - ensure communication and escalation arrangements are clear.



3. Transition to routine operations
 - formalise recurring engagement arrangements;
 - define triggers for re-engagement or re-assessment; and
 - ensure continuity where personnel or organisations change.

Clarification of roles and authority:

Ports should explicitly document:

- which organisation acts as the competent authority at each stage;
- how responsibilities are shared where multiple authorities apply; and
- how decisions, approvals, and enforcement actions are coordinated.

Where roles overlap, interfaces should be resolved before authorisation is granted.

Coordination with port users, neighbours, and emergency services:

Ports should implement proportionate engagement arrangements to:

- inform other port users of planned bunkering activities and any temporary restrictions;
- coordinate schedules and constraints where SIMOPs are present;
- consider neighbouring facilities where safety or assessment zones extend beyond the immediate bunkering area; and
- engage emergency services, including fire, police, and **medical services**, to confirm response roles, access routes, and casualty management arrangements.

Engagement should be scaled to the assessed risk and potential impact.

Documentation and traceability:

Ports should ensure that:

- stakeholder and public-authority inputs are recorded;
- agreed assumptions and constraints are traceable; and
- records are retained to support audits, regulatory review, and future re-assessments.

Review and continuous improvement:

Stakeholder and public engagement arrangements should be reviewed periodically and updated where:

- bunkering activities expand or change in nature;
- regulatory, security, or emergency-planning requirements evolve; or
- lessons learned indicate a need for earlier or clearer engagement.

Site selection, permitting and port planning tools 4.2

This section describes how ports identify suitable bunkering locations, integrate navigational and traffic considerations, and establish licensing and authorisation frameworks.

It includes guidance for:

- Site identification, design and risk assessment
- Port bunkering map
- Bunkering licensing process
- Nautical safety assessments
- Vessel traffic services and vessel traffic management

Site identification, design and risk assessment 4.2.1

The identification of suitable locations for methanol and ammonia bunkering within a port should follow a structured, risk-based approach led by the port authority, often acting as or supporting the competent authority. This process ensures that bunkering activities can be safely integrated into the port environment while remaining compatible with existing operations and local regulatory requirements.

Appendix B provides a practical, staged process that ports can apply to identify, approve, and operationalise bunkering locations for methanol and ammonia.

Site identification – What to consider 4.2.1.1

Site identification should be grounded in the port's existing safety framework, supplemented by the guidance provided in this Guidebook and any additional port-specific rules or by-laws.

Ports should define, at a strategic level:

- **which fuels** they intend to accommodate within the harbour or port area, informed by commercial considerations, fuel availability, and risk assessment;
- **which areas of the port** may be considered suitable for bunkering, taking into account existing port infrastructure, land availability, navigation constraints, and surrounding activities, and under what conditions bunkering may be permitted.
- **which areas are not currently suitable for bunkering but could be adapted or developed in the future**, for example through infrastructure upgrades, changes in land use, additional safety controls, or revised operational arrangements.

Identifying both current and potential future bunkering locations allows ports to plan proactively, manage expectations with stakeholders, and support phased implementation aligned with port development strategies and IAPH Port Readiness Levels.

This framework should establish clear principles, acceptance criteria, and assessment processes for identifying and approving bunkering locations. Once defined, it should be consistently applied across different fuels and bunkering scenarios, providing clarity to stakeholders and supporting efficient, defensible decision-making.



Port infrastructure and surrounding environment

The suitability of a bunkering site depends on its interaction with both port infrastructure and areas outside the port boundary. Key considerations include:

- proximity to buildings, roads, railways, terminals, and utilities;
- presence of public areas or sensitive receptors outside the port;
- availability of space to establish safety zones, marine exclusion zones, and access control;
- compatibility with existing berth layouts and quay structures.

Where neighbouring facilities or public areas may be affected, their presence should be considered within the risk assessment and reflected in site selection and mitigation measures.

Navigational considerations

Navigation and vessel traffic are critical elements of site selection. Ports should assess:

- access and manoeuvring requirements for receiving vessels and bunker vessels;
- proximity to fairways, turning basins, and pilot boarding areas;
- traffic density and the feasibility of establishing marine exclusion zones;
- interaction with Vessel Traffic Services (VTS) and pilotage requirements.

Locations where safe navigation cannot be assured during bunkering may require additional controls or may be deemed unsuitable.

Fuel-specific suitability

Not all locations within a port will be suitable for all fuels. Due to differences in hazard characteristics, a site acceptable for methanol bunkering may not be acceptable for ammonia, and vice versa. Ports should therefore assess site suitability on a fuel-specific basis, considering flammability, toxicity, dispersion behaviour, and emergency response implications.

This differentiation supports a pragmatic approach where ports may designate:

- areas suitable for multiple fuels;
- areas restricted to specific fuels; or
- areas excluded from bunkering activities altogether.

Port bunkering map 4.2.2

A port bunkering map is a planning and communication tool that visually identifies where and under what conditions bunkering of alternative fuels may be conducted within the port area. It provides a spatial representation of the port's strategic approach to bunkering, translating policy, risk assessment outcomes, and operational constraints into a clear, accessible format for both internal use and engagement with external stakeholders.

Ports are encouraged to develop and maintain a bunkering map identifying:

- approved or potential bunkering locations (berths, quays, anchorages);
- applicable bunkering supply scenarios;
- fuels permitted at each location;
- key constraints (e.g. maximum vessel size, operational limits).

Such a map supports transparency, consistent decision-making, and early engagement with stakeholders.

Licensing, permits and authorisation

Site identification and design should be closely linked to local licensing, permitting, and authorisation processes. Risk assessments conducted at the site level form the technical basis for these approvals and should demonstrate compliance with national legislation, port by-laws, and applicable international guidance.

Ports should ensure that permitting requirements are clearly defined and proportionate, with conditions reflecting the specific risks associated with the site, fuel, and bunkering scenario (See section 4.2.3).

Bunkering licensing process 4.2.3

Purpose of licensing 4.2.3.1

The licensing process should define the framework under which bunker suppliers and/or receiving vessels are permitted to conduct bunkering operations at designated locations within the port. This process may be referred to in other publications or by individual ports as permitting, authorisation, or equivalent terms.

For the purpose of this Guidebook, the term 'licensing' is used to cover permitting, authorisation, or equivalent regulatory approvals, unless explicitly stated otherwise.

The guidance provided below only marginally addresses stakeholders external to the port, such as permitting authorities or emergency response organisations as the requirements may significantly differ between various national jurisdictions. The port should establish a licensing process for bunker suppliers that is proportionate, transparent, and practicable, and which can be effectively managed with the resources and workforce available within the port organisation.

Clarification Note – Licensing versus Operation-Specific Approvals:

The underlying requirements remain essentially the same whether a port applies a one-off operational approval or a broader supplier licence. In both cases, the port must establish that the parties involved demonstrate the necessary expertise, technical capability and safety understanding.

Ports may decide to issue single-operation approvals based on specific circumstances, such as pilot projects, early-stage implementation or particular local constraints. For more routine or commercial operations, a general or standing bunker supplier licence - linked to defined locations, fuels and operational envelopes - is typically more efficient and scalable.

As a general principle, ports should regulate through standing licences where feasible, reserving operation-specific approvals for exceptional, non-routine or case-by-case situations.

Key Takeaways for Ports – Bunkering Licensing:

1. Licensing is a port-led control tool.
Licensing (also referred to as permitting or authorisation) is the mechanism through which ports define where, how, and under what conditions methanol and ammonia bunkering may take place within the port area.
2. Start with national permits and legislation.
Before establishing any bunkering licence, ports should confirm that bunkering activities are covered by existing national permits or identify where permit amendments are required. An early, structured gap analysis with regulators is essential.
3. HAZID underpins the licensing framework.
Fuel-specific HAZID workshops are a critical foundation for licensing, informing safety zones, SIMOPs constraints, operational limits, emergency preparedness, and the definition of approved bunkering locations (e.g. port bunkering maps).
4. Use existing industry frameworks to avoid duplication.
Ports are encouraged to rely on recognised schemes such as the IAPH bunker audit framework and industry guidelines, rather than creating parallel verification processes. This reduces administrative burden while maintaining assurance.
5. Be transparent and predictable.
Licensing requirements, application steps, responsibilities, and approval conditions should be clearly documented and publicly available, ideally supported by digital application and tracking tools.
6. Ports remain the single coordination point.
Even where national authorities impose additional conditions, the port authority should act as the primary interface for bunker suppliers, ensuring consistent coordination, compliance monitoring, and enforcement.
7. Licensing should evolve with maturity.
As bunkering moves from pilot projects to business-as-usual, licensing frameworks should be streamlined, proportionate, and periodically reviewed to reflect operational experience and lessons learned.

Step 1: Review ports permit requirements 4.2.3.2

Ports operate under national permits that define the activities authorised, the conditions under which such activities may be carried out, and the associated monitoring and compliance requirements. Port operators should therefore engage with their competent regulatory authorities to determine whether bunkering operations or specific support services are covered by existing permits and to identify any additional requirements that should be fulfilled.

To support this process, the port and/or terminal should conduct an initial gap analysis to identify applicable requirements arising from national legislation, regulatory frameworks, and permitting conditions. These requirements are derived from binding national laws and permit obligations under which the port operates and are distinct from industry guidelines or voluntary best practices.

This initial gap analysis constitutes the first and most critical step in engaging with regulators and other external stakeholders. During an initial coordination meeting with the competent authority, the relevant regulators and stakeholders should be identified, and their respective roles and responsibilities clarified.

Subsequently, a detailed follow-up gap analysis, conducted jointly with all relevant national and local stakeholders, should be undertaken. This process should establish a common understanding of the applicable requirements and provide clarity on the technical, operational, and procedural measures that should be fulfilled prior to permitting and commencement of operations.

Only once the port permit has been amended, where required, and all applicable national requirements have been identified, may the licensing process for bunker suppliers be established.

Port HAZID workshop 4.2.3.3

To establish an effective licensing framework, the port should develop fuel-specific procedures based on the outcomes of HAZID workshops involving the stakeholders identified in section 2.2. These procedures should account for, at a minimum:

- Local legislation and permitting requirements
- Availability and capability of emergency-response facilities
- Designated bunker suppliers
- Designated bunker receivers
- Fuel-specific operational constraints
- Existing auditing results

It is strongly recommended that these HAZID workshops be facilitated by independent industry specialists, rather than being self-facilitated by the port authority. The HAZID outcomes should identify outstanding tasks, constraints, and limiting factors within the port area, including but not limited to:

- Licensing requirements for BSVs
- Manoeuvring and tug-assistance requirements for BSVs
- Transfer, draining, and purging requirements
- Maximum permitted transfer flow rates
- Venting requirements
- Safety and toxicity-based hazard zones
- Exclusion zones
- Reporting obligations
- Operational and pre-transfer checklist requirements
- Port heat map defining approved bunker locations
- SIMOPs requirements depending on the receiving-vessel type

As an example of established good practice, the Port of Rotterdam developed a port heat map at an early stage of LNG bunkering implementation. This heat map identifies locations where bunkering is permitted under a general licence, where additional restrictions apply, and where a case-by-case approval is required.

Such heat maps can only be developed through comprehensive HAZID workshops, defining which fuels may be supplied, at which locations, and via which transfer modes. This approach has since been adopted as good practice by several ports and allows bunker suppliers to readily assess where bunkering operations can be conducted.

Step 2: Establishing a bunker supplier licencing process 4.2.3.4

Ports may adopt different licensing concepts for bunkering operations, ranging from relatively simple to highly sophisticated. Depending on the port, these concepts may focus primarily on the bunker supplier, the receiving vessel, or a combination of both. Regardless of the chosen approach, a formal licensing process is essential to ensure compliance with national legislation and adherence to local port requirements and take the results of the conducted HAZID workshop into account.

Port and terminal operators should actively participate in the qualification and approval process of bunker suppliers. All licensing requirements should be clearly documented on the port's official website, including the designation of a responsible department within the port authority to manage such applications. The use of a digital platform for information exchange, application handling, and licensing is strongly recommended.

It should be noted that, in most cases, the bunker supplier and the technical manager of the bunker supply vessel are not the same legal entity. The license should therefore be applied for by the bunker supplier, with the technical manager acting on the supplier's behalf. Consequently, the license should be issued to the bunker supplier, with the technical manager being co-permitted. Any change of bunker supplier or technical manager should trigger a reapplication and reassessment of the licensing process. When utilizing road trucks, the bunker supplier might be the only applicant.

The International Association of Ports and Harbors (IAPH) has developed a model framework providing guidance on the qualification of bunker suppliers for licensing purposes. The IAPH audit tool outlines an eight-step process for obtaining such a license and serves as a recognized reference for ports implementing clean marine fuel bunkering operations.

In all cases, the national requirements set out in the port's national permit should be fully reflected in the bunker supplier licences, including any conditions, restrictions, or limitations.

IAPH bunker auditing process 4.2.3.5

The IAPH requires that an audit be conducted at the premises of the technical manager of the of the BSV including the bunker supplier. When providing licences for road trucks, the audit should be conducted at the bunker suppliers operational office.

Such audits should be carried out by suitably trained and qualified auditors. The applicable audit requirements should be clearly defined in documentation published on the port's official website and should incorporate relevant national legislation as well as specific port and/or terminal permitting requirements.

In this context, it is advisable for ports to rely on audits already performed under recognized IAPH frameworks, rather than implementing a parallel or standalone verification process. Leveraging existing IAPH member audits can reduce duplication of effort while maintaining a robust level of assurance.

In addition, it should be noted that the maritime industry applies its own established vetting and performance management systems for tankers, such as the Ship Inspection Report Programme (SIRE) and the Tanker Management and Self-Assessment (TMSA) schemes administered by Oil Companies International Marine Forum (OCIMF). These systems are widely enforced across the industry and provide detailed insight into the operational performance, safety management, and compliance standards of technical managers.

It is therefore recommended to consider SIRE and TMSA outputs as part of the bunker supplier verification and licensing process. As the majority of technical managers are already required to comply

with these frameworks, they offer a valuable and efficient means of assessment. Access to SIRE inspection reports can be formally requested through OCIMF.

Practical bunker licence considerations 4.2.3.6

As stated above, the port and terminal operator may impose requirements that should be fulfilled in addition to national regulatory obligations enforced by the relevant authorities. The port authority should remain the single point of contact for the bunker supplier for all matters related to permitting, coordination, and compliance.

It should be noted that certain publications and permitting approaches involve the receiving vessel directly in the permitting and verification process. This effectively creates an operation-based licensing scheme under which each individual bunkering operation requires separate approval following submission of the necessary documentation.

While such an approach may be appropriate under specific circumstances, it imposes a substantial administrative burden due to the need to review documentation for every single operation. Consequently, this model is generally only advisable in limited or exceptional cases where bunker location and setup is worth reviewing it on case to case basis instead of regulating it under a general bunker licence. Or where a licencing process is just being established.

The bunker licensing process should be visualised as a flowchart and made publicly available, either via the port's website or as a formal manual accessible to bunker suppliers and receiving vessels. The documentation should provide a clear overview of where, under what conditions, and for which fuels bunkering operations may be conducted within the port area.

Step 3: Licence application 4.2.3.7

Within the scope of the initial HAZID workshop, the documentation requirements for bunker suppliers should be assessed. As a minimum, the following documentation should be provided:

- General arrangement drawings
- Manoeuvring characteristics
- Hazardous area (Ex) zoning plans
- Drawings and descriptions of transfer systems (P&IDs, transfer hoses or equivalent systems, emergency release couplings, QCDCs or otherwise)
- Lifting appliances or derricks used for bunker transfer operations
- Transfer procedures, including draining, purging, and testing
- Applicable bunker checklists
- SIMOPs procedures and requirements
- IAPH audit results
- Location-specific risk assessments for bunker supply operations

The documentation should preferably be presented in person to the port authority, together with the bunker concept and the associated risk-management framework. Following the port's review and acceptance of the submitted documentation, a bunkering permit may be issued. Such a permit may include, but is not limited to, the following conditions:

- Permitted bunkering locations or reference to an approved bunker heat map
- Maximum permitted transfer flow rates
- Venting requirements
- Safety- and toxicity-based hazard zones



- Approved connection arrangements and purging requirements
- Exclusion zones
- Tug-assistance requirements for mooring and unmooring
- Reporting requirements to the relevant authorities
- Mandatory operational and pre-transfer checklists
- SIMOPs requirements depending on the receiving-vessel type

Licensing of receiving vessels is generally less favoured. Additional permits may only be issued for specific fuel-system-related operations, such as cool-down, gassing-up, or inerting activities, and should in all cases be subject to a dedicated, operation-specific risk assessment.

Cargo transfer 4.2.3.8

Furthermore, it should be noted that STS operations between a BSV and another IGC- or IBC-certified vessel, depending on the fuel involved, are generally not classified as bunkering under international legislation. Consequently, such operations may also fall outside the scope of existing port or terminal permits. This distinction should be carefully considered where STS operations are intended to be included within the permitted operational envelope additionally to bunkering.

Nautical safety assessments 4.2.4

General requirements 4.2.4.1

In preparation for the introduction of alternative fuels, nautical safety assessments may be required where risks are identified during the initial HAZID workshop. Such assessments should focus on navigational safety, traffic interaction, and operational constraints within the port area and should be proportionate to the fuel type, transfer method, and operational complexity.

At a minimum, the following aspects should be considered:

- Manoeuvring characteristics of BSVs
- Maximum vessel sizes routinely operating within the port
- Tug assistance requirements and potential exemptions based on propulsion and thruster capability
- Traffic density in different port areas and fairways
- Vessel-passing effects for STS configurations
- Collision and allision risk analysis

BSV manoeuvring characteristics 4.2.4.2

The manoeuvring characteristics of the BSV should be carefully reviewed as part of the nautical safety assessment. Although BSVs are typically not among the largest vessels operating within a port, exemptions from compulsory pilotage and/or tug assistance may be requested by bunker suppliers, particularly where vessels are equipped with enhanced propulsion and manoeuvring capabilities (e.g. azimuth thrusters, Becker rudders, DP capability, etc).

Where such exemptions are proposed, the bunker supplier should demonstrate, through documented evidence, that the vessel can be safely manoeuvred under all relevant environmental and traffic conditions. This demonstration may include:

- Manoeuvring data and stopping distances
- Thruster and propulsion redundancy



- Track records from comparable ports
- Bridge procedures and crew competence

If required by the port authority, these submissions should be supported by nautical simulations, particularly where exemptions from pilotage or reductions in tug usage deviate from existing port regulations.

STS and passing vessels 4.2.4.3

Where STS bunkering operations are introduced in ports where such operations are not routinely conducted, the effects of passing vessels should be specifically evaluated. This includes assessment of:

- Hydrodynamic interaction forces
- Surge, sway, and yaw motions of moored vessels
- Displacement of water in narrow channels

Initial screening may be undertaken using static calculations. However, where traffic density is high or manoeuvring margins are limited, dynamic analysis, including CFD simulations, may be required to adequately capture interaction effects.

As an outcome of the HAZID process, minimum passing distances and maximum passing speeds should need to be assessed and implemented through VTS procedures, port notices, or operational permits.

Traffic density 4.2.4.4

To support the identification of safe bunkering locations, it is considered good practice to develop traffic density plots using historical AIS data. These plots provide insight into traffic patterns, peak periods, crossing points, and high-utilisation fairways.

Based on these data sets, a collision and allision risk analysis may be performed to estimate incident frequency and risk levels. Such analyses typically consider:

- Vessel type and size distribution
- Traffic volume and routing
- Historical incident and near-miss data
- Operational constraints during bunkering

The results can be used to justify bunker location selection, define exclusion zones, support heat-map development, and determine whether additional control measures such as speed restrictions, traffic windows, or tug assistance are required.

Port role and expectations 4.2.4.5

All findings from the nautical safety assessment should be integrated into the port's overall risk management framework, including VTS procedures, SIMOPs requirements, emergency response planning, and bunker permitting conditions. Where exemptions or deviations from standard port rules are granted, these should be clearly documented, risk-based, and subject to periodic review.

Vessel traffic services and vessel traffic management 4.2.5

Vessel traffic management 4.2.5.1

Each port should operate a port-specific traffic management regime under the authority of the port operator and in close coordination with terminal operators. This regime should account for berth and jetty occupancy, vessel arrival and departure sequencing, cargo as well as bunker operations and any other operational constraints arising from activities at the jetty. Traffic management should also encompass land-side movements, including the controlled entry, routing, staging, and exit of road or train vehicles within the port area.

Vessel traffic services 4.2.5.2

Vessel Traffic Services (VTS), typically operated from a dedicated VTS centre, should be responsible for ensuring the safe and efficient navigation of vessels from the designated anchorages, pilot boarding ground to the assigned berth, jetty, or operational areas. This includes the assignment of anchorage positions for bunkering if this is considered as safe location during the licencing process.

The movements of BSVs operating without pilotage should be subject to enhanced monitoring and the VTS should observe the defined operational limits, including speed restrictions, routing constraints, and time-window limitations where appropriate.

Double-Banking configurations 4.2.5.3

For ship-to-ship (STS) bunkering operations, both vessel traffic management and VTS should explicitly address double-banking configurations. This includes assessment and control of:

- Reduced available manoeuvring space;
- Passing-vessel speeds and displaced water effects;
- Hydrodynamic interaction between vessels;
- Establishment and enforcement of marine exclusion and safety zones;
- Emergency response access and escape routes.

Onshore traffic management for road vehicles 4.2.5.4

Traffic management arrangements should further consider the movement and staging of road vehicles transporting dangerous goods, regulated under national legislation and the ADR framework. This should include:

- Designation of suitable waiting, holding, and marshalling areas for bunker trucks;
- Separation of toxic-goods traffic from general port traffic where practicable;
- Control of shore-side traffic in proximity to bunkering safety and exclusion zones;
- Coordination of truck movements with marine operations, particularly during STS bunkering and SIMOPs.

Port role and expectations 4.2.5.5

All traffic management measures, marine and shore-side, should be fully integrated into the port's SIMOPs framework, emergency response planning, and communication procedures. Clear lines of responsibility between the port authority, VTS, terminal operator, bunker supplier, and emergency services should be defined to ensure that simultaneous operations are conducted without compromising navigational safety, operational integrity, or environmental protection. In any case the vessel traffic service and the VTS should have the overview of the whole picture traffic situation in the port and are

essential to in the coordination of safe movements and interfaces in the port and play an essential role during emergencies.

All marine and shore-side traffic management conducted by vessel traffic services and VTS should be fully integrated into the port's traffic and SIMOPs framework, emergency response plans, and communication procedures. Clear lines of responsibility between the port authority, VTS, traffic management, terminal operator, bunker supplier, and emergency services should be established to ensure that safe bunker operations are conducted without compromising navigational safety, operational integrity, or environmental protection.

Traffic management and the VTS should maintain a comprehensive overview of the overall traffic situation within the port and its approaches and should play a central role in the coordination of vessel movements, operational interfaces, and traffic restrictions. During emergency situations, these functions should act as the primary coordination and information hub, supporting the effective implementation of response measures and ensuring the safe and orderly management of marine traffic throughout the port area.

Risk assessment framework and controlled areas 4.3

This section provides the analytical foundation used to define safety zones, assessment zones and SIMOPs controls, and to support consistent, defensible decision-making.

It includes guidance for:

- Risk assessment, controlled areas HAZOP and SIMOPs
- Vent mast releases and gas dispersion considerations
- Assessment Zone: Purpose, Implications and Relevance for Port

Risk assessment, controlled areas HAZOP and SIMOPs 4.3.1

The safe implementation of methanol and ammonia bunkering within a port requires a structured, risk-based approach that supports decision-making on site suitability, operational limits, controlled areas, and simultaneous operations (SIMOPs). From a port perspective, risk assessment is a planning and assurance tool, rather than a design exercise, and forms the technical basis for permitting, conditions of use, and enforcement.

Ports should ensure that risk assessments are proportionate, fuel-specific, site-specific, and aligned with the port's safety framework, while remaining consistent with recognised international standards and guidance.

Appendix D provides practical guidance to support ports, operators, and other stakeholders in preparing, reviewing, and applying HAZID, HAZOP, and SIMOPs assessments for methanol and ammonia bunkering operations.



Role of risk assessment in the port implementation process 4.3.1.1

Risk assessment supports ports in:

- determining where bunkering may be permitted and under what conditions;
- defining hazardous areas, safety zones, toxic areas (where applicable), and marine exclusion zones;
- assessing compatibility with port infrastructure, navigation, and neighbouring activities;
- managing SIMOPs and operational interfaces;
- establishing clear operational envelopes and permit conditions.

Risk assessments are normally prepared by operators and designers; however, ports-often acting as the competent authority-are responsible for reviewing, accepting, and applying their outcomes.

Types of risk assessment 4.3.1.2

Ports may encounter different forms of risk assessment at various stages of implementation. These should be viewed as complementary, rather than mutually exclusive.

Ports should also be aware that national or regional regulators may mandate the use of specific risk assessment methodologies. The selection and application of risk assessment types should therefore be informed not only by the characteristics of the bunkering operation, but also by applicable statutory and regulatory requirements.

Further information can be found Appendix section D.1

Qualitative Risk Assessment (QualRA) 4.3.1.3

Qualitative risk assessments are typically used in early stages of implementation to:

- identify hazards and credible scenarios;
- support site screening and feasibility decisions;
- inform stakeholder discussions.

QualRA is particularly useful when limited operational data are available, as is often the case for early methanol and ammonia projects.

Quantitative Consequence Assessment (QCA) 4.3.1.4

Quantitative consequence assessments focus on the physical effects of credible releases, such as:

- vapour dispersion (flammable or toxic);
- thermal radiation;
- impact distances.

QCA is commonly used to define:

- hazardous areas;
- safety zones;
- toxic areas (particularly relevant for ammonia);
- marine exclusion zones.

For ammonia, gas dispersion analysis is a critical component of QCA due to toxicity considerations. For methanol, dispersion and fire consequences are typically evaluated with flammability as the dominant hazard.

Quantitative Risk Assessment (QRA) 4.3.1.5

Where required by national regulations or port policy, a full QRA may be undertaken. This combines:

- likelihood of events; and
- severity of consequences,

to evaluate individual and, where applicable, societal risk. QRAs are more resource-intensive and are usually applied for:

- permanent infrastructure;
- complex port environments; or
- locations close to public receptors.

Ports should clearly state when QRA is expected and when qualitative or consequence-based approaches are sufficient.

Use of ISO/TS 18683 as a reference framework 4.3.1.6

Although developed for LNG, ISO/TS 18683:2021 – Guidelines for Safety and Risk Assessment of LNG Fuel Bunkering Operations provides a robust, structured methodology that can be adapted for methanol and ammonia bunkering.

From a port perspective, ISO/TS 18683 is useful because it:

- promotes a risk-based approach to system design and operation;
- explicitly considers SIMOPs and interfaces between parties;
- links risk assessment outcomes to controlled areas and operational restrictions.

While LNG differs significantly in properties, the methodological structure of ISO/TS 18683 can be applied to methanol and ammonia, provided that fuel-specific hazards-particularly toxicity for ammonia-are fully addressed.

Gas dispersion analysis and controlled areas 4.3.1.7

Gas dispersion modelling, as part of a consequence analysis, has been applied for several decades, particularly in air-quality assessment and major accident hazard studies. In recent years, the use of Computational Fluid Dynamics (CFD) has become increasingly feasible for complex geometries and site-specific conditions, including port environments.

A range of modelling tools is currently used within industry, including:

- PHAST (Process Hazard Analysis Tool) – developed by DNV;
- ALOHA (Areal Locations of Hazardous Atmospheres) – developed by the U.S. National Oceanic and Atmospheric Administration (NOAA);
- FLACS-CFD – developed by GexCon AS;
among others.

From a port perspective, it is important that key elements are agreed and understood before dispersion modelling is undertaken, as modelling assumptions can significantly influence the resulting safety and toxic area definitions.



Gas dispersion quality and standards 4.3.1.8

At present, there is no fully consolidated or universally agreed industry approach for ammonia CFD modelling. The International Association of Classification Societies (IACS) is actively working toward developing harmonised guidance for gas dispersion analysis, and interim approaches may be found in classification guidance documents.

Until formal IACS guidance is published, different modelling providers may apply different assumptions and methodologies, potentially leading to different results for similar scenarios.

In this context, Lloyd's Register Guidance Note *LR-GN-057 – Guidance Notes on Gas Dispersion and Explosion Analysis for Alternative Fuelled Ships* provides a useful reference.

Link to risk assessments 4.3.1.9

Gas dispersion analysis should be undertaken as part of a broader risk assessment, with clear alignment to:

- defined credible release scenarios;
- transfer system configuration and operating conditions;
- emergency shutdown performance and response times.

Dispersion analysis should not be performed in isolation, but rather used to support decisions on controlled areas, SIMOPs limitations, and emergency planning.

Fuel considerations 4.3.1.10

For methanol:

- dispersion analysis typically supports flammability-driven safety zones and hazardous areas.

For ammonia:

- dispersion analysis can be used to determine toxic areas, commonly based on agreed concentration thresholds and exposure durations;
- both most-probable and maximum credible release scenarios should be considered.

HAZOP study 4.3.1.11

A Hazard and Operability Study (HAZOP) is a structured, systematic examination of a planned process or operation to identify potential deviations from the design intent, determine their causes and consequences, and verify that the system will perform safely under both normal and abnormal conditions.

The purpose of a HAZOP is to identify design weaknesses, operational vulnerabilities, and failure scenarios at an early stage, and to define additional safeguards or corrective actions where required. It supports the prevention of loss of containment, equipment damage, fire or toxic release, misoperation, and escalation scenarios.

HAZOP is typically performed at P&ID level and divides the system into logical “nodes” (e.g. storage tank, transfer line, vapour return system, emergency shutdown system). Each node is systematically reviewed using guidewords (e.g. *no flow, low flow, high flow, reverse flow, more pressure, less temperature*) combined with process parameters to explore all credible deviations from normal operating conditions.



For methanol and ammonia bunkering, a HAZOP study may focus on the bunker transfer system and associated interfaces, including but not limited:

- Storage and containment systems;
- Fuel transfer lines, hoses or loading arms;
- Vapour return systems;
- Emergency shutdown (ESD) integration between bunker supplier and receiving vessel;
- Drainage, purging, and inerting arrangements;
- Utility and support systems required for safe transfer.

A HAZOP does not re-perform the overall risk assessment but examines in detail how the engineered system behaves when deviations occur. It assesses whether existing safeguards are adequate and identifies where additional design measures, alarms, interlocks, procedures, or training are required.

From a port perspective, the HAZOP is normally conducted by the bunker supplier, vessel operator, terminal, or system designer. The port authority does not typically perform the HAZOP but should verify that:

- A HAZOP has been carried out by competent and independent facilitators;
- All relevant interfaces within port jurisdiction are included;
- Identified actions affecting port-controlled areas are clearly assigned and implemented;
- Findings are reflected in operating procedures, safety zones, and emergency planning.

HAZOP outputs should be documented and maintained as part of the Bunkering Management Plan and licensing documentation, and should be reviewed when significant changes occur, including modifications to transfer systems, changes in fuel type, new bunkering locations, or revised operational envelopes.

Further information can be found Appendix section D.2.

SIMOPs assessment 4.3.1.12

A SIMOPs study is required wherever bunkering takes place alongside other port activities. From a port perspective, SIMOPs assessment is critical to ensuring that bunkering does not introduce unacceptable combined risks.

Activities typically considered include:

- cargo handling;
- passenger movements;
- handling of dangerous goods;
- bunkering of other fuels;
- maintenance, construction, or testing activities;
- routine port and terminal operations;
- abnormal or unexpected events.

SIMOPs limitations should be derived from the risk assessment and dispersion analysis, and may include:

- prohibition of specific activities;
- sequencing or time separation;
- enhanced supervision or controls.

Ports should ensure that SIMOPs decisions are clearly documented, communicated, and enforceable during operations.

Further information can be found Appendix section D.3

Port role and expectations 4.3.1.13

Ports should ensure that:

- modelling assumptions reflect local weather conditions and site layout;
- results are used consistently to define safety zones, toxic areas, and SIMOPs limitations;
- controlled areas are operationally enforceable.

From an implementation perspective, ports are responsible for:

- defining expectations for risk assessment scope and quality;
- reviewing and approving outcomes relevant to port safety;
- translating technical results into permit conditions, controlled areas, and operational limits;
- coordinating SIMOPs controls across different port users;
- ensuring that risk assessments remain valid when conditions change.

Vent mast releases and gas dispersion considerations 4.3.2

In addition to releases associated directly with bunkering transfer operations, ports should consider gas dispersion arising from vent mast releases. Such releases may occur during bunkering activities or during normal or abnormal operation of the fuel system, and in some cases may result in dispersion distances greater than those associated with transfer-system failures. Vent mast releases therefore require explicit consideration within gas dispersion and explosion analyses, particularly in the port environment.

Typical vent release scenarios 4.3.2.1

A non-exhaustive list of scenarios that are commonly assessed within gas dispersion and explosion analyses includes:

- Venting of fuel storage tanks under worst-case relief conditions, such as thermal expansion or fire exposure scenarios.
- Venting due to credible failures, including pressure relief valve (PRV) passing, malfunction, or leakage.
- Ventilation-related releases, where flammable or toxic gas is discharged to atmosphere via enclosed-space ventilation or extraction systems (e.g. fuel preparation rooms, tank connection spaces).

These scenarios apply to both methanol and ammonia fuel systems, with the dominant hazard being flammability for methanol and toxicity for ammonia, although both aspects may be relevant depending on the configuration.

Key technical parameters influencing vent dispersion 4.3.2.2

For vent-related releases, the following parameters should be considered when defining release conditions at the vent tip:

- relief valve sizing and set pressure;
- expected flow rates under relief or passing conditions;
- upstream and downstream piping configuration, including pressure losses due to pipes and fittings;
- vent mast height and orientation;
- vent tip geometry and fittings, such as flame arrestors, rain ingress preventers, bird or debris protection grids, and deflectors.

These elements can significantly influence jet momentum, plume rise, dispersion direction, and dilution, and therefore the extent of hazardous, toxic, or safety zones.

Port operational considerations 4.3.2.3

From a port perspective, vent mast releases are particularly relevant because:

- vent outlets are often located at significant height, potentially affecting dispersion over a wider area;
- releases may occur independently of bunkering, meaning they can coincide with routine port operations;
- port activities such as overhead cranes, cargo-handling equipment, lighting towers, and elevated walkways may be located within the dispersion envelope of a vent release.

Ports should therefore ensure that vent mast dispersion scenarios are:

- included in site-level risk assessments and dispersion studies;
- considered when defining controlled areas, SIMOPs limitations, and access restrictions;
- reviewed in relation to activities involving personnel at height or moving equipment.

In some cases, dispersion distances from vent releases may exceed those from bunkering transfer failures and may therefore become the bounding scenario for defining safety or toxic areas.

Potential mitigation measures 4.3.3.4

Where vent dispersion presents a constraint, mitigation measures may be considered, subject to risk assessment and approval by the competent authority. These may include:

- Operational controls, such as restricting certain port activities (e.g. crane operations) during defined conditions;
- Enhanced monitoring and alarms to provide early awareness of abnormal venting;
- Procedural controls linking venting conditions to SIMOPs management.

Any mitigation intended to reduce controlled-area extents should be supported by updated dispersion analysis demonstrating an equivalent or improved level of safety.

Port role and expectations 4.3.3.5

Ports, often acting as the competent authority, should:

- ensure vent mast release scenarios are explicitly addressed in risk and dispersion analyses;
- understand how vent dispersion interacts with port infrastructure and operations;
- integrate vent-related hazards into SIMOPs planning and enforcement; and
- maintain awareness that vent releases, although less frequent, may represent a credible and potentially dominant hazard.

Assessment Zone: Purpose, Implications and Relevance for Port 4.3.3

Ports play a central role in ensuring that bunkering operations are conducted safely, not only for those directly involved in the operation but also for other port users and, where relevant, the surrounding community. In addition to the Hazardous and Safety Zones that address more frequent and localised events, ports should also consider the Assessment Zone.

The Assessment Zone is a planning and risk management concept. It is not intended to restrict routine port activities, nor does it imply that major accidents are likely. Instead, it provides a structured way for ports to consider very unlikely events with potentially wide consequences, and to confirm that appropriate preventive and emergency arrangements are in place.

Definition of the Assessment Zone 4.3.3.1

The Assessment Zone can be defined as:

The three-dimensional space within which very low-frequency, high-consequence events could, in extreme cases, have effects beyond the immediate bunkering area.

Key characteristics of the Assessment Zone are:

- it extends beyond the Safety Zone and may reach areas not under the direct control of the bunkering parties;
- it is associated with rare events, but with the potential to affect larger numbers of people, infrastructure or port operations;
- it is scenario-based, derived from credible worst-case assumptions rather than routine operational events;
- it supports planning and preparedness, rather than day-to-day operational control.

The Assessment Zone should always be understood as a three-dimensional space, taking into account height, terrain, structures, and confinement effects, not simply a horizontal distance.

Why ports need to consider the assessment zone 4.3.3.2

Considering the Assessment Zone helps ports to:

- demonstrate that bunkering activities have been assessed against societal risk expectations, not only occupational safety;
- ensure that port layout, neighbouring activities, and temporary land use (e.g. passenger areas or events) are compatible with bunkering operations;
- confirm that emergency response arrangements are proportionate to the scale of potential consequences, even if the likelihood is extremely low;



- provide confidence to regulators, stakeholders, and the public that risks are being managed responsibly and transparently.

Importantly, the Assessment Zone does not mean that bunkering is unsafe or unsuitable in ports. On the contrary, it reflects established international practice for managing rare but serious hazards in complex environments.

Port responsibilities and implications 4.3.3.3

From a port authority perspective, the Assessment Zone is primarily a strategic and regulatory tool. Typical port-level considerations include:

- reviewing and accepting the assumptions used to define the Assessment Zone as part of the bunkering risk assessment;
- understanding how the Assessment Zone interacts with port layout, access routes, nearby terminals, vessels, and public areas;
- identifying activities that may need coordination or restriction during bunkering (e.g. high-density passenger movements, SIMOPs);
- ensuring that emergency plans consider off-site or multi-agency response where relevant;
- embedding Assessment Zone considerations into port byelaws, licensing conditions, or approval processes, as appropriate.

The port is not expected to manage technical details of fuel systems. Instead, its role is to verify adequacy, ensure consistency with local conditions, and confirm that risks have been reduced to an acceptable level.

Mitigation and risk management approach 4.3.3.4

Risk management within the Assessment Zone follows the principle that:

- the likelihood of major events should be made very low, and
- the potential consequences should be mitigated as far as reasonably practicable.

This is typically achieved through a combination of:

- preventive measures that reduce the chance of initiating events;
- operational controls, including traffic management and coordination of activities;
- organisational and procedural barriers, such as competence, communication, and clear authority;
- emergency preparedness and response planning.

Ports are not required to eliminate risk entirely, but to be satisfied that risks are reduced to a level that is tolerable and broadly acceptable to society, in line with national and international practice.

Reassurance and proportionality 4.3.3.5

It is important to emphasise that Assessment Zone events are extremely unlikely. Their consideration does not imply a higher operational risk compared with conventional port activities involving any hazardous substances.

By addressing the Assessment Zone in a structured and proportionate manner, ports can:

- support the safe introduction of new fuels and technologies;
- maintain confidence among port users and authorities;
- avoid unnecessary conservatism while still meeting high safety expectations.

In this way, the Assessment Zone becomes a tool for informed decision-making, not a barrier to safe and efficient port operations.

Fuel-specific safety zone determination 4.4

This section addresses methanol and ammonia separately where their hazard profiles differ, particularly in relation to flammability, toxicity and dispersion behaviour.

It includes guidance for:

- Methanol: Determination and size of safety zones
- Ammonia: Determination and size of safety/toxic

Methanol: Determination and size of safety zones 4.4.1

The determination of safety zones for methanol bunkering is driven primarily by flammability-related hazards, with toxicity considerations addressed as secondary factors. Methanol is a low-flashpoint, volatile liquid that can form flammable vapour clouds when released. Although its flames may be less visible than those of conventional fuels, methanol fires can generate significant thermal radiation and escalation risk if not properly controlled.

Methanol is also toxic if ingested or inhaled at sufficient concentrations; however, under open-air bunkering conditions the concentrations associated with flammable vapour clouds are typically reached before acute toxic exposure thresholds become the dominant concern. Consequently, safety zones for methanol bunkering are generally defined on the basis of flammability and fire risk, rather than toxic exposure.

Appendix C provides a practical process that ports can apply to review and where requested approve a safety zone proposal from operators planning bunkering operations under their port jurisdiction.

Methanol flammability and toxicity levels 4.4.1.1

Figure 4-1 presents a simplified schematic illustrating relevant methanol concentration ranges for both flammability and toxicity, shown on a horizontal axis propagating outward from a hypothetical release source.

For clarity and consistency, concentrations are expressed in parts per million (ppm) throughout this section, including flammability thresholds.

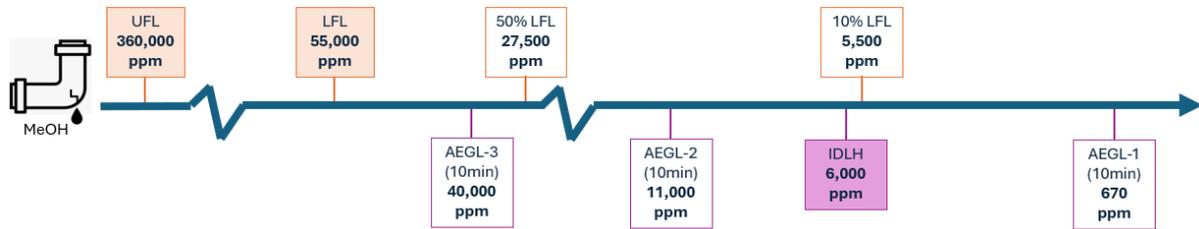


Figure 4-1: Methanol flammability and toxicity ppm levels of interest

Note: It should be recognised that safety zones are three-dimensional spaces, extending not only horizontally but also vertically, and therefore should take into account elevated structures, working at height, vent releases, crane operations, and multi-level access routes within the port environment.

Flammability limits:

- Methanol has a wide flammability range in air, approximately 5.5–36% by volume, equivalent to 55,000–360,000 ppm.
- In gas dispersion analyses, flammable hazard zones are commonly defined using a fraction of the Lower Flammable Limit (LFL). Typical practice applies 50% LFL as a conservative boundary for defining safety zones, although 10% LFL may be used in some contexts to provide additional margin.
- Methanol vapour is heavier than air and may accumulate near the ground or in low-lying areas, particularly under calm or obstructed conditions, increasing the likelihood of ignition if sources are present.

Toxicity exposure limits:

- Toxicity thresholds for methanol vary internationally, as different organisations and regulatory bodies apply different methodologies and exposure criteria.
- Human health impacts depend on both concentration and exposure time: the higher the concentration, the shorter the time a person can be safely exposed, and vice versa.
- Many national legislations define Occupational Exposure Limits (OELs) such as:
 - TWA (Time-Weighted Average) – the average concentration to which workers may be exposed over a typical 8-hour shift;
 - STEL (Short-Term Exposure Limit) – the maximum concentration permitted over a short reference period (typically 15 minutes).
- A useful reference for comparing exposure limits across countries, including EU Member States, is the IFA occupational exposure limit database (<https://limitvalue.ifa.dguv.de/substances>). However, ports are advised to confirm applicable limits with their national health and safety authority.
- In Figure 4-1, the following widely used toxicity reference levels are illustrated:
 - AEGL (Acute Exposure Guideline Levels) for 10 minutes exposure, developed by the U.S. Environmental Protection Agency (EPA), which define concentration thresholds for general public exposure during accidental releases, based on severity of health effects and short exposure durations (see Table 4-1 for definitions).
 - IDLH (Immediately Dangerous to Life or Health), defined by the U.S. National Institute for Occupational Safety and Health (NIOSH), representing a concentration that poses

an immediate threat to life or would impair the ability to escape. IDLH values are not linked to a specific exposure duration but represent a maximum escape threshold.

- While toxicity should not be disregarded, for open-air methanol bunkering operations flammability-based thresholds normally govern safety zone definition.

Table 4-1: Methanol acute exposure guideline levels (US EPA, 2016).

Methanol	10 min	30 min	60 min	4 hours	8 hours
AEGL 1	670 ppm	670 ppm	530 ppm	340 ppm	270 ppm
AEGL 2	11,000 ppm	4,000 ppm	2,100 ppm	730 ppm	520 ppm
AEGL 3	40,000 ppm	14,000 ppm	7,200 ppm	2,400 ppm	1,600 ppm

AEGL 1: Notable discomfort, irritation, or certain asymptomatic non-sensory effects. However, the effects are not disabling and are transient and reversible upon cessation of exposure.
 AEGL 2: Irreversible or other serious, long-lasting adverse health effects or an impaired ability to escape.
 AEGL 3: Life-threatening health effects or death

Methanol gas dispersion analysis considerations 4.4.1.2

CFD modelling for methanol dispersion can provide robust indication of the boundaries of a safety zone, nevertheless, results remain sensitive to how CFD are conducted and dispersion and release assumptions taken into account.

Exposure thresholds and regulatory context:

Before undertaking dispersion modelling for methanol bunkering, it is essential to agree the exposure thresholds and assessment criteria that will be applied. These thresholds are not globally harmonised, and different jurisdictions may apply different occupational health, fire safety, and environmental criteria.

While figure 4-1 provides indicative concentration levels, ports should recognise that:

- national legislation or guidance may impose specific exposure or safety thresholds;
- dispersion studies prepared for one jurisdiction may not be directly applicable in another if different criteria are applied;
- ports should be actively involved in agreeing the applicable thresholds, in coordination with national health and safety and fire authorities, to ensure regulatory alignment and enforceability.

Unlike ammonia, methanol dispersion modelling for bunkering is typically governed by flammability criteria rather than toxicity thresholds. Toxicity considerations remain relevant for occupational safety, but they do not usually define the extent of safety zones in open-air bunkering scenarios.

Note on a practical assessment approach for methanol:

In practice, a commonly adopted and conservative approach to define safety zones based on 10% of the Lower Flammable Limit (LFL) for dispersion analysis. This threshold is reached at concentrations that already encompass widely used acute exposure reference levels, including AEGL-2 and IDLH, under open-air conditions. As a result, applying a 10% LFL criterion can provide a pragmatic means of addressing both flammability and acute toxicity considerations simultaneously for open port environments, without the need to define separate toxicity-driven safety distances.

Ports should nevertheless confirm that this approach is acceptable under national regulatory frameworks and document its use clearly within the risk assessment and permitting process.

Methanol behaviour and implications for vapour cloud extent:

Methanol is a low-flashpoint, flammable liquid, stored and transferred at ambient temperature and pressure. At atmospheric pressure, methanol produces sufficient vapour to ignite at temperatures above approximately 12°C if an ignition source is present. However, its physical behaviour differs significantly from LNG and ammonia in ways that influence dispersion outcomes.

Methanol has a boiling point of approximately 64.7°C, which is substantially higher than that of LNG (approximately -162°C) and ammonia (-33°C). As a result:

- methanol does not flash-boil when released at ambient conditions;
- vapour generation is governed primarily by evaporation from a liquid pool, rather than rapid phase change;
- evaporation rates are influenced by ambient temperature, wind speed, surface area of the pool, and available heat input from the surroundings.

In the absence of an external heat source, methanol evaporation occurs more gradually than for LNG or ammonia.

The following implications should be also considered for safety zone definition:

- **Evaporation and pooling:** Methanol released as a liquid forms a pool that evaporates relatively slowly. However, vapour generation can continue for long time and as long as liquid remains present.
- **Spills on water:** Methanol is fully miscible with water. Releases onto water may disperse rapidly, reducing pool formation but potentially increasing vapour generation over a wider surface area.
- **Ignition and escalation:** Methanol burns with a low-luminosity flame, which can be difficult to detect visually. This characteristic increases the importance of ignition prevention, detection systems, and controlled access.
- **Storage condition:** Methanol is typically stored and transferred at ambient temperature and low pressure. Releases are therefore dominated by liquid pooling and evaporation, rather than high-momentum jets.

These characteristics should be explicitly reflected in dispersion modelling assumptions and the interpretation of results.

As a result of its physical properties and behaviour following a spill or release, methanol vapour plumes generated during credible bunkering scenarios are generally more limited in extent than those associated with LNG or ammonia, particularly in open and well-ventilated port environments.

This typically leads to:

- smaller and more localised vapour clouds;
- lower initial vapour momentum;
- shorter downwind dispersion distances under comparable conditions.

Credible release scenarios and hole size:

Defining credible release scenarios, including the assumed release or hole size, is one of the most influential aspects of dispersion modelling and often a subject of debate. The selected scenarios should be consistent with the risk assessment and reflect realistic failures of the transfer system.

As a reference, the most comprehensive industry work on representative release sizes has been undertaken by SGMF, particularly in its guidance “*Gas as a Marine Fuel – Recommendation of Controlled Zones during LNG Bunkering*”. While developed for LNG, this work provides a useful methodological reference when defining credible release scenarios for ammonia, subject to appropriate fuel-specific considerations. In addition, the guidance proposes representative hole sizes for assessing safety zones arising from hose or fitting failures, ranging from 3 mm for a 2-inch transfer hose to 15 mm for a 10-inch transfer hose.

Port role in approval and enforcement 4.4.1.3

From a port perspective, the characteristics of methanol imply that:

- flammability-based safety zones for methanol are often smaller and more site-contained than those typically applied for ammonia or LNG;
- dispersion modelling should focus primarily on liquid pool formation, evaporation rates, and ignition prevention, rather than long-range toxic exposure;
- local conditions-such as deck materials, surface drainage, wind sheltering, and nearby structures-can have a significant influence on vapour behaviour;
- particular attention should be given to where liquid methanol may drain or collect, ensuring that runoff does not migrate into areas assumed to be safe or uncontrolled.

Ports, often acting as the competent authority, play a central role in:

- reviewing dispersion analyses and the assumptions used to define safety zones;
- ensuring that safety zones are compatible with port layout, access routes, and neighbouring activities;
- coordinating methanol safety zones with hazardous zones, SIMOPs arrangements, and marine exclusion zones;
- enforcing access control and operational restrictions during bunkering operations.

Evolution over time:

For simplicity and conservatism during early-stage implementation, LNG safety distances have in some cases been applied to methanol bunkering, providing a high level of inherent safety. However, this

approach may be overly conservative for certain port layouts or operational profiles and may unnecessarily constrain operations.

As experience is gained, ports may require methanol-specific gas dispersion analyses to refine safety zones. Any adjustment to safety distances should remain risk-based, transparent, and subject to approval by the competent authority, ensuring that the protection of people, infrastructure, and the port environment is not compromised.

Ammonia: Determination and size of safety/toxic zones 4.4.2

The determination of safety zone for ammonia bunkering is driven primarily by toxicity-related hazards, with flammability generally playing a secondary role. While ammonia is technically flammable, under typical open-air bunkering conditions the concentrations required for ignition are significantly higher than those that would already pose a severe toxic risk. In confined or enclosed spaces (e.g. machinery spaces), flammability considerations may become more relevant; however, for bunkering operations conducted in open port environments, toxicity is the prevailing hazard.

Ammonia is both toxic and corrosive, and even relatively small releases can result in harmful airborne concentrations extending over considerable distances, depending on release conditions and meteorology. As a result, the definition of safety zone for ammonia bunkering focuses primarily on limiting human exposure and protecting access to accommodation spaces, air intakes, and populated areas, rather than on ignition prevention.

Appendix C provides a practical process that ports can apply to review and where requested approve a safety zone proposal from operators planning bunkering operations under their port jurisdiction.

Ammonia flammability and toxicity levels 4.4.2.1

Figure 4-2 presents a simplified schematic illustrating relevant ammonia concentration ranges for both flammability and toxicity, shown on a horizontal axis propagating outward from a hypothetical release source.

For clarity and consistency, concentrations are expressed in parts per million (ppm) throughout this section, including flammability thresholds.

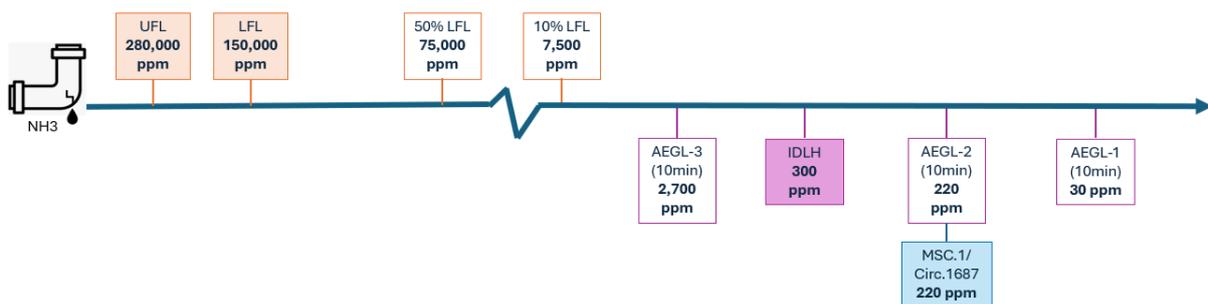


Figure 4-2: Ammonia flammability and toxicity ppm levels of interest

Note: It should be recognised that safety zone is a three-dimensional spaces, extending not only horizontally but also vertically, and therefore should take into account elevated structures, working at height, vent releases, crane operations, and multi-level access routes within the port environment.



Flammability limits:

- Ammonia has a relatively narrow flammability range in dry air, approximately 15–28% by volume, equivalent to 150,000–280,000 ppm.
- In gas dispersion analyses, flammable hazard zones are often defined using a fraction of the Lower Flammable Limit (LFL). Common practice may apply 50% LFL as a conservative boundary, although in some contexts 10% LFL is used for additional margin.
- For ammonia, these concentrations are typically well above levels that would already cause serious toxic effects, reinforcing why flammability is usually not the dominant driver for safety zone definition during bunkering.

Toxicity exposure limits:

- Toxicity thresholds for ammonia vary internationally, as different organisations and regulatory bodies apply different methodologies and exposure criteria.
- Human health impacts depend on both concentration and exposure time: the higher the concentration, the shorter the time a person can be safely exposed, and vice versa.
- Many national legislations define Occupational Exposure Limits (OELs) such as:
 - TWA (Time-Weighted Average) – the average concentration to which workers may be exposed over a typical 8-hour shift;
 - STEL (Short-Term Exposure Limit) – the maximum concentration permitted over a short reference period (typically 15 minutes).
- A useful reference for comparing exposure limits across countries, including EU Member States, is the IFA occupational exposure limit database (<https://limitvalue.ifa.dguv.de/substances>). However, ports are advised to confirm applicable limits with their national health and safety authority.
- In figure 4-2, the following widely used toxicity reference levels are illustrated:
 - AEGL (Acute Exposure Guideline Levels) for 10 minutes exposure, developed by the U.S. Environmental Protection Agency (EPA), which define concentration thresholds for general public exposure during accidental releases, based on severity of health effects and short exposure durations (see table 4-2 for definitions).
 - IDLH (Immediately Dangerous to Life or Health), defined by the U.S. National Institute for Occupational Safety and Health (NIOSH), representing a concentration that poses an immediate threat to life or would impair the ability to escape. IDLH values are not linked to a specific exposure duration but represent a maximum escape threshold.
 - The toxic area threshold specified by the IMO in MSC.1/Circ.1687 – Interim Guidelines for the Safety of Ships Using Ammonia as Fuel, which defines a fixed concentration limit intended for design and safety-zone purposes, rather than time-based exposure assessment.
- These toxicity thresholds form the basis for dispersion modelling and safety zone determination for ammonia bunkering, with ports applying them-together with national regulatory requirements-to define controlled areas, access restrictions, and SIMOPs limitations.

Table 4-2: Ammonia acute exposure guideline levels (US EPA, 2016).

Ammonia	10 min	30 min	60 min	4 hours	8 hours
AEGL 1	30 ppm	30 ppm	30 ppm	30 ppm	30 ppm
AEGL 2	220 ppm	220 ppm	160 ppm	110 ppm	110 ppm
AEGL 3	2700 ppm	1600 ppm	1100 ppm	550 ppm	390 ppm
AEGL 1: Notable discomfort, irritation, or certain asymptomatic non-sensory effects. However, the effects are not disabling and are transient and reversible upon cessation of exposure. AEGL 2: Irreversible or other serious, long-lasting adverse health effects or an impaired ability to escape. AEGL 3: Life-threatening health effects or death					

Ammonia gas dispersion analysis considerations 4.4.2.2

Compared to LNG and methane, CFD modelling for ammonia dispersion remains more complex, due to ammonia’s physical behaviour, phase change characteristics, and interaction with surfaces and water. In addition, there is currently less operational and experimental validation data available for ammonia compared to LNG. This situation is evolving as more studies, pilots, and experimental work are completed.

Exposure thresholds and regulatory context 4.4.2.3

It is essential to agree exposure thresholds and criteria before undertaking dispersion modelling. These thresholds are not globally harmonised, and different jurisdictions may apply different toxicity limits for ammonia.

While figure 4-2 provides informative concentration levels, ports should recognise that:

- national legislation or guidance may impose specific exposure limits;
- dispersion studies prepared for one region may not be directly applicable in another if different thresholds apply;
- ports should be involved in discussions on acceptable thresholds to ensure alignment with national health and safety requirements.

Credible release scenarios and hole size 4.2.2.4

Defining credible release scenarios, including the assumed release or hole size, is one of the most influential aspects of dispersion modelling and often a subject of debate. The selected scenarios should be consistent with the risk assessment and reflect realistic failures of the transfer system.

As a reference, the most comprehensive industry work on representative release sizes has been undertaken by SGMF, particularly in its guidance “Gas as a Marine Fuel – Recommendation of Controlled Zones during LNG Bunkering”. While developed for LNG, this work provides a useful methodological reference when defining credible release scenarios for ammonia, subject to appropriate fuel-specific considerations. In addition, the guidance proposes representative hole sizes for assessing

safety zones arising from hose or fitting failures, ranging from 3 mm for a 2-inch transfer hose to 15 mm for a 10-inch transfer hose.

Behaviour of ammonia compared to LNG 4.4.2.5

Ammonia behaves significantly differently from LNG following a release, with important implications for safety and toxic area duration:

- **Evaporation and persistence:** Ammonia evaporates more slowly than LNG. As a result, safety or toxic areas may remain in place for a longer duration following a spill.
- **Liquid pooling on land:** When liquid ammonia is released, a fraction flashes immediately depending on release conditions (e.g. refrigerated or pressurised). The remainder forms a pool, which may take hours to fully evaporate, particularly in cold climates (note ammonia boiling point -33°C). Even small quantities can persist significantly longer than LNG pools, which typically evaporate within minutes.
- **Spills on water:** When ammonia is released onto water, approximately 50% may dissolve, releasing heat in the process. The total amount vaporised is generally lower than for land spills, but vapour may be generated more rapidly. In port environments, water currents can transport dissolved ammonia away from the release location, introducing additional considerations for emergency response and environmental protection. Firefighting water may similarly transport contamination and should be considered in mitigation planning.
- **Effect of storage condition:** Storage condition has a significant influence on dispersion:
 - **Refrigerated ammonia** typically drains under gravity with low initial velocity, forming a pool that evaporates over time.
 - **Pressurised ammonia** releases may form a jet with higher momentum and potentially larger dispersion distances, although mass flow rates may still be lower than for LNG.

These characteristics should be explicitly reflected in dispersion modelling assumptions and in the interpretation of results.

Ports should therefore focus on transparency and justification of assumptions, rather than expecting identical numerical results across studies.

Mitigation measures to reduce ammonia safety distances 4.4.2.6

Where site constraints limit the available space for safety or toxic areas, risk-reduction measures may be considered to reduce the extent of safety distances, provided that an equivalent or improved level of safety can be demonstrated through the risk assessment and dispersion analysis. The following mitigation measures are commonly discussed in relation to ammonia bunkering and may influence the size and duration of safety or toxic areas.

Flange guards and spray containment 4.4.2.7

Flange guards may be used to contain or deflect small leaks from flanged connections, reducing spray dispersion and the formation of airborne ammonia clouds. By limiting jet direction and momentum, flange guards can help reduce the horizontal spread of a release, particularly for minor failures. Their effectiveness should be assessed case by case, taking into account inspection, maintenance, and drainage arrangements.

Collection and downward direction of liquid releases 4.4.2.8

Design measures that collect released liquid and direct it downwards can significantly influence dispersion behaviour. By reducing aerosolization and horizontal jetting, liquid ammonia can be encouraged to form a pool rather than an airborne plume. Where feasible, liquid may be directed towards a safer area, such as a bunded zone or controlled drainage area, provided that secondary risks (e.g. prolonged evaporation, environmental contamination) are properly addressed.

Double-walled hoses or pipe-in-pipe systems 4.4.2.9

The use of double-walled hoses or pipe-in-pipe transfer systems may reduce the likelihood and severity of releases from the primary containment. Depending on design, monitoring, and failure detection arrangements, such systems may limit leak rates or provide early detection, thereby reducing the mass released before isolation. Any benefit to safety distances should be demonstrated through the risk assessment and supported by credible failure scenarios.

Reduction of ESD response time 4.4.2.10

Reducing the time to emergency shutdown (ESD) is one of the most effective measures for limiting release duration and total released inventory. Improvements may include faster detection, optimised control logic, or reduced valve closing times. Shorter ESD response times can directly reduce predicted toxic distances in dispersion modelling, provided that system reliability and spurious trip risks are adequately managed.

Port considerations 4.4.2.11

From a port perspective, the application of mitigation measures should be guided by the following principles:

- Mitigations should be risk-based and justified, not assumed.
- Any reduction in safety or toxic areas should be supported by updated dispersion modelling reflecting the mitigation measures.
- Mitigations should be robust, inspectable, and enforceable within the port environment.
- Secondary risks (e.g. prolonged pooling, environmental impact, contaminated runoff) should be explicitly assessed.
- Ports may accept mitigation-driven reductions in safety distances only where an equivalent level of safety is demonstrated and agreed.

Port role in approval and enforcement 4.4.2.12

Ports, often acting as the competent authority, play a central role in reviewing and approving safety/toxic areas for ammonia bunkering. This includes:

- verifying that safety zones are based on appropriate dispersion modelling and assumptions (exposure limits and hole size among others);
- ensuring that safety zones are compatible with port layout, access routes, and neighbouring activities;
- confirming that access control, monitoring, and enforcement arrangements are practical and effective;
- coordinating safety zones with marine exclusion zones, SIMOPs, and emergency response planning.

Because ammonia safety zones may extend further than those for methane/LNG early coordination with terminal operators, emergency services, and neighbouring facilities is particularly important.

Evolution over time 4.4.2.13

As ammonia bunkering progresses from pilot operations to routine activity, safety zones may be reviewed and optimised. Any changes should remain risk-based and subject to approval by the competent authority, ensuring that protection of people and the port environment is not compromised.

Core operational controls 4.5

This section describes the tools used to manage individual bunkering operations, including compatibility assessments, checklists, emergency shutdown, and training and how ports maintain control during operations.

It includes guidance for:

- Bunkering compatibility assessment
- Bunkering checklist
- Bunkering emergency shutdown (ESD)
- Communication protocols
- Enforcement protocols
- Training requirements and safety drills

Bunkering compatibility assessment 4.5.1

Compatibility assessment is a critical process to ensure that all elements of a bunkering operation can interface safely and effectively. While the compatibility assessment is normally prepared by the bunkering operator and receiving ship, ports play a key role in ensuring that compatibility has been systematically addressed before approving operations.

Purpose of compatibility assessment 4.5.1.1

A compatibility assessment confirms that:

- the bunkering supply system and receiving ship are technically compatible;
- operating parameters are aligned and understood;
- safety systems and procedures can function together as intended;
- the operation can be safely integrated into the port environment.

For methanol and ammonia, compatibility assessment is particularly important due to:

- low-flashpoint fuel characteristics;
- toxicity (ammonia);
- evolving regulatory frameworks and operational experience.

Typical elements of a compatibility assessment 4.5.1.2

While the detailed scope may vary, compatibility assessments typically address:

- fuel properties and operating conditions (temperature, pressure, phase);
- transfer system interfaces, including hoses, connectors, and manifolds;
- emergency shutdown (ESD) logic and response times;
- vapour return or venting arrangements, where applicable;
- communication protocols between supplier and receiver;



- procedural alignment, including checklists and emergency actions;
- training and competence of personnel involved.

A compatibility assessment is operation-specific, but it does not necessarily need to be repeated for every individual bunkering operation. Where a proposed operation is fully covered by an existing, approved compatibility assessment, a new assessment is not required. In such cases, the assessment should be validated or confirmed as still applicable, rather than re-performed in full.

Compatibility assessments may also be developed to cover a defined range of operational variations, such as different transfer rates, quantities, supply scenarios, or vessel types. Provided that the specific bunkering operation falls within the assessed operational envelope, the existing compatibility assessment may continue to be used. A new or updated assessment should be required only where material changes occur that fall outside the previously assessed conditions.

Port role in reviewing compatibility 4.5.1.3

From a port perspective, compatibility assessment supports confidence that:

- assumptions used in the risk assessment and safety zone definition remain valid;
- SIMOPs limitations are appropriate and enforceable;
- emergency response arrangements are realistic for the specific interfaces involved.

Ports should not duplicate the operator's technical assessment, but should:

- verify that a compatibility assessment process is in place and/or it has been completed;
- ensure that port-relevant interfaces (e.g. berth layout, access routes, neighbouring activities) are considered;
- confirm that outcomes are reflected in the bunkering management plan and joint bunkering plan;
- require reassessment where material changes occur.

Summary for ports 4.5.1.4

The compatibility assessment is a key input to the bunkering documentation framework described earlier in section 2.7 of this Guidebook. Its outcomes should be clearly reflected in the Bunkering Management Plan (BMP) and, where applicable, in the Joint Bunkering Plan (JBP/JPBO), operating procedures, and checklists.

From a port perspective, this linkage ensures that the technical compatibility conclusions are translated into practical operational controls, defined responsibilities, and enforceable conditions. Ports should therefore expect consistency between the compatibility assessment and the submitted bunkering documentation, and may use this alignment as part of their review and approval process.

Ports should:

- define when compatibility assessments are required (e.g. first operation, new vessel, new fuel, new site);
- ensure that compatibility outcomes are aligned with port procedures and permit conditions;
- recognise that compatibility is not a one-off exercise, but part of an ongoing assurance process as bunkering operations evolve.

Ports should be also aware that recognised industry guidance already exists for bunkering compatibility assessments. In particular, SGMF has published "LNG as a Marine Fuel – A Bunkering Compatibility Assessment Methodology", which provides standardised forms and structured questions.

Although developed for LNG, the methodology can be applied to methanol and ammonia bunkering, provided that fuel-specific risks are explicitly addressed. Ports are therefore encouraged to use established industry frameworks rather than develop bespoke compatibility formats, supporting consistency, completeness, and efficient review.

Bunkering checklist 4.5.2

The bunkering checklist is a core operational tool within the bunkering documentation framework as discussed in section 2.7 of this Guidebook. It provides a structured, step-by-step verification that all required technical, procedural, and safety conditions are in place before, during, and after bunkering. For methanol and ammonia bunkering, checklists are particularly important due to the involvement of low-flashpoint fuels, evolving operational experience, and multiple interacting stakeholders.

The IAPH Bunkering Checklists:

The IAPH Clean Marine Fuels Working Group has developed standardised bunkering checklists, available as a free download from the IAPH website.

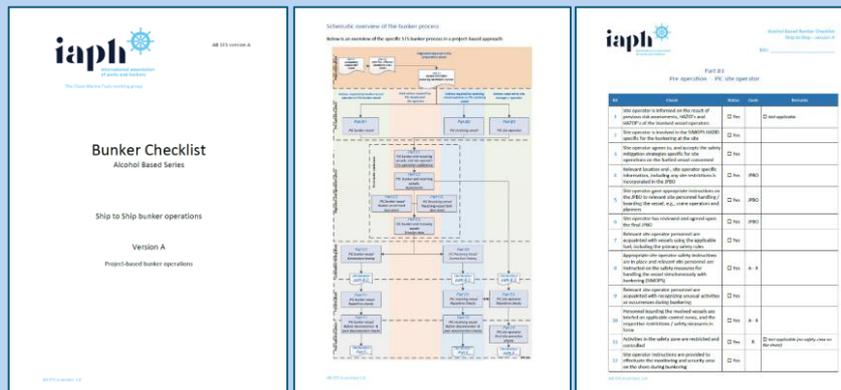


Figure 4-3: IAPH bunkering checklist
Source: <https://www.iaphworldports.org/products/>

These checklists are well established and widely used across the industry. They support the operationalisation of bunkering activities and are recommended for use rather than creating new ad hoc checklists.

IAPH updates these documents regularly. Users should always ensure they are working with the latest version.

The checklist is an on-site operational verification tool. It does not substitute pre-operational work such as HAZID, HAZOP, SIMOPS or the development of bunkering procedures.

During preparation and operations, the checklist is used by the supplier and receiving ship operator, typically through their respective Persons in Charge (PICs), to validate each step of the bunkering process.

Different checklists exist for various fuels and transfer scenarios (e.g. truck-to-ship, ship-to-ship). Users should select the correct version.

The checklist is structured in phases:

- Part A – Preparation phase
- Part B – Pre-operation phase
- Part C – Alignment and agreement phase
- Part D – Connection testing phase
- Part E – Transfer phase
- Part F – Post-operation phase

The checklists originated from LNG operations over 12 years ago and have since been expanded to cover multiple fuels, including liquid gases (e.g. LNG, liquefied biogas, liquid hydrogen), alcohol-based fuels (e.g. methanol, bio/e-methanol, ethanol) and ammonia, including refrigerated toxic gases.

Purpose of the bunkering checklist 4.5.2.1

The primary purpose of the bunkering checklist is to:

- confirm operational readiness of the supplier, receiving ship, and transfer system;
- ensure alignment and shared understanding between all parties involved;
- verify that critical safety controls are in place and functioning;
- provide a clear go / no-go decision point before transfer commences.

While the checklist itself is completed by the bunkering operator and receiving ship, it forms an important part of the assurance framework reviewed by ports.

Use of industry-standard checklists 4.5.2.2

Ports should be aware that industry-standard bunkering checklists are already available and widely used. In particular, the International Association of Ports and Harbors Clean Marine Fuels Working Group Bunker Checklists provide structured templates applicable to alternative fuels, including methanol and ammonia. These checklists are publicly available and designed to support consistent implementation across ports and regions.

From a port perspective, the use of recognised industry checklists is strongly recommended, and the development of bespoke or informal checklists should be discouraged unless clearly justified.

Typical content of a bunkering checklist 4.5.2.3

Although the exact format may vary, a bunkering checklist typically covers:

- confirmation of fuel type, quantity, and transfer method;
- verification of compatibility between supplier and receiving ship;
- readiness of transfer system, hoses, connectors, and ESD systems;



- confirmation of communication protocols and emergency signals;
- verification of controlled areas, access restrictions, and SIMOPs limitations;
- confirmation of weather, traffic, and operational conditions;
- readiness of emergency response equipment and personnel.

The checklist is normally divided into phases (pre-transfer, during transfer, post-transfer), with clear responsibility for each item.

Port role and expectations 4.5.2.4

Ports do not complete bunkering checklists themselves; however, they play an important role in:

- setting expectations that an approved, recognised checklist will be used;
- verifying that the checklist is consistent with the Bunkering Management Plan (BMP) and Joint Bunkering Plan;
- confirming that checklist items reflect port-specific requirements, including safety zones, SIMOPs controls, and emergency arrangements;
- requiring evidence that the checklist has been completed, where appropriate, as part of permitting or audit processes.

Ports may also specify minimum checklist elements or reference preferred industry templates (e.g. IAPH) within port by-laws or permitting conditions.

Summary for ports 4.5.2.5

- Require the use of recognised industry-standard bunkering checklists.
- Avoid bespoke formats unless clearly justified.
- Ensure checklist content reflects port-specific conditions and controls.
- Use the checklist as a practical assurance link between planning, permitting, and execution.

Bunkering emergency shutdown (ESD) 4.5.3

Emergency shutdown (ESD) is a safety-critical function of bunkering operations. It provides a controlled means to stop fuel transfer and, where necessary, to separate the transfer system from the receiving vessel in response to abnormal or emergency conditions.

From a port perspective, understanding the bunkering ESD concept, and in particular ESD-2, is important because:

- ESD activation can affect port traffic management, and SIMOPs;
- ESD-2 may be initiated if a vessel moves unexpectedly or is required to depart urgently, potentially leading to hose disconnection and spill risk;
- ESD-2 events often represent the point at which escalation from a contained event to a wider port emergency may occur; and
- port authorities may need to coordinate access control, emergency response, and post-event recovery following an ESD event.

Ports are not expected to manage the technical design of ESD systems. However, they should understand how ESD functions, what its implications are for port safety and emergency response, and how ESD scenarios are addressed within the bunkering risk assessment and procedures.

Overview of the bunkering ESD concept 4.5.3.1

The bunkering emergency shutdown process is initiated in response to defined emergency conditions to protect people, assets, and the environment. It is divided into two consecutive but independent stages:

- ESD-1: termination of the bunkering operation; and
- ESD-2: separation of the bunkering transfer system.

Although ESD-1 should normally be initiated before ESD-2, initiation of ESD-1 does not automatically imply that ESD-2 will follow.

The bunkering ESD system discussed in this guide relates specifically to bunkering transfer systems and should not be confused with ESD functions associated with machinery spaces under the IGF Code, which act on different equipment and systems.

ESD-1: termination of transfer 4.5.3.2

ESD-1 is the first stage of the bunkering emergency shutdown process. Its primary purpose is to stop the fuel transfer in a controlled manner.

For ports, ESD-1 is generally of limited direct interest, as it primarily affects:

- internal transfer systems;
- pressures and flow within hoses or transfer arms; and
- operational decision-making by the bunkering parties.

Nevertheless, ports should ensure that:

- ESD-1 initiation criteria are clearly defined in the bunkering risk assessment and procedures;
- ESD-1 events are reported to the port where required; and
- procedures address the management of trapped inventory and confirmation of system integrity before any resumption of operations.

ESD-2: separation of the transfer system 4.5.3.3

ESD-2 is the second stage of the bunkering emergency shutdown process and is of direct relevance to ports.

ESD-2 is intended to protect the transfer system, bunkering equipment, and ship manifolds if the vessel moves outside a predetermined operating envelope. Typical initiating conditions may include excessive drift, loss of moorings, or other scenarios where continued physical connection would create a greater hazard.

Activation of ESD-2:

- stops the transfer (if not already stopped); and
- activates an emergency release system (ERS), typically involving an emergency release coupling (ERC), to separate the transfer system from the receiving vessel.

ESD-2 may be initiated automatically by sensors or manually from the bunkering facility. It is not typically designed to be initiated from the receiving vessel.

Why ESD-2 matters for ports 4.5.3.4

From a port authority perspective, ESD-2 is critical because it may:

- occur during unexpected vessel movement or urgent departure scenarios;
- result in hoses or hose sections becoming suspended, partially submerged, or detached;
- create a potential spill or vapour release during or after disconnection;
- require immediate control of surrounding areas, traffic, and access; and
- it might trigger coordination with emergency services, including fire and medical response.

Ports should therefore ensure that ESD-2 scenarios are explicitly considered when:

- approving bunkering locations;
- reviewing safety zones and marine exclusion zones;
- assessing SIMOPs and traffic control measures; and
- validating emergency response and recovery arrangements.

Port expectations and implementation considerations 4.5.3.5

Ports should verify, through the risk assessment and supporting documentation, that the bunkering parties have:

- Clearly defined ESD-1 and ESD-2 scenarios, including initiating conditions and system responses.
- Documented procedures for managing ESD-1 and ESD-2 events, including:
 - control of trapped inventory on both sides of the transfer system;
 - management and recovery of hoses or transfer equipment following separation; and
 - criteria for declaring the operation safe or escalating to a port emergency.
- Arrangements for hose and equipment recovery, including:
 - minimising personnel exposure;
 - avoiding metal-to-metal contact that could cause sparks;
 - managing interaction with water, vessel movements, and port traffic.
- Clear communication and notification protocols, including when and how the port authority and emergency services are informed of an ESD-2 event.

Ports are not required to approve detailed ESD logic or system programming, but they should be satisfied that ESD-2 outcomes are compatible with port safety management and emergency response capabilities.

Spurious ESD and recovery considerations 4.5.3.6

Ports should be aware that ESD events may be triggered legitimately or spuriously. Any activation of a bunkering ESD should be:

- investigated;
- documented; and
- resolved before further transfer is authorised.

While specific ESD initiators may, under strict procedures, be overridden by the bunkering parties, ports should expect that:

- overall ESD system functionality remains intact;
- overrides are subject to risk assessment and clear authorisation; and
- recovery from ESD events, particularly ESD-2, may take longer than anticipated.

Port procedures and traffic management arrangements should allow for this potential extended recovery period.

Summary for ports 4.5.3.7

- ESD-1 primarily concerns the bunkering parties and transfer process.
- ESD-2 is of direct relevance to ports, as it may involve vessel movement, system separation, spill risk, and escalation to wider port emergency response.
- Ports should ensure that ESD-2 scenarios are explicitly addressed in risk assessments, safety zones, SIMOPs management, and emergency planning.
- Clear expectations, communication pathways, and recovery arrangements support safe and controlled management of ESD events within the port environment.

Communication protocols 4.5.4

Effective communication and information exchange are essential throughout the entire process. Communication requirements can be broadly divided into three distinct but interrelated areas, each involving partially different points of contact and responsibilities:

- Licensing and permitting communication
- Nautical and traffic-related communication
- Operational and emergency communication

Clear definition of interfaces and responsibilities is critical to ensure safe, efficient, and compliant operations.

Licensing and Permitting Communication 4.5.4.1

The licensing process should, wherever possible, be administered by a single entity. This may be the port authority itself or another designated competent body.

As outlined in section 4.2.3, a single point of contact should be established to ensure clarity, efficiency and consistency in the licensing process.

The harbour master's office (or equivalent) should coordinate and communicate with all relevant external authorities required to be involved in the initial licensing and permitting process. This may include environmental authorities, occupational safety authorities, fire services, and other competent bodies. Bunker suppliers and other applicants should interface exclusively with the designated single point of contact, thereby avoiding fragmented communication and ensuring consistent regulatory oversight.

Nautical and traffic-related communication 4.5.4.2

The approach, arrival, and departure of a BSV should be planned, coordinated, and authorised by VTS. While the vessels are in port and alongside, vessel operations shall be continuously monitored by vessel traffic management. This should include trucks supplying fuel from the shore side. The vessel traffic management monitor the following:



- The scheduled commencement of bunkering operations
- The completion of bunkering operations
- The specific fuel type being transferred (e.g. ammonia or methanol)
- Any deviations from the approved operational plan

Vessel Traffic Management should act as the primary operational point of contact for marine-related emergencies during bunkering operations, while the VTS should coordinate navigational matters, manage traffic conflicts, and ensure the safe and orderly movement of marine traffic.

Operational and emergency communication 4.5.4.3

During bunkering operations, the receiving vessel should maintain close coordination with the terminal operator, where applicable, and should comply with the terminal's emergency response and contingency plans.

Clear communication channels should be established between:

- The port authority
- The bunker supply vessel
- The receiving vessel
- The terminal operator
- Vessel traffic management and VTS
- Emergency services

In the event of an incident or emergency, predefined communication and escalation procedures should apply, ensuring that vessel traffic management is immediately informed and that the appropriate emergency response plans are activated without delay.

All communication interfaces and procedures should be clearly documented within the port's bunkering manual, SIMOPs procedures, and emergency response plans. Communication protocols should be tested periodically through exercises and drills, particularly for alternative fuels with elevated toxicity or flammability risks.

Enforcement protocols 4.5.5

The port authority, harbour master's office, or an equivalent competent authority of the port should ensure that all requirements stipulated in the bunker licence are effectively enforced. This enforcement should not be limited to the initial licensing phase but should also include random inspections, regular audits or the review of conducted audits by IAPH members independently of the formal licensing process.

Such oversight activities require adequate manpower, targeted training, and a sufficient level of technical competence, particularly with regard to fuel specific transfer and safety systems, risk assessments, and operational planning. The port authority (or equivalent) should ensure that inspectors are familiar with the specific hazards, safety concepts, and emergency procedures associated with the licensed bunkering operations.

Initial bunkering operations 4.5.5.1

It is recommended that the port authority (or equivalent) attends the first bunkering operation conducted under a newly issued licence. In addition, participation in the pre-transfer transfer meeting between the

BSV or road truck and the receiving vessel is advisable to verify that procedures, communication lines, and responsibilities are clearly understood and correctly implemented by all parties.

When planning physical inspections, it should be recognised that boarding or leaving the BSV during active bunkering operations may be restricted or prohibited due to established safety, exclusion, or toxic areas. Inspection concepts should therefore account for these limitations and may include alternative measures such as inspections prior to commencement of transfer or being conducted on the receiving vessel.

Training requirements and safety drills 4.5.6

Training is a critical enabler for the safe introduction and continued operation of methanol and ammonia bunkering in ports. Ports should ensure that all personnel involved in, supervising, authorising, or responding to bunkering operations are competent, trained, and familiar with:

- the specific fuels hazards,
- fuel handling procedures, and
- emergency actions associated with these fuels.

Training forms an integral part of the port's risk management, permitting, and SIMOPs framework and should be regarded as a prerequisite for authorising bunkering activities. Training requirements should be proportionate to role, exposure, and responsibility, and reviewed whenever bunkering locations, supply scenarios, fuels, or regulatory requirements change.

Port responsibilities for training 4.5.6.1

From a port perspective, training obligations extend beyond port staff alone. Ports should:

- define minimum training and competence expectations for all relevant stakeholders operating within the port area;
- verify that training requirements are met as part of licensing and permitting processes;
- ensure internal port personnel are trained to a level commensurate with their authority and responsibilities;
- coordinate training expectations with terminal operators, emergency services, and regulators.

Where training is not mandated by international or national regulation, ports should still set clear minimum requirements as a condition of authorisation.

Clarification Note – Training Responsibilities:

It should be noted that ports are responsible for training their own personnel to a level commensurate with their authority and operational responsibilities. Personnel employed by operators, suppliers, terminals or contractors remain the responsibility of their respective employers.

However, as part of the bunkering licensing and authorisation process, ports should verify that all parties involved demonstrate appropriate training and competence. Ports may define minimum training standards for stakeholders operating within their jurisdiction and require evidence of compliance during permitting.

Where training is not explicitly mandated by national or international regulation, ports may still establish minimum competence requirements as a condition of authorisation, ensuring safe and consistent operational practices.

Stakeholders, roles, and training scope 4.5.6.2

Training requirements vary depending on stakeholder role and degree of exposure. As a minimum, ports should consider the following groups:

- Bunkering personnel
- Port authority personnel
- Terminal operators
- Port workers (terminal personnel)
- Vessel Traffic Services (VTS) / Vessel Traffic Management
- Emergency response services
- External port stakeholders

Bunkering personnel

This includes personnel from the bunkering organisation (e.g. bunker supply vessel crew, truck operators, or terminal staff) and the receiving ship operator.

Training focus:

- Fuel-specific hazards of methanol and ammonia (flammability, toxicity, vapour behaviour);
- Transfer procedures, communication protocols, and ESD coordination;
- Use of PPE and gas detection equipment;
- Emergency response actions and initial mitigation measures.

For shipboard personnel, minimum competence requirements are governed by the STCW Convention and associated national regulations. Where bunkering is conducted ship-to-ship or shore-to-ship, additional national requirements may apply to bunker operators.

It should be noted that ongoing discussions at IMO include revisions to STCW to further address training needs related to alternative fuels, including methanol and ammonia.

Port authority personnel

Roles include acting as competent authority, leading licensing processes, enforcing conditions, and coordinating emergency preparedness.

Training focus:

- fuel-specific hazards for methanol and ammonia;
- interpretation of risk assessments, safety zones, toxic areas, and SIMOPs;
- bunkering documentation (Bunkering Management Plan, JBP, checklists);
- authority and procedures to suspend or stop unsafe operations;
- coordination with emergency services and other port users.

Key port personnel (e.g. safety officers, harbour masters, permit-issuing staff) should be trained by industry-qualified experts.

Terminal operators

Interface directly with bunkering operations at quays and berths.

Training focus:

- operational hazards and safety zones;
- interface management with bunkering vessels;
- emergency response actions and communication protocols.

Port workers (terminal personnel)

Work in areas where bunkering operations may occur.

Training focus:

- general understanding of methanol and ammonia properties and hazards;
- recognition of alarms, restricted areas, and emergency signals;
- basic response actions and evacuation procedures.

Vessel Traffic Services (VTS) / Vessel Traffic Management

Manage marine traffic during bunkering operations.

Training focus:

- awareness of fuel-specific hazards;
- understanding of marine exclusion zones and traffic restrictions;
- coordination during emergency scenarios.

Emergency response services

Fire, medical, police, and specialised response teams.

Training focus:

- ammonia and methanol properties and health effects;
- use of detection equipment and PPE;
- response to toxic dispersion, fires, and spills;
- coordination with ship, terminal, and port command structures.

External port stakeholders

Other port users operating nearby bunkering activities.

Training focus:

- general awareness of methanol and ammonia hazards;
- understanding of access restrictions and emergency instructions.

Training stages aligned with implementation 4.5.6.3

Training should evolve in line with the port's implementation stage and outcomes of the initial HAZID.

Initial training

- Conducted before formal engagement with national regulators.
- Aimed at preparing the port organisation for methanol and ammonia bunkering.
- Focus on regulatory context, high-level hazards, and implementation pathways.

Implementation phase training

- Conducted once regulatory requirements are clarified and permits amended.
- Provides detailed knowledge of bunkering systems, risk controls, and emergency procedures.
- Includes tabletop emergency exercises.

Operational phase training

- Ongoing and recurrent once bunkering becomes routine.
- Focuses on:
 - lessons learned from operations;
 - updates to standards and guidance;
 - refresher emergency response training and drills.

Core training content 4.5.6.4

Including port safety officers, harbour masters, enforcement officers, and permit-issuing staff.

Required competence:

- Understanding of methanol and ammonia properties, hazards, and risk drivers
- Interpretation of risk assessments, safety zones, toxic areas, and SIMOPs restrictions
- Familiarity with bunkering documentation (Bunkering Management Plan, JBP, checklists)
- Authority to suspend or stop operations under unsafe conditions
- Coordination with emergency services and other port users

Training programmes should, as a minimum, cover the following elements:

General (methanol and ammonia)

- Regulatory framework overview (IGF Code, interim IMO guidelines, port rules)
- Bunkering supply scenarios (STS, shore-to-ship, mobile-to-ship)
- Roles and responsibilities during bunkering
- Bunkering stages: design, planning, preparation, operation
- Hazardous areas, safety zones, marine exclusion zones, SIMOPs
- Human-factor considerations and communication protocols
- Incident reporting and lessons learned

Methanol-specific

- Flammability characteristics and ignition risks
- Toxicity thresholds and exposure control
- Vapour behaviour and confined-space risks



- Spill behaviour and environmental impact
- Methanol-compatible PPE and material considerations
- Fire-fighting principles for alcohol fires

Ammonia-specific

- Acute toxicity and health effects
- Odour threshold vs harmful concentration
- Gas dispersion behaviour and toxic area concept
- Use of gas detection and alarm systems
- Escape, evacuation, and sheltering principles
- Interaction with SCR systems and ammonia slip awareness

Operational rehearsals and system testing 4.5.6.5

As part of personnel training and operational readiness, ports may require structured operational rehearsals prior to first bunkering at a new location, when introducing a new fuel, or following significant modifications to the transfer system or procedures.

Such rehearsals may take the form of:

- Dry-runs (no product transfer), focusing on procedures and coordination; or
- Water-runs (wet rehearsals using water or another inert medium), focusing on system functionality;

The type of rehearsal required should depend on the circumstances, fuel type, complexity of the operation, and regulatory expectations.

Rehearsals may be used to test and validate:

- Roles and responsibilities;
- Communication protocols;
- Checklist execution;
- Permit and documentation flow;
- Emergency procedures and ESD logic coordination;
- Physical interfaces, including hoses, couplings, and connections.

Operational rehearsals are particularly useful prior to first-ever bunkering operations within a port. They help identify procedural gaps and interface mismatches before hazardous fuel is introduced. They can reduce the risk of aborted transfers, incidents, and operational delays, and build confidence among crews, regulators, emergency services, and port authorities.

Note:

Following a water-run, the transfer system should be thoroughly drained and, where necessary, cleaned and completely dried before introducing methanol or ammonia. Residual water may adversely affect fuel quality, increase corrosion risks, or create operational complications. Complete removal of water should therefore be verified in accordance with approved procedures.

Emergency drills and exercises 4.5.6.6

Ports should ensure that emergency drills are conducted at appropriate intervals and after significant changes to operations.

Drills should include:

- Methanol spill and fire scenarios
- Ammonia leak and toxic dispersion scenarios
- Emergency shutdown and evacuation
- Communication and coordination with emergency services
- Interface between ship, supplier, terminal, and port authority

The frequency and complexity of drills should be proportionate to:

- Fuel type
- Bunkering frequency
- Proximity to populated or sensitive areas
- National regulatory requirements

Documentation, records, and review 4.5.6.7

Ports should require and maintain evidence of training and competence, including:

- Training matrices by role
- Certificates or attendance records
- Drill reports and corrective actions
- Records of refresher training

Training requirements should be reviewed:

- following incidents or near misses;
- after operational or regulatory changes;
- as bunkering transitions from pilot activities to business-as-usual.

Emergency management and response 4.6

This section explains how ports respond to incidents, and apply lessons learned.

It includes guidance for:

- Emergency preparedness
- Incidents reporting and lesson learned

NOTE- Scope and Use of this Section:

This section provides high-level guidance on emergency preparedness considerations relevant to methanol and ammonia in port environments. It is intended to support ports in understanding key principles, typical response challenges, and areas requiring attention when integrating these fuels into their emergency planning frameworks.

Emergency preparedness measures described in this section apply both to bunkering operations and to the presence and operation of methanol- or ammonia-fuelled vessels within the port.

The content is not site-, or operation-specific, nor does it replace detailed emergency response plans, statutory requirements, or incident-specific procedures. Actual preparedness measures, response strategies, and resource requirements should always be defined through site-specific risk assessments, engagement with competent authorities, and alignment with national legislation, emergency services, and terminal operators.

Ports should use this section as a reference framework to inform further analysis and planning, recognising that emergency preparedness arrangements should be tailored to local layouts, bunkering scenarios, fuel characteristics, and the specific risk profile of each port location.

Emergency preparedness 4.6.1

The port authority and the respective terminal operators should be adequately prepared to manage incidents involving methanol and ammonia, taking into account their distinct physical, chemical, and toxicological properties. Furthermore, it should be pointed out that this does not only apply to bunkering operations but also to vessel using methanol or ammonia as fuel. Preparedness should, as a minimum, address the following:

- Accidental releases of methanol and ammonia, including the identification, modelling, and management of toxic exposure zones, with particular emphasis on ammonia vapour cloud dispersion and methanol inhalation and contact hazards;
- Leak detection, isolation, and mitigation measures, enabling a rapid response to product releases, including spill containment for methanol and vapour dispersion control for ammonia;
- Fire and emergency response capabilities, recognising methanol's high flammability and low flame visibility, and ammonia's limited flammability but significant toxic and corrosive effects;
- First-aid and medical response procedures, including immediate actions in the event of eye or skin contact, inhalation exposure, or chemical burns, supported by suitably located emergency showers, eyewash stations, and trained personnel.

Accidental release and leak detection of methanol and ammonia 4.6.1.1

Within the licensing process (see section 4.2.3), the outputs of the initial HAZID—including the underlying assumptions, identified hazards, and the resulting controlled areas / safety zones (see section 4.4) should be documented and made available to all relevant stakeholders, in particular those involved in emergency preparedness and response (terminal emergency teams, port emergency services, fire brigade, medical response, VTS/traffic management, and the bunker supplier's emergency organisation). This information should be incorporated into the port's emergency response framework to ensure that response actions, exclusion zones, muster points, and escalation triggers are aligned with the defined hazardous scenarios.

Furthermore, sufficient and fit-for-purpose gas detection equipment should be provided to support both routine operations and emergency response. As a minimum, detection capability should include:

- Ammonia toxic gas detection in ppm (low-range, resolution suitable for occupational exposure management and early warning), using equipment designed for toxic gas measurement performance in workplace atmospheres.
- Methanol vapour monitoring appropriate to the identified hazards, providing detection of methanol as a flammable vapour and enabling the monitoring of toxic exposure levels.

Due to the physical properties of methanol, elevated vapour concentrations are generally limited to the immediate vicinity of a spill and are only likely to form larger vapour clouds in the case of large-scale releases. Such scenarios are typically more localised and manageable when compared to ammonia releases, which can rapidly form larger vapour clouds that are toxic and corrosive, even at relatively low concentrations.

Methanol fire-fighting considerations 4.6.1.2

Methanol is a highly flammable liquid that burns with a nearly invisible flame, creating a significant hazard for emergency responders. Consequently, appropriate flame detection systems (e.g. IR/UV detectors) and thermal imaging equipment should be available where applicable to support early fire identification and safe response.

Extinguishing media and response strategy:

- Alcohol-resistant (AR) foam should be provided as the primary extinguishing medium for methanol pool and spill fires;
- Water spray or fog may be used for equipment cooling and vapour dispersion but should not be relied upon as the sole means of fire extinguishment;
- Dry chemical extinguishers may be used only for small, incipient fires;
- Fire-fighting strategies should prioritise fuel isolation and leak control, where safe to do so, while accounting for the limited visibility and low radiant heat of methanol flames.

Ammonia fire-fighting considerations 4.6.1.3

Ammonia is not readily flammable under normal ambient conditions; however, it poses a severe toxic and corrosive hazard. Fire-fighting strategies should therefore primarily focus on life safety, exposure control, vapour dispersion, and equipment cooling, rather than direct flame extinguishment.

In open areas, the likelihood of ignition of an ammonia vapour cloud is low. Ignition would generally require the presence of an external heat or ignition source in combination with a sustained high vaporisation rate, typically associated with a very large exposed liquid surface area. In the absence of

such conditions, vapour concentrations will not remain at or above the LFL, and sustained combustion is unlikely.

Key considerations include:

- Ammonia releases may form dense, toxic vapour clouds with significant downwind impact; life safety, evacuation, and access control should take precedence over fire suppression activities;
- In the event of an ammonia fire (typically under confined conditions or elevated concentrations), water spray or fog should be used to cool exposed equipment and structures and to support vapour dispersion;
- High-pressure water jets should not be applied directly to leaking liquid ammonia unless specifically required for vapour knock-down;
- The generation and management of contaminated firefighting runoff should be considered as part of the emergency response and environmental protection strategy.

Ammonia vapour suppression 4.6.1.4

The application of water as a response measure during an ammonia release should be evaluated on a case-by-case basis, with careful consideration of the potential consequences for personnel safety, environmental impact, and asset protection. The indiscriminate or automatic use of water may, under certain circumstances, aggravate the incident by increasing vapour generation or by spreading contamination.

In some scenarios, an ammonia release may disperse naturally into the atmosphere, limiting exposure. The application of water to suppress vapours can instead lead to the formation of ammonium hydroxide, resulting in contamination of soil, paved surfaces, or water bodies, with potentially greater impacts on responders, infrastructure, and the environment.

Emergency managers and response teams should understand the different release modes of ammonia including liquid releases, aerosols, and vapour releases and the distinct interactions that occur when water is applied to each.

Where water is used as part of the response strategy, the following should be considered:

- Direct application of water onto liquid ammonia should be avoided, as the interaction can significantly increase vaporisation and result in rapid and aggressive off-gassing;
- In confined or enclosed spaces, increased vapour generation may lead to elevated concentrations and, under certain conditions, may enter the flammable range, thereby increasing ignition risk;
- In open areas, while ignition is generally unlikely, the application of water may increase the density and extent of the vapour cloud and may intensify the effects of any associated fire;
- Aerosol releases may react less violently with water than liquid pools, but water application can still enhance vaporisation and produce effects similar to those observed with liquid releases;
- For vapour-phase releases, water curtains or sprays may absorb ammonia; however, depending on the release rate and water flow, a significant portion of the vapour cloud may pass through the water barrier, potentially exposing downwind personnel and receptors.
- Contaminated water runoff containing dissolved ammonia may travel beyond the immediate incident area, particularly via drainage systems, paved surfaces, or watercourses, and may continue to off-gas ammonia over distance and time, creating secondary exposure risks for responders, port personnel, and adjacent areas.

Response strategies involving water should therefore be carefully planned, risk-based, and aligned with the specific release scenario, taking into account atmospheric conditions, site layout, and the availability of alternative control measures.

Methanol first aid considerations 4.6.1.5

Methanol is a toxic substance that can be absorbed by inhalation, skin contact, or ingestion. Due to the risk of delayed and systemic effects, all suspected exposures should be treated seriously and followed by appropriate medical evaluation.

Methanol vapour inhalation, the affected person should be removed immediately to fresh air and kept warm, calm, and at rest. Breathing, level of consciousness, and general condition should be continuously monitored. Even if symptoms appear mild or absent initially, urgent medical assessment is required, as methanol exposure may result in delayed effects such as headache, dizziness, visual disturbances, or metabolic acidosis.

In the event of skin or eye contact with methanol, contaminated clothing, footwear, and contact lenses should be removed immediately. The affected skin or eyes should be flushed thoroughly with water for at least 15 minutes. Medical advice should be sought in cases of persistent irritation, significant exposure, or suspected systemic absorption, recognising that methanol can be absorbed through the skin. In cases of eye contact immediate medical support should be provided.

Ammonia first aid considerations 4.6.1.6

Due to the toxic and corrosive nature of ammonia, any suspected exposure whether to vapour or liquid should be treated as a medical emergency, and immediate first-aid measures should be initiated.

Affected skin or eyes should be rinsed promptly with copious amounts of water at low pressure. In cases involving inhalation exposure, supplemental oxygen should be administered where available, taking into account the severity and duration of respiratory exposure.

The extent of ammonia exposure may be difficult to assess initially, as symptoms can appear mild at first and subsequently worsen rapidly. Individuals who appear to recover following initial treatment may still experience delayed respiratory effects. For this reason, medical evaluation and continued observation for several hours are essential following any ammonia exposure. Access to specialist medical care should be arranged as early as practicable.

Decontamination of exposed personnel should be completed prior to transport into enclosed spaces, such as ambulances or rescue craft. Off-gassing from contaminated clothing or skin in confined environments can hinder medical treatment and pose additional risks to responders, even if concentrations are not immediately life-threatening.

Where clothing or personal protective equipment has been contaminated by cold liquid ammonia, removal should be undertaken with caution. Items should be thoroughly flushed with water before removal to prevent adhesion to the skin and further injury.

Methanol & Ammonia PPE requirements 4.6.1.7

It is essential to assess the potential exposure risk in order to define the appropriate personal protective equipment (PPE). As a minimum, standard PPE should be worn at all times, including long-sleeved coveralls, safety helmet, safety footwear, and protective gloves.

Based on the assessed exposure level, additional PPE requirements should apply as follows:

- Low exposure risk: Additional face shield should be worn. For ammonia an escape device should be considered.



- High exposure risk: Chemical-resistant protective suits with a full-face mask should be worn.
- Emergency responders: Fully encapsulating chemical protective suits in combination with self-contained breathing apparatus (SCBA) should be required.

Incidents reporting and lessons learned 4.6.2

Incident reporting is a key mechanism for ports to maintain oversight of bunkering safety and to support continuous improvement. For methanol and ammonia bunkering, ports should ensure that incidents, near-misses, and abnormal events are reported, reviewed, and used to inform future decisions on site suitability, operational controls, and permitting conditions.

This section addresses incident reporting from the port authority perspective, rather than internal company reporting systems.

What should be reported to the port 4.6.2.1

Ports should define clear reporting expectations covering, as a minimum:

- loss of containment, spills, or releases (liquid or vapour);
- activation of emergency systems, including ESD-1, ESD-2, or ERC;
- unexpected vessel movement, mooring failure, or drift outside the approved operational envelope;
- unplanned interruptions, aborted operations, or spurious shutdowns with safety relevance;
- SIMOPs conflicts or breaches of operational controls; and
- near-misses with credible potential for escalation.

Reporting thresholds and timescales should be proportionate to the severity of the event and aligned with existing port and national reporting requirements.

Immediate notification and escalation 4.6.2.2

Ports should require prompt notification of incidents that:

- affect safety zones, marine exclusion zones, or access control;
- may require emergency services involvement; or
- could have off-site or community impacts.

Clear escalation pathways should be established so that the port can:

- activate internal response arrangements;
- coordinate with emergency services, VTS, and other stakeholders; and
- implement temporary operational restrictions if required.

Investigation and follow-up 4.6.2.3

Ports should expect that:

- incidents are investigated by the responsible parties in line with their management systems; and
- findings relevant to port safety and operations are shared with the port authority.

For significant events, ports may:

- request a formal incident report;



- require corrective actions before further bunkering is authorised; and
- review whether site approvals, operational envelopes, or permit conditions remain appropriate.

The focus should be on causal understanding and risk reduction, rather than attribution of fault.

Lessons learned and continuous improvement 4.6.2.4

Ports should establish a mechanism to capture and apply lessons learned from:

- incidents and near-misses within the port;
- comparable events at other ports, where information is available; and
- relevant industry guidance and experience.

Lessons learned may inform:

- updates to port procedures, by-laws, or guidance;
- changes to site suitability or operational constraints;
- additional training or competence requirements; and
- engagement with stakeholders, including emergency services and neighbouring facilities.

Where appropriate, ports may share anonymised lessons learned with operators to promote consistency and learning across the port community.

Integration with permitting and governance 4.6.2.5

Incident reporting and lessons learned should be integrated into the port's governance framework, including:

- permitting and authorisation processes;
- periodic review of approved bunkering sites;
- renewal or modification of conditions for repeat operations.

This ensures that experience gained from operations is systematically fed back into decision-making, supporting safe and controlled development of methanol and ammonia bunkering within the port.

Special and non-routine cases 4.7

This section addresses special and non-routine cases, supporting ports in managing infrequent or non-standard scenarios that fall outside business-as-usual operations but still require appropriate controls.

It includes guidance for:

- Methanol or ammonia as fuel at ports without a bunkering framework
- Quantity and quality of fuel
- Support services, e.g. maintenance and gas freeing
- Debunkering

Methanol or ammonia as fuel at ports without a bunkering framework 4.7.1

Ports may receive vessels that use methanol or ammonia as fuel even where the port does not permit, support, or intend to develop bunkering for these fuels. This may occur during routine port calls, cargo operations, layovers, or when a vessel requests access as a port of refuge.

In such cases, the presence of a vessel using methanol or ammonia does not in itself constitute a bunkering activity. However, it introduces specific considerations for ports related to safety, emergency preparedness, and coordination.

This section provides guidance for ports on how to manage such situations without establishing or implying acceptance of bunkering operations.

Key principle for ports 4.7.1.1

A port that does not have a bunkering framework in place:

- is not required to permit bunkering or debunkering of methanol or ammonia; and
- may still safely accept vessels using these fuels, provided that appropriate precautions and awareness measures are in place.

The focus for the port is on safe presence and contingency readiness, not fuel transfer.

Routine port calls (no bunkering) 4.7.1.2

When a methanol- or ammonia-fuelled vessel calls at a port for purposes other than bunkering, ports should consider the following.

1. Awareness of fuel type
 - Confirm the fuel type used by the vessel as part of normal port call information.
 - Ensure relevant port departments (marine operations, safety, emergency response) are informed.
2. No-fuel-transfer condition
 - Clearly state that bunkering and debunkering are not permitted unless a specific framework and authorisation are in place.
 - Ensure this condition is reflected in port instructions or permits for the call.



3. Emergency preparedness
 - Confirm that port emergency plans can address credible scenarios involving the vessel's fuel (e.g. leak, fire, toxic release).
 - Ensure emergency services are aware that the vessel carries methanol or ammonia fuel, even if no transfer is planned.
4. Interface with port activities
 - Consider proximity to passenger areas, other vessels, or sensitive operations.
 - Apply additional controls only where justified by risk (e.g. access control during alongside stay).

Port of refuge situations 4.7.1.3

Where a methanol- or ammonia-fuelled vessel requests access as a port of refuge, additional considerations apply.

Ports should assess:

- the nature of the casualty and whether fuel systems are involved;
- whether remaining at sea presents a greater risk than controlled access to port waters;
- the dominant hazard (toxicity for ammonia; flammability for methanol); and
- the port's ability to establish temporary safety measures and coordinate emergency response.

Granting refuge does not imply approval for bunkering or debunkering. Any fuel-related intervention beyond stabilisation (e.g. fuel removal) should be subject to separate, explicit authorisation.

Emergency actions without a bunkering framework 4.7.1.4

Even where no bunkering framework exists, ports should be prepared for fuel-related emergencies involving visiting vessels. This includes:

- isolating areas and managing access if required;
- coordinating with fire, medical, and hazardous-materials responders;
- supporting the vessel in making the situation safe, without engaging in fuel transfer unless specifically authorised; and
- escalating to national or regional authorities where required.

Ports should avoid ad-hoc technical decisions and instead rely on existing emergency governance structures.

Communication and documentation 4.7.1.5

Ports should:

- document decisions taken when accepting methanol- or ammonia-fuelled vessels without a bunkering framework;
- clearly communicate any limitations or conditions imposed on the vessel; and
- ensure that lessons learned are captured to inform future preparedness.

Summary for ports 4.7.1.6

In summary:

- ports may safely receive methanol- or ammonia-fuelled vessels without permitting bunkering;
- the presence of such vessels requires awareness and emergency preparedness, not a full bunkering framework;
- port-of-refuge decisions should be risk-based and case-specific; and
- any fuel transfer remains a separate decision requiring explicit authorisation.

This approach allows ports to fulfil their safety and refuge responsibilities while maintaining clear boundaries on permitted activities.

Quantity and quality of fuel 4.7.2

The management of fuel quantity and fuel quality is an essential element of safe and reliable methanol and ammonia bunkering. While responsibility for fuel supply, custody transfer, and quality assurance primarily rests with suppliers and ship operators, ports have an important oversight and coordination role, particularly where fuel characteristics may affect safety, environmental protection, or port operations.

Methanol 4.7.2.1

For methanol used as a marine fuel, an international fuel specification is available. International Organization for Standardization ISO 6583:2024 – Methanol as a fuel for marine applications: General requirements and specifications defines key quality parameters, including purity, allowable contaminants, and test methods.

From a port perspective, this provides a clear reference baseline when reviewing bunkering documentation and compatibility assessments. Ports should be aware that deviations in methanol composition (e.g. water content, impurities) may:

- affect combustion performance and emissions;
- influence corrosion or material compatibility;
- increase operational or safety risks during storage and transfer.

Ports are not expected to verify fuel quality themselves but may reasonably expect operators to declare compliance with ISO 6583 or an equivalent agreed specification.

Ammonia 4.7.2.2

At present, there is no dedicated international marine fuel quality standard for ammonia as a marine fuel equivalent to ISO 6583 for methanol. Ammonia quality requirements are therefore typically defined through:

- project-specific specifications;
- supplier–operator agreements.

From a port perspective, the absence of a harmonised standard increases the importance of:

- clarity in declared fuel composition and purity;
- awareness of potential contaminants (e.g. water, oil, other nitrogen compounds) that may influence safety, corrosion, or release behaviour.

Ports should ensure that fuel quality assumptions used in risk assessments and dispersion modelling are consistent with the declared ammonia specification.

Fuel quantity and measurement 4.7.2.3

Accurate measurement of fuel quantity is important for:

- custody transfer;
- verification of transferred volumes / masses;
- post-incident investigation, if required.

Fuel quantity measurement may be achieved using:

- tank level measurements before and after bunkering;
- mass flow measurement systems.

In any case, standardized calculation methods for density and energy content are well established across the industry and are routinely applied when methanol and ammonia are shipped as cargo. In addition, local customs requirements should be evaluated to determine the units in which these products are to be declared. While this forms part of the bunker supplier's due-diligence obligations, the port can and should support the establishment of the initial framework for these fuels.

Summary for ports 4.7.2.4

Ports are not responsible for commercial custody transfer, but clarity on quantity measurement supports transparent risk management and emergency planning.

- the measurement method should be clearly defined in the bunkering documentation;
- assumptions on transferred quantity should be consistent with those used in risk assessment, particularly when defining worst-case or credible release scenarios;
- ports may wish to ensure that measurement systems are suitable for the fuel and operating conditions, especially where bunkering is conducted regularly.

Ports should:

- understand which fuel quality specification applies to each bunkering operation;
- ensure consistency between declared fuel properties and those assumed in risk and dispersion studies;
- confirm that fuel quantity measurement arrangements are clearly documented;
- recognise that changes in fuel composition or operating conditions may trigger the need for review of safety zones or compatibility assessments.

Support services, e.g. maintenance and gas freeing 4.7.3

General support services 4.7.3.1

Support services required for gas-freeing, gassing-up, cool-down, or debunkering operations typically necessitate additional technical assessments and, in many cases, a dedicated review of port permitting conditions and national regulatory requirements. These services may be provided by bunker suppliers, shipyards, or specialised repair and service facilities operating within the port area.

While the majority of such services are commonly offered by bunker suppliers, they introduce specific operational, environmental, and safety implications that should be addressed in advance. These activities may include, but are not limited to:

- Venting of inert or process gases
- Cool-down of bunker tanks (ammonia)
- Flaring or the use of portable gas combustion units (GCUs) during gas-freeing or cool-down operations, where applicable
- Debunkering or removal of fuel from bunker tanks

Venting operations 4.7.3.2

This section addresses planned, operational venting only, such as venting associated with inertisation, gas-freeing, purging, or other foreseeable and controlled operational activities. It does not cover emergency venting, which is considered an abnormal event and should be managed under the port's emergency response framework.

Any emergency venting, including venting required to protect life, vessel integrity, or prevent escalation of an incident, falls outside the scope of this section. Such events should be treated as emergencies, immediately reported to the port authority, and managed in accordance with the port's emergency response and incident reporting procedures.

National legislation, environmental permitting conditions, and port-specific operational limits should be carefully reviewed to determine which gases may be vented, which are prohibited from venting, and under what conditions venting is permitted. This assessment should explicitly consider both safety and environmental protection requirements, including air-quality limits, occupational exposure thresholds, odour nuisance, greenhouse gas emissions, and potential off-site impacts.

Venting of toxic, flammable, or environmentally harmful gases should not be considered normal or acceptable practice. In many jurisdictions, such venting is explicitly restricted or prohibited under environmental or occupational health legislation. Where venting is permitted, it should be minimised, justified, and subject to clear controls.

This is particularly relevant during inertisation, gas-freeing, or purging of bunker tanks and transfer systems, where vented streams may include nitrogen or other inert gases, as well as residual methanol or ammonia vapours. Ports should ensure that venting of residual fuel vapours is not undertaken unless explicitly authorised, appropriately controlled, and limited to designated locations.

Venting requirements should address:

- Permitted gas types and compositions
- Maximum allowable flow rates and durations
- Dispersion and exposure considerations
- Meteorological limitations



- Notification and reporting obligations to authorities

Flaring and GCUs 4.7.3.3

Where flaring is proposed, a site-specific assessment should be conducted to verify the suitability of the intended flare location. This assessment should typically include:

- Heat radiation calculations
- Assessment of safe distances to personnel, vessels, structures, and equipment
- Evaluation of ignition and escalation risks
- Notification and coordination with the local fire brigade and emergency services
- Compliance with environmental and emission limits

As an alternative, the use of portable gas combustion units (GCUs) is generally preferred, as these systems operate without open flames and therefore reduce ignition risks. However, GCUs may generate significant noise levels, which should be assessed against local noise regulations and port operational limits. Where required, additional mitigation measures or operational time restrictions may need to be implemented.

Summary for ports 4.7.3.4

All support-service activities related to gas-freeing, gassing-up, cool-down, flaring, GCU operation should be integrated into the port's permitting framework, SIMOPS procedures, and emergency response planning. Clear roles and responsibilities between the port authority, service provider, bunker supplier, terminal operator, and emergency services should be defined to ensure that these non-routine operations are conducted safely and in compliance with applicable legislation.

Debunkering 4.7.4

Debunkering is the removal of fuel from a vessel's fuel tanks, typically by transferring it to a receiving facility or temporary storage. It is considered a non-routine operation and is distinct from normal bunkering.

From a port perspective, debunkering may occur only in special circumstances, such as:

- urgent or unplanned maintenance;
- preparation for dry-docking or repair;
- damage to fuel systems; or
- other exceptional or emergency situations.

Debunkering is not normally part of routine port operations and is not expected to occur frequently. Debunkering operations may also require separate permitting or authority notification, particularly where hazardous or toxic fuels are involved.

Why debunkering is relevant for ports 4.7.4.1

Ports need to consider debunkering because, compared with bunkering, it may:

- take significantly longer to complete;
- involve reverse flow through transfer systems;
- it might generate higher quantities of vapour;
- require temporary storage or onward transfer of removed fuel; and
- introduce additional safety, environmental, and security considerations.

Debunkering may also interact with port traffic, berth availability, emergency planning, and environmental controls over an extended period.

Port approach to authorisation:

Debunkering is typically not automatically permitted in ports. Instead, ports may:

- allow debunkering only on a case-by-case basis;
- restrict it to clearly defined emergency or exceptional situations; and
- apply additional conditions compared with normal bunkering.

Ports should clearly define whether debunkering:

- is allowed within the port jurisdiction;
- is limited to emergency or maintenance-related scenarios; and
- requires specific authorisation from the port authority and, where applicable, national regulators.

Vessel procedures and port requirements:

Vessels intending to carry out debunkering should have specific, debunkering procedures in place, supported by a risk assessment.

Where debunkering is proposed, ports should request and review the vessel's debunkering procedures as part of the authorisation process. These procedures should demonstrate that:

- the operation can be carried out safely with the available equipment;
- vapour management and emissions are controlled as far as practicable;
- emergency shutdown and disconnection arrangements are addressed; and
- responsibilities between the vessel, receiving facility, and port are clearly defined.

Ports should avoid authorising debunkering where suitable procedures are not available or where risks cannot be adequately managed.

Handling of debunkered fuel 4.7.4.2

Ports should ensure that arrangements for debunkered fuel are clearly defined before authorisation is granted. This includes:

- identifying the receiving facility or storage location;
- confirming compatibility of transfer systems and reverse-flow arrangements;
- ensuring that environmental controls are in place to manage spills, and vapour release; and
- confirming responsibility for the fuel once it is removed from the vessel.

Ports should avoid authorising debunkering unless a safe and compliant destination for the removed fuel has been confirmed.

Safety and environmental considerations:

Ports should expect debunkering proposals to address:

- safety zones and access control for the full duration of the operation;
- management of vapour generation and venting, including minimisation of emissions where practicable;
- extended exposure of personnel and port users to the operation; and



- emergency response arrangements, including escalation pathways if conditions change.

Where debunkering is proposed as part of an emergency response, ports should recognise that normal controls may need to be adapted, while still aiming to minimise environmental impact and risk to people.

Summary for ports 4.7.4.3

In summary:

- debunkering is a non-routine, exceptional operation;
- ports may choose to permit it only under defined conditions, often limited to emergencies or essential maintenance;
- the destination and handling of debunkered fuel should be clearly defined and agreed in advance; and
- safety, environmental protection, and prolonged operational impacts should be explicitly considered before authorisation;
- Impose additional permitting requirements for the port

References

EMSA - Safety of ammonia for use in ships

IAPH - Port Readiness Level for Marine Fuels (PRL-MF) assessment tool for bunker ports

IMO - Interim guidelines for ships using ammonia as fuel - MSC.1/Circ.1687

IMO - Interim guidelines for ships using methyl/ethyl alcohol as fuel - MSC.1/Circ.1621

IMO - IGF Code, International Code of Safety for Ships using Gases or other Low-flashpoint Fuels

IMO - IGC Code, International Code for the Construction and Equipment of Ships Carrying Liquefied Gases in Bulk

IMO - IBC Code, International Code for the Construction and Equipment of Ships carrying Dangerous Chemicals in Bulk

ISO 6583:2024 - Methanol as a fuel for marine applications: General requirements and specifications.

ISO 20519:2021 - Specification for bunkering of liquefied natural gas fuelled vessels

ISO/TS 16901:2022 - Guidance on performing risk assessment in the design of onshore LNG installations including the ship/shore interface

ISO/TS 18683 - Guidelines for safety and risk assessment of LNG fuel bunkering operations

OCIMF - International Safety Guide for Oil Tankers and Terminals (ISGOTT 6)

SGMF - GD-A033_Methanol as a Marine Fuel – An Introduction

SGMF - GD-A032_Ammonia as a Marine Fuel – An Introduction

SGMF - FP25-01_Accidental Release Preparedness and Response

SGMF - FP22-01_Methanol As Marine Fuel – Safety and Operational Guidelines – Bunkering

SGMF - FP23-01_Ammonia – Safety and Operational Guidelines – Bunkering

SGMF - FP02-01_Recommendations of Controlled Zones During LNG Bunkering

Appendix A: Bunkering Documentation for Ports

Port Documents Review Matrix A.1

Summary of typical key bunkering documents and actions required by ports:

1. Actual requirements may vary by port, bunkering scenario, and national regulation.
2. Ports typically focus on assurance and oversight, not operational control.

Table A-1: Port Documents Review Matrix

	Bunkering Stages				
Document	Design / Early Planning	Planning & Permitting	Preparation (Operation-specific)	Operational Oversight	Typical Port Role
Bunkering Management Plan	Review (draft)	Review for license approval	Reference	---	Primary assurance document
Design package / equipment technical specification	---	Reference	---	---	Vessel and equipment codes and regulatory compliance assurance
Risk assessment (incl. HAZID)	Review	Review -> approve	Confirm applicability	---	Verify risk acceptability
Safety zones & hazardous areas	Review (concept)	Review -> approve	Confirm implementation	Enforce	Assure safe port operations

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	Bunkering Stages				
Document	Design / Early Planning	Planning & Permitting	Preparation (Operation-specific)	Operational Oversight	Typical Port Role
SIMOPs assessment	Review (concept)	Review -> approve	Confirm implementation	Enforce	Coordinate port activities
Emergency response arrangements	Review	Review -> approve	Confirm emergency preparedness	Coordinate	Assure port emergency readiness
Training & competence records	---	Review (framework)	Confirm availability	---	Verify preparedness
Quality and quantity agreement	---	Reference	Reference	---	Awareness / emergency input
Bunkering procedure	---	Acknowledge	Reference	---	Operator responsibility
Bunkering checklist	---	Acknowledge format	Confirm completeness	---	Execution tool (operators)
Compatibility assessment / report	---	Acknowledge format	Confirm completeness	---	Interface assurance (operators)
Joint Bunkering Plan (JBP)	---	Review (framework)	Review -> acknowledge or approve (if required)	Reference	Key short operational summary

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Documentation Expectations by Operation Maturity Level A.2

Table A-2: Documentation Expectations by Operation Maturity Level

	Early-Stage Ports (Pilot / First-of-a-Kind Operations)	Business-as-Usual Ports (Established Operations)
Aspect	Typical Expectation	Typical Expectation
Documentation depth	More detailed and conservative	Proportionate and streamlined
Bunkering Management Plan	Full submission typically required	Referenced master document
Risk assessment	Site-specific, conservative assumptions	Updated only when conditions change
Safety zones	Larger, precautionary zones	Optimised based on experience
SIMOPs assessment	Restrictive controls	Standardised procedures
Emergency planning	Extensive coordination and drills	Integrated into port systems
Training evidence	Detailed and fuel-specific	Periodic verification
Bunkering checklist	Detailed and operation specific	Standardised procedures
Compatibility assessment	Detailed and operation specific	Standardised procedures
Joint Bunkering Plan (JBP)	Mandatory and closely reviewed	Primary approval document
Port involvement	High (frequent reviews, inspections)	Oversight and enforcement
Objective:	Build confidence, manage uncertainty, and capture lessons learned.	Enable efficient operations while maintaining safety and compliance.

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Documentation Expectations Aligned with IAPH PRLs A.3

The IAPH Port Readiness Level for Marine Fuels (PRL-MF) framework defines nine progressive levels covering research, development, deployment, and market maturity for bunkering a specific marine fuel.

Documentation requirements for methanol and ammonia bunkering should evolve in line with these levels and remain proportionate to port maturity and operational experience.

Key alignment principles:

1. Documentation depth decreases as PRL-MF increases, but never disappears.
2. Early PRL-MF levels emphasise learning, analysis and framework design.
3. Middle levels focus on testing, pilots and validation.
4. Higher levels prioritise standardisation, efficiency and market growth.
5. The Bunkering Management Plan and Joint Plan of Bunkering Operation are central tools throughout, with their role evolving rather than expanding.

Note on Port Readiness Level (PRL) applicability

This Guidebook is designed primarily to support ports at Port Readiness Levels (PRL-MF) 1 to 4, where ports are developing foundational knowledge, assessing feasibility, and establishing the frameworks required for methanol and ammonia bunkering. It provides practical guidance to help ports progress through these early readiness stages and prepare for implementation.

At the same time, the Guidebook supports ports in transitioning from pilot and project-based operations to business-as-usual bunkering, corresponding to PRL-MF 5 to 9. As ports gain experience, the guidance can be used to refine procedures, streamline documentation, and support the safe scaling-up of methanol and ammonia bunkering operations.

PRL-MF 1 – Foundational Background Information

Objective (IAPH): establish baseline understanding of the target fuel.

Documentation expectations

- High-level overview of methanol or ammonia properties and hazards
- Initial regulatory scan (IMO, ISO, EU, national)
- Preliminary stakeholder mapping
- Reference material (IAPH, EMSA, SGMF, class guidance)

Port authority focus

- Awareness building
- Internal capacity development
- No operational approvals

PRL-MF 2 – Stakeholder Interest and Feasibility Assessment

Objective: assess stakeholder interest and feasibility of bunkering.

Documentation expectations

- Preliminary feasibility and safety considerations
- Initial identification of bunkering scenarios
- Early engagement records with regulators and emergency services

Port authority focus

- Understanding feasibility and constraints
- Identifying regulatory and safety gaps

PRL-MF 3 – Detailed Research, Analysis and Conclusions

Objective: support an informed decision on whether to proceed.

Documentation expectations

- Gap analysis against regulatory and safety requirements
- Preliminary risk assessment (high-level)
- Initial safety-zone concepts
- Identification of required services (e.g. emergency response, debunkering)

Port authority focus

- Decision point: proceed or halt
- Early definition of competent-authority roles

PRL-MF 4 – Framework Drafted, Roadmap and Timeline Developed

Objective: define how bunkering could be implemented.

Documentation expectations

- Draft port-level bunkering framework
- Draft permitting and approval process
- Draft SIMOPs and emergency-response concepts
- Communication and stakeholder-engagement plan

Port authority focus

- Acting as framework owner
- Ensuring alignment with national legislation

PRL-MF 5 – Framework Implementation, Testing and Training

Objective: test and validate the framework.

Documentation expectations

- Bunkering Management Plan submitted for review
- Detailed risk assessment (incl. safety zones and SIMOPs)
- Compatibility assessment methodology
- Training plans and competence requirements
- Emergency response plans aligned with port systems
- Draft JBP templates

Port authority focus

- Acting clearly as competent authority
- Approving framework and readiness to pilot

PRL-MF 6 – Pilot-Scale Demonstration

Objective: conduct controlled pilot bunkering operations.

Documentation expectations

- Operation-specific JBP
- Confirmed Bunkering Management Plan
- Final risk assessment for pilot
- Emergency drills and exercise records
- Incident and lessons-learned reporting

Port authority focus

- Close operational oversight
- Conservative safety zones and controls
- Feedback into framework refinement

PRL-MF 7 – Project-Based Bunkering Established

Objective: repeat operations on a project basis.

Documentation expectations

- Bunkering Management Plan maintained as a living document
- JBP for each operation
- Updated risk assessments where conditions change
- Standardised checklists and procedures

Port authority focus

- Oversight and enforcement
- Refinement of SIMOPs and traffic management

PRL-MF 8 – Full Capabilities for Bunkering Established

Objective: enable routine bunkering operations.

Documentation expectations

- Bunkering Management Plan referenced rather than resubmitted
- JBP as primary approval document
- Risk assessments updated only for material changes
- Integrated emergency and Vessel Traffic Services (VTS) procedures
- Periodic training verification

Port authority focus

- System-level governance
- Reduced case-by-case intervention

PRL-MF 9 – Market Penetration and Growth

Objective: support mature, competitive bunkering market.

Documentation expectations

- Standardised documentation processes
- Continuous-improvement and performance monitoring
- Periodic framework reviews

Port authority focus

- Strategic oversight
- Market facilitation while maintaining safety

Appendix B: Bunkering Site Identification Process

This appendix provides a practical, staged process that ports can apply to identify, approve, and operationalise bunkering locations for methanol and ammonia.

It complements section 4.2 by expanding on implementation-level considerations, with a particular focus on port activities.

Note: The bunkering site identification process described in this appendix is indicative and non-prescriptive. It is intended to provide a practical reference framework for ports, rather than a mandatory sequence of steps.

Depending on national legislation, port governance structures, regulatory arrangements, and local practice:

- some steps may be undertaken in a different order;
- certain steps may be combined or iterated;
- responsibilities may sit with different organisations; and
- additional steps or decision gates may be required.

Ports are therefore encouraged to apply this process flexibly, adapting it to their local regulatory and organisational context, while ensuring that all key considerations described in this appendix are addressed before bunkering operations are authorised.

Establish governance and ownership

- Assign clear internal ownership and decision authority for alternative fuel bunkering.
- Define competent authority roles and escalation paths across port and national bodies.
- Agree risk acceptance criteria and documentation expectations upfront.

Identify candidate bunkering locations

- Proactively shortlist suitable berths, terminals, and anchorages.
- Assess space for safety zones, access control, and emergency response.
- Exclude locations that are clearly unsuitable at an early stage.

Define applicable bunkering supply scenarios

- Identify feasible supply modes (STS, shore-to-ship, mobile-to-ship) per location.
- Check physical and interface constraints (manifolds, hoses, access, infrastructure).
- Base later risk assessments on realistic, achievable configurations.

Screen fuel suitability by location

- Assess dominant hazards (flammability or toxicity) for each fuel.
- Evaluate impacts on people, infrastructure, and neighbouring areas.
- Exclude locations where fuel-specific risks cannot be reasonably managed.

Undertake site-level risk assessment

- Define safety zones, exclusion areas, and navigational controls.
- Assess SIMOPs restrictions and emergency access arrangements.
- Document assumptions, credible scenarios, and required controls.

Define operational envelopes and constraints

- Translate risk outcomes into clear operational limits.
- Set constraints for inventory, weather, SIMOPs, and traffic management.
- Adjust transfer parameters where space is constrained, not safety distances.

Engage external stakeholders

- Review sites and envelopes with regulators, terminals, VTS, and emergency services.
- Confirm alignment with legislation and emergency response requirements.
- Identify additional conditions early to avoid late objections.

Develop the bunkering map and site register

- Consolidate approved and conditional bunkering locations.
- Define permitted fuels, supply scenarios, and operating limits per site.
- Use the register to support transparency and consistent decision-making.

Integrate into permitting and port procedures

- Embed site decisions into by-laws, permits, and port rules.
- Align document submission and review workflows.
- Enable efficient, consistent assessment of future bunkering requests.

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Establish governance and ownership B.1

Ports should begin by establishing clear governance arrangements for alternative fuel bunkering. This includes assigning internal responsibility and defining how decisions will be made and approved.

Key actions include:

- Appointing port leads responsible for alternative fuel bunkering, typically involving safety, marine operations, environment, and permitting functions.
- Clearly defining decision authority, including when the port acts as the competent authority and when responsibilities sit with national administrations, regulators, or other bodies.
- Establishing how decisions are escalated and documented, particularly where multiple authorities are involved at different stages.
- Agreeing an internal risk acceptance approach, including high-level criteria for what constitutes acceptable risk for methanol and ammonia bunkering.
- Defining documentation expectations, including the level of detail required at site, planning, and operation stages (e.g. BMP, JBP, risk assessments).

Early clarity on governance avoids uncertainty later and supports consistent, defensible decision-making.

Identify candidate bunkering locations B.2

Ports should proactively identify and shortlist potential bunkering locations rather than assessing requests on an ad-hoc basis.

This typically includes:

- Reviewing existing berths, quays, terminals, anchorages, and lay-by areas.
- Considering physical space available for safety zones, access control, and emergency response.
- Assessing proximity to neighbouring terminals, public areas, buildings, roads, railways, and utilities, including outside the port boundary.
- Evaluating whether emergency services can reach and operate safely at the location.
- Identifying locations where bunkering is clearly unsuitable and excluding them early.

The outcome should be a shortlist of candidate locations suitable for further assessment.

Define applicable bunkering supply scenarios B.3

For each candidate location, ports should identify which bunkering supply scenarios are feasible.

This includes:

- Assessing suitability for ship-to-ship (STS), shore-to-ship, and mobile-to-ship operations.
- Identifying interface constraints such as:
 - hose or transfer arm reach;
 - manifold height and orientation;
 - availability of fixed infrastructure;
 - road access and turning space for trucks or portable tanks.
- Recognising that some locations may support only one scenario, while others may support multiple.

This step ensures that later risk assessments are based on realistic and achievable configurations.

Screen fuel suitability by location B.4

Ports should apply an early fuel-specific screening to determine whether a location is suitable for methanol, ammonia, or both.

This screening should consider:

- Dominant hazard drivers (flammability for methanol, toxicity for ammonia).
- Potential impact on people, infrastructure, and neighbouring areas.
- Ability to establish and enforce safety zones and marine exclusion zones.
- Compatibility with emergency response capabilities.

Locations where the fuel-specific risks cannot be reasonably managed should be excluded at this stage, even if they are suitable for other fuels.



Undertake site-level risk assessment B.5

For each shortlisted location and fuel, a baseline site-level risk assessment should be performed.

This assessment should address:

- Definition of hazardous areas, safety zones, and toxic areas (as applicable).
- Identification of required marine exclusion zones and navigational controls.
- Assessment of SIMOPs, including which activities may need to be restricted or prohibited during bunkering.
- Evaluation of emergency access, escape routes, and escalation pathways.

The assessment should clearly document:

- assumptions and limitations;
- credible release scenarios;
- operational boundaries;
- required mitigation and control measures.

Define operational envelopes and constraints B.6

Risk assessment outputs should be translated into practical, enforceable operational limits, often referred to as the operational envelope.

This may include:

- Maximum inventory involved in a single operation.
- Weather and visibility limits.
- SIMOPs restrictions and traffic management measures.
- Minimum competence, training, and staffing requirements.

Where physical space is constrained, ports should require adjustment of transfer parameters and operational limits so that safety zone remain achievable and enforceable, rather than arbitrarily reducing safety distances.

Engage external stakeholders B.7

Early and structured engagement with external stakeholders is essential.

Ports should:

- Review proposed sites and operational envelopes with national regulators, terminal operators, VTS/pilotage services, and emergency services.
- Confirm alignment with national legislation, emergency planning requirements, and response capabilities.
- Identify any additional conditions or constraints required by external authorities.

This step reduces the risk of late objections or conflicting requirements.

Develop the bunkering map and site register B.8

Ports should consolidate outcomes into a bunkering map and site register, which may be internal or partially public.

The map/register should identify:

- approved and conditionally approved bunkering locations;
- fuels permitted at each location;
- permitted bunkering supply scenarios;
- key operational envelopes and constraints.

Integrate into permitting and port procedures B.9

Finally, the site framework should be embedded into port governance and processes, including:

- port by-laws and local rules;
- permitting and authorisation workflows;
- document submission requirements (e.g. BMP, JBP);
- review and approval timelines.

This ensures that future bunkering requests can be assessed efficiently and consistently against an established framework.

WHY EARLY SITE IDENTIFICATION IS USEFUL:

Conducting site identification and risk-based location assessment in advance allows ports to move from reactive decision-making to a planned, consistent approach. This is particularly important for methanol and ammonia because early operations often involve uncertainty, multiple stakeholders, and evolving regulatory expectations.

Early work enables the port to:

- **Reduce lead time** when a vessel or supplier requests bunkering, avoiding ad-hoc approvals under time pressure.
- **Provide clarity to the market** by indicating where and under what conditions bunkering may be accepted.
- **Apply consistent risk acceptance criteria** across different requests, improving transparency and defensibility.
- **Identify infrastructure or capability gaps** (space for safety zones, access control, emergency response resources) and address them before operations begin.
- **Coordinate stakeholders early** (regulators, terminals, emergency services, VTS, neighbours), reducing late-stage changes and misalignment.
- **Support permitting and authorisation** with pre-established site-level assessments, rather than repeating foundational work for each operation.

Aependix C: Port checklist: reviewing a proposed safety zone

This appendix complements section 4.4 and it provides a practical process that ports can apply to review and where requested approve a safety zone proposal from operators planning bunkering operations under their port jurisdiction.

When a bunkering operator proposes safety zone for a methanol or ammonia bunkering operation, the port authority-often acting as, or supporting, the competent authority-should verify that the proposal is risk-based, site-specific, and operationally enforceable.

1. Basis and methodology

- Confirm that the safety zone is derived from a documented risk assessment, using recognised methodologies appropriate to the fuel and bunkering scenario.
- Verify that credible release scenarios have been identified for the actual transfer system configuration (e.g. hoses, transfer arms, connectors, ERCs, valves, manifolds).
- Check that the hazard driver used to define the safety zone is clearly justified (e.g. flammability for methanol, toxicity for ammonia, or a combination where relevant).

2. Assumptions and key drivers

- Review the main assumptions that influence safety zone size, including:
 - transfer pressure and flow rate;
 - storage and transfer conditions (temperature, phase);
 - detection and isolation time (ESD performance);
 - static inventory involved;
 - local meteorological conditions and dispersion assumptions;
 - physical layout, obstructions, and ventilation.
 - appropriate and compliant flammability and toxicity threshold levels have been selected
- Confirm that assumptions reflect local port conditions and are not generic or overly optimistic.

3. Control, access and enforceability

- Ensure that the proposed safety zone lies within a space where effective control can be exercised during bunkering.
- Verify that access restrictions, exclusion measures, and control of ignition sources or personnel exposure can be implemented and enforced in practice.
- Check that the safety zone is clearly defined, communicated, and compatible with port security and access arrangements.

4. Interface with port operations and SIMOPs

- Confirm that the safety zone has been assessed against simultaneous operations (SIMOPs), including cargo handling, passenger movements, maintenance activities, and vessel traffic.

- Verify that any required restrictions, suspensions, or sequencing of activities are clearly identified and acceptable from a port operations perspective.
 - Ensure alignment with marine exclusion zones and vessel traffic management measures, where applicable.
5. Emergency preparedness and escalation
- Check that emergency response arrangements are consistent with the assumptions used to define the safety zone.
 - Verify coordination with port emergency plans, emergency services, and neighbouring facilities, where relevant.
 - Confirm that escalation procedures are defined should conditions change or an abnormal situation occur.

Additional considerations for ports C.1

1. **Safety zone sizing is fuel-specific.** Although safety zones for LNG and methanol are both influenced by flammability-related hazards, the flammability characteristics and dispersion behaviour of the two fuels differ significantly. For ammonia, the dominant driver for safety zone definition is typically toxicity and exposure, rather than flammability. As a result, LNG safety distances and zone definitions should not be directly reused for methanol or ammonia without a fuel-specific risk assessment and appropriate modelling.
 - a. **National toxicity thresholds for ammonia and methanol may differ** across countries and national legislations. Ports should therefore confirm the applicable national exposure limits and emergency planning criteria and ensure that dispersion modelling assumptions, safety zone definitions, PPE requirements, and emergency procedures are aligned with those national requirements.
2. **Safety zones are operation-specific and should be reviewed for each bunkering operation,** taking into account the actual vessel, location, transfer system, and conditions. This does not necessarily require recalculation of the safety zone, but confirmation that the assumptions and conditions on which they were based remain valid and applicable.
3. **Use of generic or envelope safety zones.** Where appropriate, ports may agree on a generic or envelope safety zone that covers a defined range of operational profiles (e.g. different vessels or transfer rates), provided this is supported by a conservative risk assessment.
4. **Applicability limits should be explicit.** Any safety zone intended to cover multiple operational profiles should clearly define its assumptions, limits, and applicability, and identify when a re-assessment is required.
5. **Adjusting transfer parameters to match physical constraints.** Safety zone for a specific location and bunkering scenario are normally defined based on the bunkering risk assessment and the associated transfer parameters (e.g. flow rate, pressure, inventory, duration). However where physical layout limitations-such as buildings, roads, rail lines, quays, or other fixed infrastructure-constrain the available space, ports may agree to adjust the bunkering transfer parameters so that the resulting safety zones fit within the space available.
 - a. In such cases, the safety zone should not be arbitrarily reduced. Instead, the risk assessment should demonstrate that the modified transfer parameters (e.g. reduced



flow rate or pressure, staged transfer, reduced inventory, or shorter transfer duration) lead to a corresponding reduction in the extent of the safety zone.

- b. Additional operational controls-such as enhanced monitoring, stricter access control, tighter weather limits, or increased supervision-may also be required to ensure that an equivalent level of safety is maintained.

6. **Onshore inventory limits and land-based permitting considerations.** For shore-to-ship and mobile-to-ship arrangements, ports should consider whether national or regional legislation places inventory limits on the quantity of hazardous or toxic substances permitted on land, even when held temporarily (e.g. within a terminal boundary, in temporary storage, or in mobile units). Such limits may influence:

- a. allowable transfer quantity;
- b. siting and separation distances for temporary equipment;
- c. permitting routes, notifications and competent authority involvement; and
- d. emergency planning assumptions for onshore populations and neighbouring facilities.

Where such constraints apply, they should be addressed explicitly in the authorisation process and reflected in operational controls.

7. **Security-related restrictions for toxic substances.** Some national legislation may impose additional restrictions for toxic substances on security grounds (e.g. due to misuse potential). These requirements may apply to both land and waterside activities and may include enhanced access control, escorting, surveillance, restricted areas, movement controls, and additional verification of personnel and contractors. Ports should:

- a. confirm applicable security requirements early in the planning stage;
- b. integrate them with existing port security arrangements (e.g. ISPS and local security plans); and
- c. ensure roles and responsibilities are clear between port, terminal, supplier and ship.

8. **Safety zones should remain temporary and dynamic**, applied only for the duration of bunkering and adjusted or withdrawn once operations are complete.

9. **Change management.** Changes to the operation (e.g. different supply scenario, equipment, weather limits, or SIMOPs) should trigger a review of the safety zone.

10. **Optimisation over time.** As ports gain experience and move toward business-as-usual operations, safety zone may be optimised, but only where supported by updated risk assessments and competent-authority approval.

Appendix D: Further considerations on HAZID, HAZOP and SIMOPs

This Appendix provides practical guidance to support ports, operators, and other stakeholders in preparing, reviewing, and applying HAZID, HAZOP, and SIMOPs assessments for methanol and ammonia bunkering operations.

It complements sections 4.3 by expanding on implementation-level considerations, with a particular focus on port environments and interfaces.

Hazard Identification (HAZID) D.1

HAZID is a systematic hazard identification exercise, typically applied at an early stage of development or prior to first or pilot operations. From a port perspective, HAZID is particularly valuable to:

- identify hazards at the ship–shore–port interface;
- support site screening and selection;
- identify constraints affecting controlled areas and SIMOPs;
- inform permit conditions and operational envelopes.

HAZID workshops should involve representatives from the bunkering supplier, receiving ship, port authority, terminal operator, and emergency services, as appropriate.

Typical operational nodes for HAZID:

The following list may be used to structure a HAZID exercise for methanol and ammonia bunkering. These nodes define the extent of the system being analysed and should be considered for all operations that will take place:

- preparation (compatibility checks, testing, mooring);
- connection of transfer system;
- inerting or purging of relevant pipe sections;
- transfer start;
- transfer at nominal flow;
- transfer stop, including topping-up;
- draining and purging;
- inerting (post-transfer);
- disconnection;
- commissioning or return to service;
- security and access control;
- local factors (e.g. weather, visibility);
- generic and port-specific issues.

Ports should ensure that port-side activities and interfaces are explicitly included, not only shipboard systems.

HAZID guidewords:

To guide and structure the HAZID workshop, the following guidewords may be applied. The list is not exhaustive and should be adapted to the fuel and scenario:

- toxicity (particularly critical for ammonia);
- leakage;
- rupture;
- corrosion;
- impact (e.g. ship, vehicle, dropped objects);
- fire/explosion;
- structural integrity;
- mechanical failure;
- control or electrical failure;
- human error;
- manufacturing defects;
- material selection;
- flange or connector failure;
- vapour management;
- ESD valve control failure;
- ERC failure;
- loss of containment (piping, valves);
- liquid leaks;
- hose damage;
- major structural damage;
- vapour dispersion;
- vapour entering air intakes;
- excessive transfer rate;
- hydraulic power unit failure;
- communication failure;
- blackout;
- relative motion of vessels;
- SIMOPs;
- vent unexpectedly not closing;
- harsh weather.

For ammonia, toxicity-related consequences and dispersion should be explicitly addressed at each node. For methanol, flammability, ignition sources, and fire escalation require particular attention.

Hazard and Operability Study (HAZOP) D.2

HAZOP is a detailed, structured analysis, typically applied once system design and operating philosophy are defined. It focuses on how the system behaves under deviations from intended operation.

From a port perspective, HAZOP is relevant where:

- fixed or semi-permanent infrastructure is involved;



- complex interfaces exist between ship, shore, and port systems;
- deviations could affect controlled areas or SIMOPs.

Ports are not expected to lead HAZOPs but should review outcomes that affect port safety, operability, and emergency response.

Operational modes to be considered:

HAZOP should address the full range of operational modes, including:

- start-up;
- normal operations;
- normal shutdown;
- emergency shutdown.

Typical HAZOP nodes:

HAZOP is normally conducted at P&ID level. Typical nodes include:

- storage tank;
- fuel transfer system;
- vapour return system;
- fuel supply to consumers;
- utility systems supporting operations;
- emergency and supporting systems (e.g. venting, detection).

Guidewords and deviations:

Each node should be examined using guidewords such as:

- no flow;
- low flow;
- high flow;
- reverse flow;
- overpressure;
- underpressure;
- wrong composition;
- loss of containment.

Practical considerations for ports:

When reviewing HAZOP outcomes, ports should focus on:

- joining and coordination of ESD systems between ship, shore, and transfer system;
- emergency shutdown and quick-release protocols;
- emergency unmooring scenarios;
- loss of power (ship and shore, including changeover);
- emergency venting of fuel or vapour;
- need for external assistance (e.g. tugs);
- implications for controlled areas and marine exclusion zones;



- human-factor issues, including fatigue, stress, and workload during bunkering.

SIMOPs (Simultaneous Operations) Assessment D.3

SIMOPs assessments address combined risks arising when bunkering occurs alongside other activities. From a port perspective, SIMOPs management is critical, as ports are responsible for coordinating multiple users and activities within a shared environment.

The risk level for each SIMOP should be acceptable and consistent with the port's risk tolerance, as defined by the competent authority, and agreed by all parties involved.

Activities requiring SIMOPs assessment:

SIMOPs assessment should consider, as a minimum:

- cargo handling;
- ballasting operations;
- passenger embarking/disembarking;
- vehicles embarking/disembarking;
- dangerous goods loading/unloading;
- loading or unloading of stores and provisions;
- handling of chemical products, including toxic cargoes;
- handling of other low-flashpoint products;
- bunkering of fuels other than methanol or ammonia;
- maintenance, construction, testing, and inspection activities;
- hot work or any activity that could generate sparks;
- any external activities that may pose a hazard during bunkering;
- activities that may distract the bunkering crew;
- shipboard operations affecting vessel stability or power systems.

Minimum considerations for SIMOPs risk assessment

SIMOPs risk assessment should take into account, at a minimum:

- size and location of the bunkering Safety Zone, Monitoring and Security Area, and any Toxic Area;
- interaction between safety zones introduced by bunkering and those associated with other activities;
- credible failure and impact scenarios;
- access, egress, and escape/evacuation routes;
- transfer scenario (ship-to-ship, shore-to-ship, mobile-to-ship);
- largest credible spill or release;
- transfer flow rate and duration;
- type of cargo or passenger operation;
- safeguards to control passenger and cargo movements;
- dropped-object risks;
- vent mast positions, air intakes, and exhausts;
- restrictions related to hazardous cargo handling.



Port expectations:

Ports should ensure that:

- SIMOPs decisions are clearly documented and reflected in permits and operational plans;
- prohibited or restricted activities are unambiguous and enforceable;
- SIMOPs arrangements are communicated to all relevant port users;
- SIMOPs assessments are reviewed whenever operational conditions change.



Appendix E: Ports Roadmap Checklist

H2Deri@BSP - A cooperation project to develop proof-of concepts for the uptake of H2 derivative fuels!

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Ports Roadmap to Bunkering

CHECKLIST for steps and decision gates for alternative fuels bunkering

The ports roadmap is structured into 15 implementation steps, grouped into four development phases, and punctuated by four decision gates.

Phase A – Strategic foundation *(Steps 1–4 | Gate 1)*

Step 1 – Assess the business case and strategic rationale

Clarify why alternative fuel bunkering is relevant to the port, which fuels are in scope, and over what timeframe.

Strategic drivers

- Market demand from shipping lines, bunker suppliers, or other interests has been assessed.
- Alignment with national or regional decarbonisation policy has been reviewed.
- Competitive positioning relative to neighbouring ports has been considered.
- Existing cargo flows and/or fuel handling experience have been analysed.
- Strategic positioning (e.g. fuel hub, early mover, follower) has been discussed at leadership level.

Strategic clarity

- Fuels in scope have been identified (fuel-agnostic approach applied).
- Indicative time horizon has been defined (near-term pilots / medium-term deployment / long-term).
- The intended port role has been clarified (facilitator, regulator, competent authority, landlord, operator).
- Internal strategic risks and opportunities have been documented.

Deliverable

- A documented internal position paper or briefing note.

Step 2 – Build internal knowledge and assign ownership

Establish baseline fuel knowledge and assign clear internal responsibility across safety, marine, environment, and permitting functions.

Organisational ownership

- A named internal lead or cross-functional team has been appointed.
- Reporting lines and accountability are defined.
- Responsibilities across, safety, marine, environment, permitting, legal, and communications are mapped.

Technical baseline knowledge

- Basic properties and hazards of relevant alternative fuels are understood.
- Operational implications for navigation, cargo handling, SIMOPs, and emergency response are reviewed.

Institutional capability

- Key knowledge gaps have been identified.
- External advisory or technical support needs have been assessed

Deliverable

- Internal briefing materials or knowledge pack prepared.

Step 3 – Establish governance and competent authority roles

Define decision authority, escalation paths, and internal risk acceptance principles.

Authority and legal position

- The role of the port authority has been clarified (full or partial competent authority).
- Interfaces with national regulators and administrations are mapped.
- Legal basis for port decision-making has been reviewed.

Decision-making framework

- Decision responsibilities are formally assigned.
- Escalation pathways are defined.
- Cross-department coordination mechanisms are agreed.

Risk governance

- High-level risk acceptance principles are defined.
- Alignment with national risk criteria (where applicable) has been considered.

Deliverable

- Governance and authority structure documented and approved internally.

Ports Roadmap to Bunkering

CHECKLIST for steps and decision gates for alternative fuels bunkering

The ports roadmap is structured into 15 implementation steps, grouped into four development phases, and punctuated by four decision gates.

	<p>Step 4 – Understand the regulatory and standards landscape Identify applicable national and international regulations, standards, and guidance, and where early regulator engagement is needed.</p> <p>Regulatory mapping</p> <ul style="list-style-type: none"> <input type="checkbox"/> National legislation relevant to bunkering has been identified. <input type="checkbox"/> Port permit conditions and local by-laws have been reviewed. <input type="checkbox"/> Applicable international conventions and IMO instruments are identified. <input type="checkbox"/> Relevant ISO standards and recognised industry guidance are identified. <p>Gap and interface analysis</p> <ul style="list-style-type: none"> <input type="checkbox"/> Areas requiring clarification or interpretation are identified. <input type="checkbox"/> Potential regulatory gaps are documented. <input type="checkbox"/> Early regulator engagement needs are identified. <p>Principle confirmation</p> <ul style="list-style-type: none"> <input type="checkbox"/> No attempt has been made to create new port-specific rules prematurely. <input type="checkbox"/> The approach is based on adapting and applying existing instruments where possible. <p>Deliverable</p> <ul style="list-style-type: none"> <input type="checkbox"/> Regulatory landscape summary prepared and approved internally.
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	<p>Gate 1 – Strategic Readiness and Internal Alignment</p> <p>Decision focus: Is there a clear strategic case and sufficient internal alignment to proceed?</p> <p>Confirms that:</p> <ul style="list-style-type: none"> <input type="checkbox"/> A strategic rationale and indicative timeline are defined <input type="checkbox"/> Internal ownership and governance are clear <input type="checkbox"/> Regulatory context is understood at a high level <input type="checkbox"/> No fundamental barriers are evident
--	--

Phase B – Feasibility and alignment (Steps 5–8 | Gate 2)

	<p>Step 5 – Wider stakeholder and public engagement Engage regulators, terminals, emergency services, port users, and - where relevant - local authorities and the public</p> <p>Stakeholder identification</p> <ul style="list-style-type: none"> <input type="checkbox"/> National regulators identified and mapped. <input type="checkbox"/> Local regulators and authorities identified. <input type="checkbox"/> Terminal operators and berth owners identified. <input type="checkbox"/> Shipowners and bunker suppliers identified. <input type="checkbox"/> Emergency services identified (fire, medical, coastguard, etc.). <input type="checkbox"/> Neighbouring industries and port users identified. <input type="checkbox"/> Local authorities and public stakeholders identified where relevant. <p>Engagement strategy</p> <ul style="list-style-type: none"> <input type="checkbox"/> Engagement objectives defined (information, consultation, alignment). <input type="checkbox"/> Communication channels agreed (meetings, workshops, briefings). <input type="checkbox"/> Engagement responsibilities assigned internally. <p>Risk and perception management</p> <ul style="list-style-type: none"> <input type="checkbox"/> Key stakeholder concerns identified and documented. <input type="checkbox"/> Public perception risks assessed (particularly for higher-consequence fuels). <input type="checkbox"/> Alignment with emergency services initiated. <input type="checkbox"/> Clear explanation of port role and authority communicated. <p>Deliverables</p> <ul style="list-style-type: none"> <input type="checkbox"/> Stakeholder engagement log created and maintained. <input type="checkbox"/> Summary of stakeholder feedback documented. <input type="checkbox"/> Issues register created with mitigation actions.
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Ports Roadmap to Bunkering

CHECKLIST for steps and decision gates for alternative fuels bunkering

The ports roadmap is structured into 15 implementation steps, grouped into four development phases, and punctuated by four decision gates.

	<p>Step 6 – Identify potential bunkering locations</p> <p>Proactively screen and shortlist candidate locations based on navigational, spatial, and emergency response considerations.</p> <p>Physical screening</p> <ul style="list-style-type: none"> <input type="checkbox"/> Berths, quays, anchorages, and interfaces reviewed. <input type="checkbox"/> Manoeuvring and navigation constraints assessed. <input type="checkbox"/> Traffic density and SIMOPs complexity considered. <input type="checkbox"/> Access routes for supply modes reviewed (marine and/or road). <p>Spatial and sensitivity review</p> <ul style="list-style-type: none"> <input type="checkbox"/> Proximity to people, buildings, and sensitive receptors assessed. <input type="checkbox"/> Interaction with neighbouring industrial activities reviewed. <input type="checkbox"/> Emergency access and egress routes assessed. <input type="checkbox"/> Compatibility with existing port zoning evaluated. <p>Fuel-agnostic suitability assessment</p> <ul style="list-style-type: none"> <input type="checkbox"/> Recognition that suitability may vary by fuel type. <input type="checkbox"/> Preliminary constraints documented for each candidate location. <p>Location classification</p> <ul style="list-style-type: none"> <input type="checkbox"/> Preliminary locations classified as been assigned <p>Deliverables</p> <ul style="list-style-type: none"> <input type="checkbox"/> Draft port bunkering map prepared. <input type="checkbox"/> Location screening rationale documented.
	<p>Step 7 – Define bunkering scenarios and fuel suitability</p> <p>Identify feasible supply modes and fuel-specific constraints for each candidate location.</p> <p>Supply mode definition</p> <ul style="list-style-type: none"> <input type="checkbox"/> Feasible supply modes identified (ship-to-ship, shore-to-ship, mobile-to-ship). <input type="checkbox"/> Compatibility with port layout confirmed. <input type="checkbox"/> Frequency and scale assumptions defined. <p>Physical and operational constraints</p> <ul style="list-style-type: none"> <input type="checkbox"/> Hose reach and manifold access reviewed. <input type="checkbox"/> Mooring and positioning constraints assessed. <input type="checkbox"/> Road access and traffic impacts considered. <input type="checkbox"/> SIMOPs implications identified. <p>Fuel-specific considerations</p> <ul style="list-style-type: none"> <input type="checkbox"/> Key hazard characteristics considered (flammability, toxicity, cryogenic risks, etc.). <input type="checkbox"/> Operational limitations documented. <input type="checkbox"/> Differences between fuels reflected in scenario assumptions. <p>Deliverables</p> <ul style="list-style-type: none"> <input type="checkbox"/> Scenario definition document for each candidate location. <input type="checkbox"/> Assumptions clearly recorded for use in risk assessment.

Ports Roadmap to Bunkering

CHECKLIST for steps and decision gates for alternative fuels bunkering

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	<p>Step 8 – Undertake risk assessments and define controlled areas</p> <p>Review risk assessments to define safety zones, toxic areas (where applicable), SIMOPs constraints, and operational limits.</p> <p>Risk assessment framework</p> <ul style="list-style-type: none"> <input type="checkbox"/> Type(s) of risk assessment agreed with competent authority. <input type="checkbox"/> Applicable risk acceptance criteria identified. <input type="checkbox"/> Applicable exposure thresholds (where relevant) confirmed. <p>Analytical studies</p> <ul style="list-style-type: none"> <input type="checkbox"/> Qualitative and/or quantitative risk assessments reviewed. <input type="checkbox"/> Consequence and dispersion analyses reviewed (where applicable). <input type="checkbox"/> HAZID / HAZOP studies reviewed. <input type="checkbox"/> SIMOPs studies reviewed. <p>Assumption validation</p> <ul style="list-style-type: none"> <input type="checkbox"/> Credible release scenarios agreed. <input type="checkbox"/> Representative release sizes defined. <input type="checkbox"/> Operational frequency assumptions validated. <input type="checkbox"/> Environmental and meteorological assumptions confirmed. <p>Controlled areas definition</p> <ul style="list-style-type: none"> <input type="checkbox"/> Hazardous areas defined. <input type="checkbox"/> Safety zones defined. <input type="checkbox"/> Toxic areas defined where applicable. <input type="checkbox"/> Marine exclusion zones identified. <input type="checkbox"/> Assessment zone boundaries documented. <p>Operational boundary review</p> <ul style="list-style-type: none"> <input type="checkbox"/> Compatibility with port layout confirmed. <input type="checkbox"/> Conflicts with neighbouring activities identified. <input type="checkbox"/> Navigational safety implications assessed. <p>Documentation and defensibility</p> <ul style="list-style-type: none"> <input type="checkbox"/> Risk assessment review findings documented. <input type="checkbox"/> Decision rationale recorded. <p>Deliverables</p> <ul style="list-style-type: none"> <input type="checkbox"/> Approved risk assessment framework. <input type="checkbox"/> Preliminary controlled area definitions. <input type="checkbox"/> Updated port bunkering map reflecting constraints.
	<p>Gate 2 – Strategic feasibility and stakeholder alignment check</p> <p>Decision focus: Can bunkering be supported in principle within the port’s operational, regulatory, and social context?</p> <p>Confirms that:</p> <ul style="list-style-type: none"> <input type="checkbox"/> Stakeholders and regulators are broadly aligned <input type="checkbox"/> Feasible locations and bunkering scenarios are identified <input type="checkbox"/> Risks can be managed within agreed criteria <input type="checkbox"/> No prohibitive constraints remain



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Phase C – Implementation and authorisation

(Steps 9–13 | Gate 3)

Step 9 – Infrastructure development

Address any physical, spatial, or access constraints needed to support controlled bunkering.

Physical infrastructure assessment

- Berth and quay strength and load-bearing capacity assessed.
- Layout and spatial constraints evaluated.
- Adequate space exists to establish and enforce safety and segregation zones.
- Marine access for bunker supply vessels or barges assessed.
- Road access for mobile supply units assessed (where applicable).

Utilities and support systems

- Power, lighting, and communications availability confirmed.
- Drainage and containment arrangements reviewed.
- Monitoring systems evaluated where required.
- Traffic management and access control arrangements assessed.

Emergency access

- Emergency vehicle access routes confirmed.
- Evacuation routes reviewed.
- Interface with neighbouring operations assessed.

Development planning

- Locations classified as fully suitable or conditionally suitable with defined constraints.
- Required upgrades identified (fixed or temporary).
- Phased or scalable infrastructure approach documented.

Deliverables

- Infrastructure assessment report.
- Updated bunkering map reflecting physical constraints.
- Implementation plan for required upgrades.

Step 10 – Licensing, permitting, and authorisation processes

Establish proportionate licensing and approval processes aligned with national requirements.

Framework alignment

- Licensing approach aligned with national permits and legislation.
- Legal authority to issue conditions confirmed.

Requirements definition

- Clear documentation requirements defined for applicants.
- Conditions of operation linked to risk assessment outcomes.
- Approval criteria documented and transparent.

Proportionality and consistency

- Use of recognised frameworks where appropriate.
- Administrative burden proportionate to risk and scale.

Compliance and oversight

- Compliance monitoring procedures defined.
- Enforcement mechanisms clarified.
- Record-keeping and audit processes established.

Deliverables

- Published licensing and authorisation framework.
- Standard application and review process defined.

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	<p>Step 11 – Documentation and operational controls</p> <p>Define documentation requirements to support safe operations and oversight.</p> <p>Documentation requirements</p> <ul style="list-style-type: none"> <input type="checkbox"/> Bunkering Management Plan required. <input type="checkbox"/> Compatibility assessment required. <input type="checkbox"/> Joint Plan of Bunkering Operation required. <input type="checkbox"/> Bunkering checklists defined. <input type="checkbox"/> Any fuel-specific supporting documents identified. <p>Port role clarification</p> <ul style="list-style-type: none"> <input type="checkbox"/> Port role limited to specifying, reviewing, and verifying documentation. <input type="checkbox"/> Operators retain responsibility for preparing operational documents. <input type="checkbox"/> Review and approval responsibilities internally assigned. <p>Review and control processes</p> <ul style="list-style-type: none"> <input type="checkbox"/> Review / approval criteria documented. <input type="checkbox"/> Clear linkage between documentation and licence conditions confirmed. <p>Deliverables</p> <ul style="list-style-type: none"> <input type="checkbox"/> Published documentation requirements.
	<p>Step 12 – Training and competence</p> <p>Ensure port personnel, terminals, contractors, and emergency services are trained and prepared.</p> <p>Key port personnel</p> <ul style="list-style-type: none"> <input type="checkbox"/> Harbour master and marine staff trained. <input type="checkbox"/> Safety and enforcement officers trained. <input type="checkbox"/> VTS personnel trained. <input type="checkbox"/> Communications staff briefed on fuel-specific considerations. <p>Stakeholder verification</p> <ul style="list-style-type: none"> <input type="checkbox"/> Minimum competence standards defined where not mandated by regulation. <input type="checkbox"/> Operators and suppliers competence confirmed. <input type="checkbox"/> Terminal staff competence confirmed. <input type="checkbox"/> Contractors' competence confirmed. <p>Drills and exercises</p> <ul style="list-style-type: none"> <input type="checkbox"/> Joint drills conducted or scheduled. <input type="checkbox"/> Fuel-specific scenarios included. <input type="checkbox"/> Lessons from exercises documented. <p>Competence management</p> <ul style="list-style-type: none"> <input type="checkbox"/> Training records maintained. <input type="checkbox"/> Refresher intervals defined. <input type="checkbox"/> Training scaled to frequency and complexity of operations. <p>Deliverables</p> <ul style="list-style-type: none"> <input type="checkbox"/> Training matrix and competence framework. <input type="checkbox"/> Verification process integrated into licensing.



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	<p>Step 13 – Emergency preparedness and response</p> <p>Integrate fuel-specific scenarios into port emergency planning and conduct joint exercises.</p> <p>Planning and integration</p> <ul style="list-style-type: none"> <input type="checkbox"/> Fuel-specific emergency scenarios incorporated into port emergency plan. <input type="checkbox"/> Spill, fire, toxic release, and escalation pathways defined. <input type="checkbox"/> Clear command and control structure documented. <p>External coordination</p> <ul style="list-style-type: none"> <input type="checkbox"/> Fire, medical, coastguard, and other responders engaged. <input type="checkbox"/> Mutual aid arrangements reviewed. <input type="checkbox"/> Interface protocols tested. <p>Communication and escalation</p> <ul style="list-style-type: none"> <input type="checkbox"/> Notification procedures defined. <input type="checkbox"/> Communication lines rehearsed. <input type="checkbox"/> Public communication strategy considered. <p>Validation</p> <ul style="list-style-type: none"> <input type="checkbox"/> Emergency response drills conducted. <input type="checkbox"/> Lessons learned incorporated. <input type="checkbox"/> Alignment with risk assessment assumptions confirmed. <p>Deliverables</p> <ul style="list-style-type: none"> <input type="checkbox"/> Updated emergency response plan. <input type="checkbox"/> Drill and exercise reports.
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	<p>Gate 3 – Operational authorisation decision</p> <p>Decision focus: Can the port authorise first or pilot bunkering operations under controlled conditions?</p> <p>Confirms that:</p> <ul style="list-style-type: none"> <input type="checkbox"/> Infrastructure, procedures, and controls are in place <input type="checkbox"/> Roles and responsibilities are clear <input type="checkbox"/> Personnel and responders are trained <input type="checkbox"/> Emergency arrangements are tested
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Phase D – Operation and scale-up (Steps 14–15 | Gate 4)

	<p>Step 14 – Pilot operations and controlled introduction</p> <p>Conduct first or pilot operations with enhanced oversight to validate assumptions and controls.</p> <p>Pilot bunkering controls</p> <ul style="list-style-type: none"> <input type="checkbox"/> Operation-specific approvals issued. <input type="checkbox"/> Additional constraints defined where necessary. <input type="checkbox"/> Enhanced monitoring requirements implemented. <p>Validation</p> <ul style="list-style-type: none"> <input type="checkbox"/> Risk assessment assumptions tested. <input type="checkbox"/> Safety zones validated in practice. <input type="checkbox"/> SIMOPs controls evaluated. <input type="checkbox"/> Emergency response tested under realistic conditions. <p>Continuous improvement</p> <ul style="list-style-type: none"> <input type="checkbox"/> Lessons learned captured. <input type="checkbox"/> Gaps identified and documented. <input type="checkbox"/> Corrective actions defined. <p>Deliverables</p> <ul style="list-style-type: none"> <input type="checkbox"/> Pilot bunkering evaluation report. <input type="checkbox"/> Updated risk and operational documentation.
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	<p>Gate 4 – Pilot validation and scale-up decision</p> <p>Decision focus: Can operations transition beyond pilots?</p> <p>Confirms that:</p> <ul style="list-style-type: none"> <input type="checkbox"/> Pilot operations have validated assumptions <input type="checkbox"/> Procedures and controls work in practice <input type="checkbox"/> Lessons learned are embedded
	<p>Step 15 – Transition to business-as-usual operations</p> <p>Progressively integrate bunkering into routine port operations, maintaining a risk-based approach.</p> <p>Operational consolidation</p> <ul style="list-style-type: none"> <input type="checkbox"/> Documentation streamlined and consolidated. <input type="checkbox"/> Administrative processes optimised. <input type="checkbox"/> Transition from operation-specific to standing licences where appropriate. <p>Expansion</p> <ul style="list-style-type: none"> <input type="checkbox"/> Additional locations assessed and approved where justified. <input type="checkbox"/> Additional bunkering scenarios authorised where justified. <p>Ongoing governance</p> <ul style="list-style-type: none"> <input type="checkbox"/> Risk-based review process maintained. <input type="checkbox"/> Periodic reassessment of operational envelope conducted. <input type="checkbox"/> Continuous improvement mechanism active. <p>Deliverables</p> <ul style="list-style-type: none"> <input type="checkbox"/> Standard licensing / authorisation framework in place. <input type="checkbox"/> Updated bunkering map reflecting expanded capability. <input type="checkbox"/> Periodic review schedule defined.